ISSN 3046-8701

Sixth ASEAN State of the Environment Report

one vision
one identity
one community

ISSN 3046-8701

Sixth ASEAN State of the Environment Report

Profile

The Association of Southeast Asian Nations (ASEAN) was established on 8 August 1967.

The Member States are Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam.

The ASEAN Secretariat is based in Jakarta, Indonesia

For inquires contact:

The ASEAN Secretariat
Community Relations Division (CRD)
70A Jalan Sisingamangaraja
Jakarta 12110, Indonesia
Phone: (62 21) 724-3372, 726-2991
Fax: (62 21) 739-8234, 724-3504
E-mail: public@asean.org

Catalogue-in-Publication Data

Sixth ASEAN State of the Environment Report
Jakarta, ASEAN Secretariat, September 2023

333.705
1. ASEAN – Environment – Policy
2. Sustainable Development – Natural Resources

ISSN 3046-8701

ASEAN: A Community of Opportunities for All

General information on ASEAN appears online at the ASEAN Website: www.asean.org

Supported by:

JAIF
Japan-ASEAN Cooperation

Implemented by:

IGES Institute for Global Environmental Strategies

2108-11 Kamiyamaguchi, Hayama, Kanagawa, 240-0115 Japan
+81 (46) 855 3700
https://www.iges.or.jp/

Foreword:
Message from the Secretary-General of ASEAN

The Association of Southeast Asian Nations (ASEAN) is pleased to present the 6th ASEAN State of the Environment Report. Since its last iteration in 2017, the region has witnessed significant and unprecedented changes, most notably the COVID-19 pandemic, as well as socio-economic developments, global supply chain disruptions, and environmental pressures and threats, among others. A key lesson of the past few years is the need for a whole-of-Community approach to address the wide-ranging impacts of non-traditional threats to our lives and livelihoods.

As the ASEAN region is prone to climate change and natural disasters, this report aims to provide strategic guidance on environmental management and planning in the region for policymakers, stakeholders and partners beyond the environmental sector. Through the Drivers-Pressures-State-Impacts-Response methodology, this paper provides a comprehensive and scientific assessment of the region's environmental landscape to suggest ways forward to strengthen environmental management and cooperation in ASEAN and its member states.

This publication also delves into ASEAN's critical environmental priorities, such as climate change, air pollution, biodiversity conservation, water resources management, coastal and marine environment, chemicals and waste, sustainable cities, and environmental education, amongst others. It offers practical suggestions for each of the identified priority areas, all of which call for our urgent attention, collective efforts and creative solutions.

The examination of the emerging environmental risks and cross-cutting issues in consideration of the changing global context and the lingering impacts of the pandemic shows that there is a real need for adaptive approaches to future crises in our environmental outlook. This study also features environmental insights for the implementation of other ASEAN-led strategies and initiatives in areas such as energy, transport, agriculture, fisheries, forestry and land use, blue economy, health, disaster management, as well as investment.

The study also serves as a reminder that a sustainable future can only be achieved through a shared commitment and vision for a greener and more resilient ASEAN. In this regard, this publication is also intended to increase public awareness of environmental developments and efforts across the region, as well as the broader perspective, to realize a more inclusive and sustainable ASEAN.

I, therefore, hope that our readers will find this report useful and informative in their work, and that this report serves as the foundation for effective regional management of environmental assets, in line with the ASEAN Community Vision 2025 and beyond.

DR. KAO KIM HOURN
Secretary-General of ASEAN

Acknowledgements

The ASEAN Secretariat with the initiative and leadership of H.E. Ekkaphab Phanthavong, Deputy Secretary-General of ASEAN for the ASEAN Socio-Cultural Community, is grateful for the publication of the Sixth ASEAN State of the Environment Report (SOER6) after an extensive consultation process with the ASEAN Member States (AMS) and relevant stakeholders. The completion of this report would not have been possible without the funding support from the Government of Japan through the Japan-ASEAN Integration Fund (JAIF).

The ASEAN Secretariat would like to also express its sincere gratitude for technical inputs and review comments provided by ASEAN Member States through their membership on the Task Force and their participation in three Task Force Meetings:

Brunei Darussalam: Hajah Norharniah Haji Jumat, Hj Mosaidi Mohd Said

Cambodia: Prak Thaveak Amida, Srey Sunleang, Uy Kamal, Roath Sith

Indonesia: Firman Maulana

Lao PDR: Khonsavanh Loungraj

Malaysia: Zuraini Ahmad Tajudin, Abu Bakar Tajuddin

Myanmar: Arkar San

The Philippines: Karen Ann Pacpaco

Singapore: Mohana Selvam

Thailand: Chatchai Intatha, Siriwan Laptuptimtong

Viet Nam: Tran Thi Hien Hanh, Pham Thi Vuong Linh

This report was developed through commissioned work by the Institute for Global Environmental Strategies (IGES), with additional inputs provided by experts from the ASEAN Centre for Biodiversity (ACB), Asian Institute of Technology (AIT), PEMSEA, Sunway University (Malaysia), the UN Capital Development Fund (UNCDF), UNDP, and UNU-IAS. The project was led by Mark Elder and Peter King and coordinated by Erin Kawazu from IGES. Authors and contributors of each chapter are as follows:

Ch. 1 Mark Elder, Peter King, Erin Kawazu

Ch. 2 Peter King, Erin Kawazu

Ch. 3 Eric Zusman, Sivapuram Ventaka Rama Krishna Prabhakar, Yosuke Arino, Nanda Kumar Janardhanan, Nguyen Thi Kim Oanh (AIT), Shobhakar Dhakal (AIT)

Ch. 4 Andre Mader, Erin Kawazu, Filiberto A. Pollisco (ACB)

Ch. 5 Ngoc-Bao Pham, Yukako Inamura, Bijon Kumer Mitra, Marianne Kjellen (UNDP), Thammarat Koottatep (AIT)

Ch. 6 Peter King, Andre Mader, Keita Furukawa (PEMSEA)

Ch. 7 Premakumara Jagath Dickella Gamaralalage, Rajeev Kumar Singh, Amila Abeyanaka, Miho Hayashi, Miwa Tatsuno, Agamutu Pariatamby (Sunway Univ.)

Ch. 8 Yatsuka Kataoka, Fernando Ortiz-Moya, Abdullah Zed (UNCDF), Fakri Karim (UNCDF), Jaffer Machano (UNCDF)

Ch. 9 Atsushi Watabe, Dwayne Appleby, Mario Tabucanon (UNU-IAS), Erin Kawazu

Ch. 10 Vivek Asokan, Chika Aoki, Agamutu Pariatamby (Sunway Univ.)

Ch. 11 Mark Elder, Simon Hoiberg Olsen

Ch. 12 Peter King, Mark Elder, Erin Kawazu

Ch. 13 Peter King

Ch. 14 Mark Elder, Peter King, Erin Kawazu

The layout was prepared by Masato Aoki, the text was edited by Emma Fushimi, and administrative support was provided by Takashi Otsuka, Eiko Kitamura, and Tomoko Kawakita. Yasuo Takahashi compiled Fig. 4.1 and Jasmine Upton compiled Fig. 4.5.

ISSN 3046-8701

Table of Contents

List of Tables

List of Figures

List of Boxes

List of Acronyms and Abbreviations

3Rs	reduce, reuse, recycle
4IR	Fourth Industrial Revolution
ACB	ASEAN Centre for Biodiversity
ACE	ASEAN Centre of Energy
ACP	Asia Co-benefits Partnership
ACSDSD	ASEAN Centre for Sustainable Development Studies and Dialogue
ADB	Asian Development Bank
AEC	ASEAN Economic Community
AECEN	Asian Environmental Compliance and Enforcement Network
AEEAP	ASEAN Environmental Education Action Plan
AEEID	ASEAN Environmental Education Inventory Database
AF	Adaptation Fund
AFOLU	agriculture, forestry, and other land use
AHP	ASEAN Heritage Parks
AJCSD	ASEAN-Japan Chemical Safety Database
AKCF	ASEAN-ROK Cooperation Fund
AMME	ASEAN Ministerial Meeting on Environment
AMS	ASEAN Member States
AN-IUU	ASEAN Network for Combatting IUU Fishing
APAEC	ASEAN Plan of Action for Energy Cooperation (2016-2025)
APAN	Asia-Pacific Adaptation Network
APASTI	Committee on Science and Technology, and the Plan of Action on Science, Technology, and Innovation (2016-2025)
APBON	Asia-Pacific Biodiversity Observation Network
APCAP	Asia Pacific Clean Air Partnership
APEC	Asia-Pacific Economic Cooperation
APFSD	Asia Pacific Forum on Sustainable Development
APMS	ASEAN Peatland Management Strategy
APN	Asia-Pacific Network for Global Change Research
APT	ASEAN Plus 3
AQI	air quality index
AR5	Fifth Assessment Report of the IPCC
AR6	Sixth Assessment Report of the IPCC

ARIAHS	ASEAN Regionally Important Agro-Ecological Heritage Systems
ARPA-AD	ASEAN Regional Plan of Action for Drought Adaptation (2021-2025)
ASCC	ASEAN Socio-Cultural Community
ASCCR	ASEAN State of Climate Change Report
ASCN	ASEAN Sustainable Cities Network; ASEAN Smart Cities Network
ASCOPE	ASEAN Council on Petroleum
ASEAN	Association of South East Asian Nations
ASMC	ASEAN Specialised Meteorological Centre
ASOEN	ASEAN Senior Officials on Environment
ASPA-WRM	ASEAN Strategic Plan of Action on Water Resources Management
ASPEN	ASEAN Strategic Plan on Environment (2016-2025)
ASPnet	UNESCO Associated Schools Project Network
ASUS	ASEAN Sustainable Urbanisation Strategy
AWGCC	ASEAN Working Group on Climate Change
AWGCW	ASEAN Working Group on Chemicals and Waste
AWGCME	ASEAN Working Group on Coastal and Marine Environment
AWGEE	ASEAN Working Group on Environmental Education
AWGESC	ASEAN Working Group on Environmentally Sustainable Cities
AWGNCB	ASEAN Working Group on Nature Conservation and Biodiversity
AWGWRM	ASEAN Working Group on Water Resources Management
AYEF	ASEAN+3 Youth Environment Forum
Bappenas	Ministry of National Development Planning (Indonesia)
BAU	business as usual
BIMP-EAGA	Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BOD	biochemical oxygen demand
bpd	barrels per day
BRN	Brunei Darussalam
CAA	Clean Air Asia
CAPEX	capital expenditure
CBD	Convention on Biological Diversity
CCA	climate change adaptation

CCET	IGES Centre Collaborating with UNEP on Environmental Technologies
CCAC	Climate and Clean Air Coalition
CE	circular economy
CES	Circulating and Ecological Sphere
CGIAR	Consultative Group on International Agricultural Research
CH_4	methane
CIESIN	Center for International Earth Science Information Network
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMIP6	Coupled Model Intercomparison Project Phase 6
CO_2	carbon dioxide
COBSEA	Coordinating Body on the Seas of East Asia
COP	Conference of the Parties
COP-AATHP	Conference of Parties to the ASEAN Agreement on Transboundary Haze Pollution
COST	Committee on Science and Technology
CPL	city planning labs
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
CSR	corporate social responsibility
CTI-CFF	Coral Triangle Initiative for Coral Reefs, Fisheries, and Food Security
DALYs	disability adjusted life years
DENR-EMB	Environmental Management Bureau of the Philippines
DMC	domestic material consumption
DMI	direct material input
DO	dissolved oxygen
DPSIR	drivers-pressures-state-impacts-responses
DRM	disaster risk management
DRR	disaster risk reduction
EANET	Acid Deposition Monitoring Network in East Asia
EE	environmental education
EEZ	exclusive economic zone
EPR	extended producer responsibility
E-READI	Enhanced Regional EU-ASEAN Dialogue Instrument
ERIA	Economic Research Institute for ASEAN and East Asia

ESABII	East and Southeast Asia Biodiversity Information Initiative
ESC	Environmental Study Centre
ESD	education for sustainable development
ESP	Eco-Stewardship Programme
ETS	emission trading scheme
EU	European Union
EV	electric vehicle
FAO	Food and Agriculture Organisation of the United Nations
FTA	free trade agreement
GAP	Global Action Programme
GCE	Global Citizenship Education
GCF	Green Climate Fund
GDP	gross domestic product
GEF	Global Environment Facility
GEO	Global Environment Outlook
GHI	Global Hunger Index
GHS	Globally Harmonised System (for chemicals)
GMS	Greater Mekong Subregion
GNI	Gross National Income
GTI	Global Taxonomy Initiative
ha	hectare
HCW	healthcare waste
HEI	higher educational institute
HFC	hydrofluorocarbon
HLPF	High Level Political Forum
HSF	Hans Seidel Foundation
I&M	inspection and maintenance
ICT	information and communication technology
IDN	Indonesia
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IGES	Institute for Global Environmental Strategies

IHL	Institute of Higher Learning
IMF	International Monetary Fund
IMT-GT	Indonesia-Malaysia-Thailand Growth Triangle
IOMC	Inter-Organization Programme for the Sound Management of Chemicals
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IRWR	internal renewable freshwater resource
IsDB	Islamic Development Bank
IUCN	International Union for the Conservation of Nature
IUU	illegal, unreported, and unregulated (fishing)
IWRM	integrated water resource management
JAIF	Japan-ASEAN Integration Fund
JICA	Japan International Cooperation Agency
JPL	Jaringan Pendidikan Lingkungan (Environmental Education Network, Indonesia)
KHM	Cambodia
KLA	Kelab Pencinta Alam (School Nature Club, Malaysia)
KMGBF	Kunming-Montreal Global Biodiversity Framework
KPI	key performance indicator
LAO	Lao PDR
LCOE	levelised cost of electricity
LDC	least developed country
Leap-IBC	Long-range Energy Alternative Planning– Integrated Benefits Calculator
LEDS	low emissions development strategy
LMB	Lower Mekong Basin
LMC	Lancang-Mekong Cooperation
LoCARNet	Low Carbon Asia Research Network
LTS	long-term strategies
LULC	land use/land cover
LULUCF	land use, land use change and forestry
$\mu g/m^3$	micrograms per cubic metre
M&E	monitoring and evaluation
MDG	Millennium Development Goal

MEA	multilateral environment agreement
MEB	Malaysia Education Blueprint
METI	Ministry of Economy Trade and Industry, Japan
MOE	Ministry of Education
MOET	Ministry of Education and Training
MOI	Ministry of Interior
MONRE	Ministry of Natural Resources and Environment
MOPH	Ministry of Public Health
MPA	marine protected area
MPAC	Master Plan on ASEAN Connectivity 2025
MPP	marine plastic pollution
MRC	Mekong River Commission
MSDI	Municipal Spatial Data Infrastructure
MSW	municipal solid waste
Mtoe	million tonnes of oil equivalent
MW	megawatt
MMR	Myanmar
Mt	million tonnes
MYS	Malaysia
NAP	national adaptation plan
NAPA	national adaptation programme of action
NbS	nature-based solution
NBSAP	national biodiversity strategy and action plan
NC	national communication
NDC	nationally determined contribution
NGO	nongovernmental organization
NH_3	ammonia
NIES	National Institute for Environmental Studies (Japan)
NOx	nitrogen oxides
NRW	non-revenue water
O_3	ozone
O&M	operation and maintenance

OECD	Organisation for Economic Cooperation and Development
OECM	other effective area-based conservation measure
OPEX	operational expenses
P4G	Partnering for Growth
PEMSEA	Partnerships in Environmental Management for the Seas of East Asia
PES	payment for ecosystem services
PHL	Philippines
PM	particulate matter
POP	persistent organic pesticide
PPP	polluter pays principle
PPWSA	Phnom Penh Water Supply Authority
PV	photovoltaic
R&D	research and development
RC3S	Regional Capacity Centre for Clean Seas
RCE	Regional Centre of Expertise
RCEP	Regional Comprehensive Economic Partnership
RCP	representative concentration pathway
RDF	refuse derived fuel
RE	renewable energy
RKC-MPD	Regional Knowledge Centre for Marine Plastic Debris
ROK	Republic of Korea
SEEN	Sabah Environmental Education Network
SCLP	short-lived climate pollutant
SCP	sustainable consumption and production
SDG	sustainable development goal
SDI	Satoyama Development Initiative
SEADRIF	Southeast Asia Disaster Risk Insurance Facility
SEAFDEC	Southeast Asian Fisheries Development Centre
SEPL	socio-ecological production landscape and seascape
SGP	Singapore
SLA	Singapore Land Authority
SLAAS	Sustainable School Environment Award (Malaysia)

SOER	State of the Environment Report
SOx	sulphur oxides
SSP	shared socio-economic pathway
TEU	twenty-foot equivalent units (container measurement)
TFC	total final consumption (of energy)
Tg	teragram
THA	Thailand
TISI	Thailand Industrial Standard Institute
TTI	Teacher Training Institute
SOER6	Sixth State of the Environment Report
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNEP-IETC	UNEP International Environmental Technology Centre
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific, and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
UNU-IAS	United Nations University Institute for the Advanced Study of Sustainability
URA	Urban Redevelopment Authority (Singapore)
VLR	Voluntary Local Review (of the SDGs)
VNM	Viet Nam
VNR	voluntary national reviews (on the SDGs)
VOC	volatile organic compound
WCED	World Commission on Environment and Development
WEPA	Water Environment Partnership in Asia
WHO	World Health Organization
WMA	Wastewater Management Authority
WTE	waste to energy
WWF	Worldwide Fund for Nature

Executive Summary

The ASEAN State of the Environment Report (SOER) is a regular flagship publication of the ASEAN Senior Officials on Environment (ASOEN). This sixth report (SOER6) provides ASEAN Member States (AMS) with relevant and useful information on environmental state and trends in the region to inform environmental management decisions that will contribute to ASEAN's sustainable development efforts. The overall methodology of SOER6 follows the Drivers-Pressures-State-Impacts-Response (DPSIR) methodology developed by the Organisation for Economic Co-operation and Development (OECD) and used for the Global Environment Outlook (GEO). The process of developing this report included intensive consultation with AMS, relevant sectoral bodies, and regional experts.

Key drivers influencing environmental quality in ASEAN include economic growth, some aspects of economic development strategies, continued population growth and demographic changes, the expected recovery from the COVID-19 pandemic, some aspects of ASEAN's global trade and investment structure, infrastructure development, technological change from the Fourth Industrial Revolution, and uncoordinated promotion of sustainability at the regional level. Global climate change and biodiversity loss are also now widely recognized as major drivers of environmental quality in addition to their social and economic impacts. Administrative jurisdiction of many drivers is typically distributed among several national government ministries in AMS and they are mostly not under the jurisdiction of environmental authorities. Moreover, many drivers are strongly influenced by non-ASEAN countries and broader global trends outside of ASEAN, so they are difficult for the AMS to influence by themselves. Therefore, it would be more effective for policies and plans, especially those outside the jurisdiction of environmental authorities, to address environmental impacts through multi-sectoral and international cooperation.

"ASEAN 2025: Forging Ahead Together" set a range of key result areas on environment including related strategic measures. The key result areas include, among others, conservation and sustainable management of biodiversity and natural resources, environmentally sustainable cities, sustainable climate, and sustainable consumption and production (ASEAN Secretariat 2015a). SOER6 examines the current and prospective efforts by AMS to address these issues.

Climate and Air Pollution

Climate change may be the most challenging environmental problem, as it is already causing serious negative impacts in the region. Unless climate change is significantly abated in the next decade or two, it will cause mounting economic and social costs, for example due to health and infrastructure damage, and threaten food security. High levels of air pollution are also threatening health and well-being in the region. The main findings and recommendations are:

(a) Emissions of greenhouse gases (GHGs) and air pollutants have continued to rise in the ASEAN region and there is little evidence of decoupling them from economic growth and energy use;

(b) High levels of air pollution and accelerating climate change pose a substantial threat to the health and well-being of the 660 million people living in ASEAN;

(c) The main sources of air pollution and GHGs in AMS are similar: fossil-fuel energy, road transport, industry, construction, residential energy, waste management, agriculture, deforestation, and land use fires;

(d) The ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–2025 set a regional target of 32% reduction in energy intensity by 2025 relative to 2005 levels, and a 23% share for renewable energy share in the total primary energy supply by 2025, but the renewable energy target is not yet on track;

(e) AMS should strengthen their ambition for both climate mitigation and adaptation, and enhance their NDCs as necessary to align with the Paris Agreement temperature goal, considering carbon pricing as a key tool; and for air pollution, AMS should adopt and implement the WHO air quality guidelines;

(f) AMS responses to climate change and air pollution should utilize a holistic approach shifting to green industrial technologies, setting more stringent emissions standards, transitioning towards renewable energy, facilitation of cross border flows of renewable energy, and improved energy efficiency;

(g) Implement policies and measures that simultaneously reduce emissions of GHGs and air pollutants, thus delivering multiple benefits and co-benefits in a cost-effective manner.

Biodiversity Conservation

ASEAN is one of the world's most biodiverse regions, on land, in freshwater and in the ocean. ASEAN has 5,776 species known to be threatened and a further 29 have already gone extinct or are extinct in the wild. As in most parts of the world, the main pressures believed to be responsible for biodiversity loss in ASEAN are habitat loss, over-exploitation, climate change, invasive alien species, and pollution, while illegal, unreported, and unregulated (IUU) fishing is one of the main pressures resulting in marine biodiversity loss. ASEAN has achieved some progress towards safeguarding essential ecosystems and ecosystem services, but the rate of progress needs to be increased to meet international targets.

All AMS are Parties to the Convention on Biological Diversity, and most are Parties to other international and regional agreements on biodiversity. The Regional Action Plan for ASEAN Heritage Parks (2016-2020), for example, guides the implementation of the ASEAN Heritage Parks (AHP) programme, which covers 51 AHPs as of 2022. In total, ASEAN has 2,202 terrestrial and marine protected areas. AMS are well on track toward developing national biodiversity strategies and action plans, which are expected to align with the Kunming-Montreal Global Biodiversity Framework, and are implementing the ASEAN Working Group on Nature Conservation and Biodiversity (AWGNCB) Action Plan and the recommendations arising from the Third ASEAN Biodiversity Outlook (ABO3).

To make further progress on biodiversity conservation, ASEAN will need to address both the drivers and pressures on biodiversity, expand protected areas and other effective area-based conservation measures as well as improve associated management measures. AMS should also continue improving efficiency of aquaculture and agriculture to relieve pressures on ecosystems, and identify and implement nature-based solutions to developmental challenges such as urbanization and infrastructure construction, and invest in natural capital. A custodial approach to natural resources, inviting the participation from indigenous peoples and local communities, can promote stewardship and attach real value to natural capital while contributing to human well-being.

Water Resources Management

In relation to water resources, remarkable progress has been made to improve access to safe and clean drinking water over the last 20 years. For example, the proportion of the ASEAN population using safely managed drinking water services reached around 90% in 2020, although for improved sanitation facilities, the ratio of coverage is still low in some areas. However, water quality degradation caused by poor sanitation and hygiene services, low water-use efficiency for agriculture, and lack of appropriate domestic wastewater treatment systems are still common challenges in many AMS. Nutrient pollution from agricultural run-off and untreated domestic wastewater discharge are considered the two greatest threats to ambient water quality, damaging ecosystem services, and threatening human health. The ASEAN Working Group on Water Resources Management (AWGWRM) Action Plan supports national level action to address key common challenges in water. ASEAN adopted the first ASEAN Declaration on Enhancing Drought Adaptation in 2020, and the ASEAN Regional Plan of Action for Drought Adaptation (ARPA-AD) 2021-2025 in 2021. Also in 2021, the ASEAN Regional Action Plan for Combating Marine Debris in the AMS was launched.

Strengthening water governance and enforcement capacity of institutions at national and local levels, as well as enhancing cross-sector coordination and collaborative partnerships on vertical and horizontal dimensions, are critical to advance sustainable water resources management in the region. Water quality monitoring and reporting need to be strengthened. Continued progress on SDG 6 will help the ASEAN region to safeguard sustainable access to water and water quality, protect against water-borne pollution and water-related disasters, and sustain aquatic ecosystems.

Coastal and Marine Environment

Coastal and marine waters in the region are increasingly affected by shipping, offshore oil and gas facilities, pipelines and cables, sand mining, wastewater disposal, tourism resort development, and potentially seabed mining, with accumulating impacts on marine biodiversity and water quality. The Coral Triangle (covering Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor Leste) is referred to as the "global epicentre of marine biodiversity" and is home to 76% of the world's 798 coral species and 37% of the world's 6,000 coral reef fish species but is subject to illegal fishing, coral mining for construction, and increased coral bleaching due to climate change, among other damaging practices. Aquaculture is rapidly replacing overexploited capture fisheries as an important source of exports from the ASEAN region but has its own adverse environmental impacts. Climate change will have major impacts on ASEAN's extensive shorelines (173,000 km) and coastal waters, as the projected sea level rise of up to 1 m by 2100 would affect 410 million people globally, with 59% in tropical Asia. Sea level rise will be exacerbated by land subsidence, which can exceed 25 mm/year in coastal cities like Jakarta, Semarang, and Bangkok, and coastal erosion.

Current responses in the coastal and marine environments include the ASEAN Leaders' Declaration on Blue Economy, marine protected areas, some coastal zone adaptation plans, the ASEAN Regional Action Plan for Combatting Marine Debris (2021-2025), a Strategic Plan of Action for ASEAN Cooperation on Fisheries (2021-2025), and sustainable port development, but much more needs to be done. Integrated coastal zone planning and management, incorporating climate change adaptation should be prioritized. National Adaptation Plans (NAPs) should include major efforts to protect coastal and marine assets and livelihoods. The number and area of coastal and marine ASEAN Heritage Parks should be expanded, as well as other marine protected areas. The ASEAN region should develop a common strategy for handling decommissioning of offshore oil and gas facilities, as well as improved environmental management of undersea pipelines and cables. Implementation of SDGs 14 and 15 on land and ocean ecosystems as well as SDG 12 on sustainable consumption and production would help to sustain coastal and marine ecosystems.

Chemicals and Waste

ASEAN needs to transition from outdated, unsustainable smokestack industries discharging untreated waste, and end-of-pipe pollution control technology needs to be augmented with cleaner, more efficient production technology. The increasing amounts of chemicals and waste and their management pose a serious challenge for most AMS. The manufacture of chemicals and chemical products across the 10 AMS involves more than 15,000 factories, and organic chemicals are in the top ten imports and intra-ASEAN exports. Municipal solid waste is likely to exceed 188 million t/yr by 2030, with a large proportion food waste and plastic, made worse by increased home deliveries and healthcare/personal protection equipment during the COVID-19 pandemic.

Gradually, the key tools of environmental management of chemicals and waste are being implemented in AMS, but much greater efforts are needed regarding source and ambient monitoring, public awareness, compliance, and enforcement. These measures could be good sources of green jobs. Chemicals and waste management are cross-cutting issues related to a range of areas like the circular economy, so holistic and integrated approaches are needed. The ASEAN Joint Declaration on Hazardous Chemicals and Wastes Management (2017) and the Regional Action Plan to Combat Marine Debris (2021-2025) as well as ASEAN's involvement in the Basel, Rotterdam and Stockholm conventions need to be supported by increased funding, R&D, and international support. The OECD Guiding Principles on Chemical Accident Prevention, Preparedness, and Response should be adopted. Implementation of SDG 12 would help to improve management of chemicals and waste.

Sustainable Cities

Many, if not most, of the environmental issues described in SOER6 have an urban dimension (e.g., consumption of resources, municipal solid waste, rising temperatures and urban heat island effects, GHG emissions, and loss of natural environments and biodiversity). By 2050, at least half the population in ASEAN will live in cities, including at least five mega-cities by 2035. Cities need to improve solid waste and wastewater management systems, control air pollution, and alleviate traffic congestion as well as plan for increasing population, providing sustainable forms of transport and housing, while confronting increasing threats from climate change and other environmental shocks and stresses.

This wide range of interrelated problems calls for integrated responses that go beyond traditional siloed policymaking approaches, which can be facilitated by the integrative approach of the SDGs. Long-term planning of ASEAN cities is an urgent priority, and some cities are already relieving some of the stresses on existing mega-cities by developing new or satellite cities that build in sustainability from the outset. Cities can be a laboratory for identifying innovative solutions to address environmental and climate change challenges and solutions, both at the local and global scales. ASEAN cities are frequently frontrunners in developing sustainable (model) cities, with multiple good practices, as demonstrated in the ASEAN environmentally sustainable cities Model Cities programme, and the SDGs Frontrunner Cities Programme. The policies and good practices identified from these programmes should be replicated or scaled up, and the ESC Awards should be strengthened, including a focus on urban biodiversity and green spaces. The region also demonstrated its commitment to realizing green and sustainable ASEAN through the development of ASEAN Sustainable Urbanisation Strategy (ASUS) and Master Plan of ASEAN Connectivity (MPAC).

The environmental sustainability of cities will be enhanced by localization of all SDGs, not only implementation of SDG 11, which targets several key environmental aspects of cities.

Environmental Education

Environmental education (EE) and education for sustainable development (ESD) are needed to develop individuals' and communities' capacities through transformative education to build sustainable environments, economies, and societies. EE/ESD is especially important for youth, which can promote their engagement with environmental issues and also help to raise public awareness. At the national level, some AMS have specific EE or ESD action plans while others use different policy frameworks such as education, climate, or environmental policies to promote EE/ESD. AMS face various challenges when implementing EE/ESD programmes such as overloaded educational programmes, resource constraints, and insufficient implementation guidelines. There is a wide variety of approaches on EE/ESD in the ASEAN region, not just a single approach. Each country aligns EE/ESD with global issues such as climate change and biodiversity and with the nationally or locally urgent issues.

What is most needed at present is a better framework or scheme for accelerating the understanding and sharing of the status of EE/ESD in the region, as well as additional capacity and resources. ASEAN Environmental Education Action Plans (2000-2005, 2008-2012, and 2014-2018) set the priority areas and activities on environmental education, and education for sustainable development at the national and regional levels. Guided by these action plans ASEAN has carried out several international programmes, such as the ASEAN Eco-schools Programme, ASEAN Green Higher Education Programme, ASEAN+3 Youth Environment Forum, ASEAN Youth Eco-champions award (2019) and the ASEAN+3 Leadership Programme focused on Sustainable Consumption and Production (2007-2018). EE/ESD are enablers of the SDGs and should be mainstreamed in the planning, programming, budgeting and implementation across all SDG programmes and projects. The concept of EE/ESD may need to be extended to include higher education as well as research and development (R&D) on emerging environmental issues and solutions.

Circular Economy

Current production and consumption practices in the ASEAN region cause several negative environmental impacts such as GHG emissions, land, air and water pollution, and waste. Resource inefficiencies contribute to these negative environmental impacts and are economically costly. Food and beverages, housing and transportation are the major consumption categories, followed by consumption of other goods and services. The negative outcomes of a linear flow economic system subsequently impact on human health and disrupt the global supply chains by increasing natural hazards risks due to climate change.

In response, some AMS are beginning to take a more comprehensive approach by promoting recycling through product design and extended producer responsibility (EPR) and expanding the market for circular economy products and services beyond waste issues alone. The ASEAN SCP Framework (APRSCP and SWITCH-Asia RPAC 2022) has been adopted and the ASEAN Circular Economy Stakeholder Platform has been established (ACSDSD 2023). Circular economy strategies such as material resource efficiency, and the role of secondary markets and EPR need to be strengthened in all AMS. This will help to create a regional circular flow. Development of a circular economy in the region would be facilitated by implementation of SDG 12 as well as the targets on resource efficiency and sustainable industrialization and infrastructure in SDGs 8 and 9. Supporting and enabling policies are needed including on sustainable lifestyles and infrastructure; these should protect vulnerable people and incorporate gender-sensitive perspectives. AMS should accelerate the application of the circular economy approach and mainstream circular economy into key economic sectors.

Sustainable Development Goals (SDGs)

The SDGs encourage countries to develop synergies between the environment and the social and economic dimensions of sustainable development. This could help gain more support for environmental measures by the public as well as a broader range of policymakers. AMS have engaged extensively with the SDG process, developing data and indicators, establishing national coordination bodies, and nine AMS have prepared Voluntary National Reviews to report on their progress to the High-Level Political Forum. Businesses, non-governmental organizations (NGOs), youth and other stakeholders have engaged in SDG implementation in ASEAN. AMS have adopted various policies to address the environment-related SDGs, but the overall assessment is that these are not sufficient to achieve the SDGs by 2030. Unfortunately, some backward trends have been observed in 2022, with the subregion off track to achieve any of the SDGs by 2030, and regression on SDGs 6,11,12,13, and 14 (on water, cities, sustainable consumption and production, climate, and life below water, respectively)(UNESCAP 2022). This seems to have been the result of many factors such as “continued unsustainable development pathways coupled with an increase in the frequency and intensity of human-made crises and natural disasters” including COVID-19 (UNESCAP 2022, p. 2). The SDGs could help guide the activities of the ASEAN Working Groups as the SDG topics are similar to the Working Group focus areas, since the scope of each Working Group is well-aligned with at least one SDG.

ASEAN Environmental Cooperation Framework

There are extensive intra-ASEAN institutional arrangements for environmental cooperation including the ASEAN Ministerial Meeting on the Environment, ASEAN Senior Officials on Environment, and seven working groups. The ASEAN Secretariat plays an important role in supporting the institutional framework and coordinating ASEAN Dialogue and Development Partners and other international organisations. In addition, there are various specialized ASEAN organizations related to the environment, such as the ASEAN Centre for Biodiversity, ASEAN Centre for Sustainable Development and Dialogue, ASEAN Centre for Energy, and the ASEAN Specialised Meteorological Centre. The ASEAN Cetre for Climate Change is expected to be established in 2023. Some activities of the ASEAN Economic Community (AEC) and ASEAN Political and Security Community (APSC) are also related to the environment.

Stronger coordination among ASEAN’s wide range of environmental cooperation frameworks is needed at all levels, in all sectors, and among key stakeholders and partners to enhance the exchange of best practices as well as to strengthen the substance of projects and programmes to support the further advancement of environmental management in the region. It is also desirable to streamline, harmonize and align the priorities of AMS, ASEAN, key stakeholders, and dialogue partners. Better coordination will require enhanced human resource capacity in the ASEAN sectoral bodies, especially the specialised Centres, the ASEAN Secretariat, and national ministries of AMS. Some activities of the AEC and APSC are also related to the environment, especially energy; so how to strengthen their involvement with international environmental cooperation should be considered. The cumulative reporting burdens for all these cooperation frameworks with many overlapping requirements can be challenging, but an ASEAN monitoring and evaluation framework would make it easier.

Outlook and Response Options

SOER6 also looks at the future potential environmental trajectory in ASEAN by examining two possible scenarios (i) business as usual, which continues current trends; and (ii) accelerated transformation towards a sustainable future. The two scenarios cover the period beyond 2025 and looking back from 2050. The scenarios also acknowledge the different entry levels of AMS which will affect their ultimate sustainable development pathways.

Overall, the business-as-usual scenario is likely to reduce human well-being resulting from increased health damage, food insecurity, deteriorating infrastructure, high economic costs and lost jobs. ASEAN's vision of an integrated, sustainable, harmonious, peaceful, and productive region, with its "One Vision, One Identity, One Community" is not likely to be achieved under the business-as-usual scenario.

In contrast, the accelerated transformation scenario will put ASEAN much closer to realizing its vision. Inclusive well-being and resilience will be significantly higher with much better health, greater food security, and overall economic prosperity with the substantial expansion of green jobs. The possible response options which would lead to transformative change across the ASEAN region are listed for reflection and further assessment by AMS.

Scientific Research, Data, and Monitoring

Strengthened scientific research, monitoring, and data are needed for improving environmental policies and making them more effective as well as to understand and address emerging environmental risks. ASEAN has made progress which has been facilitated by the need for SDG reporting. However, data are still insufficient or unavailable for many issues, impeding scientific research and impeding the development of evidence-based policies. Basic scientific capacity is also insufficient. Moreover, the lack of harmonization of data among the countries in the region has made environmental research and environmental cooperation on solutions more difficult.

More resources should be devoted to strengthening scientific research, monitoring, and data development for environmental issues, and greater international cooperation should focus on further developing the relevant capacity. The development of an ASEAN environmental monitoring and evaluation framework could be studied/considered to facilitate tracking the progress of ASEAN plans, programmes, and contributions to various cooperation frameworks, as well as ease the burden of related reporting. In particular, the framework should lead to improved data systems particularly including the regular collection and reporting of baseline data. This will also facilitate the creation of big data for future use of advanced analytical methods such as artificial intelligence to make environmental management more effective.

Emerging Environmental Risks

AMS have already begun to address some new priority environmental issues such as marine plastic pollution, ocean ecosystems, management of chemical wastes, and circular economy solutions. Nevertheless, some longstanding environmental problems are becoming increasingly serious, especially climate change, biodiversity loss, and pollution, thereby causing considerable health and economic damage.

New emerging environmental risks are also appearing. These include potential negative environmental impacts from mining of critical minerals, deep sea mining, new materials made from nano particles, other new materials and chemicals, genetic modification, and artificial intelligence. Large amounts of energy will be required for new industries such as data centres and server farms needed to support the digital revolution, and blockchain-based applications such as crypto-currencies. The COVID-19 pandemic resulted in a large increase in medical waste as well as plastic and other kinds of waste. ASEAN should also prepare for the management of waste resulting from potential future earthquakes. How to manage nuclear waste and prepare for potential nuclear accidents should also be considered if commercial nuclear power plants are built in the region. Strengthened capacity for scientific research and data collection will be needed for the region to address these risks in a timely manner.

The COVID-19 Pandemic, Economic Recovery, and the Environment

The COVID-19 pandemic worsened some environmental problems such as medical and plastic waste, while others temporarily improved, such as GHG emissions and air pollution. The pandemic also increased awareness of the linkages between the environment and health. The economic recovery from COVID-19 should proceed in an environmentally and socially sustainable direction, following the principle of "build back better," especially emphasizing energy efficiency and the transition to renewable energy and away from fossil fuels. It is a major opportunity to adopt nature-based solutions and invest in natural capital, thereby strengthening environmental, social, and economic resilience.

Conclusion

Overall, SOER6 shows that environmental problems and challenges in the ASEAN region are becoming increasingly serious, especially the risks to human health, agricultural production, and food security. Related direct and indirect economic costs of these environmental problems and challenges are also escalating, especially for climate change, extreme weather, and sea level rise. Vulnerable populations are often suffering disproportionately from these environmental problems and challenges.

Many of the solutions are already well known. The ASEAN Community Vision 2025 and other ASEAN plans and programmes aim to address these environmental problems and challenges. AMS have steadily upgraded their policies and other responses including extensive international cooperation. However, the responses to date have not been sufficient, and the costs of environmental problems and challenges have been rising and are expected to continue to escalate in the future. It is hoped that this report may encourage stronger responses by AMS, not only by highlighting the problems and challenges, but also by examining their economic and human costs, as well as the economic and human benefits of the solutions, including the potential for job creation. The SDGs promote a more holistic approach to sustainable development and achieving synergies between the environment, economy, and society which could be implemented concretely by a circular economy, reducing pollution and waste while increasing resource efficiency and creating jobs.

Chapter 1
Introduction and Methodology

1.1 Introduction

The ASEAN State of the Environment Report (SOER) is a regular flagship publication of the ASEAN Senior Officials on Environment (ASOEN) which is periodically published every 3-5 years. The SOERs present a comprehensive review of the state and trends of the environment, the pressures on it and the drivers of those pressures, and the national and regional initiatives in place to address environmental concerns, to provide an overall outlook for the ASEAN environment.

The main purpose of the SOER is to provide relevant and useful information on environmental issues to the public and decision-makers, to raise awareness and support more informed environmental management decisions that lead to more sustainable use and effective conservation of environmental assets of the region. ASEAN has published five SOERs (1997, 2001, 2006, 2009, 2017). The Fifth SOER in 2017 was published as part of the commemoration of the Golden Anniversary of ASEAN.

As the nature of environmental issues is constantly changing, the development of the Sixth ASEAN State of the Environment Report (SOER6) is pivotal to equipping the ASEAN Member States (AMS) with up-to-date information on the status and trends of the region's environment. SOER6 has several new elements. It assesses the progress and contribution towards the ASEAN Community Vision 2025, the Sustainable Development Goals (SDGs), the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), and other relevant multilateral environmental agreements (MEAs) through a balanced approach to environmental, social, and economic dimensions. Most importantly, SOER6 will address the emerging environmental challenges and opportunities of the region's recovery from the COVID-19 pandemic. SOER6 also includes new chapters on the circular economy, sustainable cities, and environmental education.

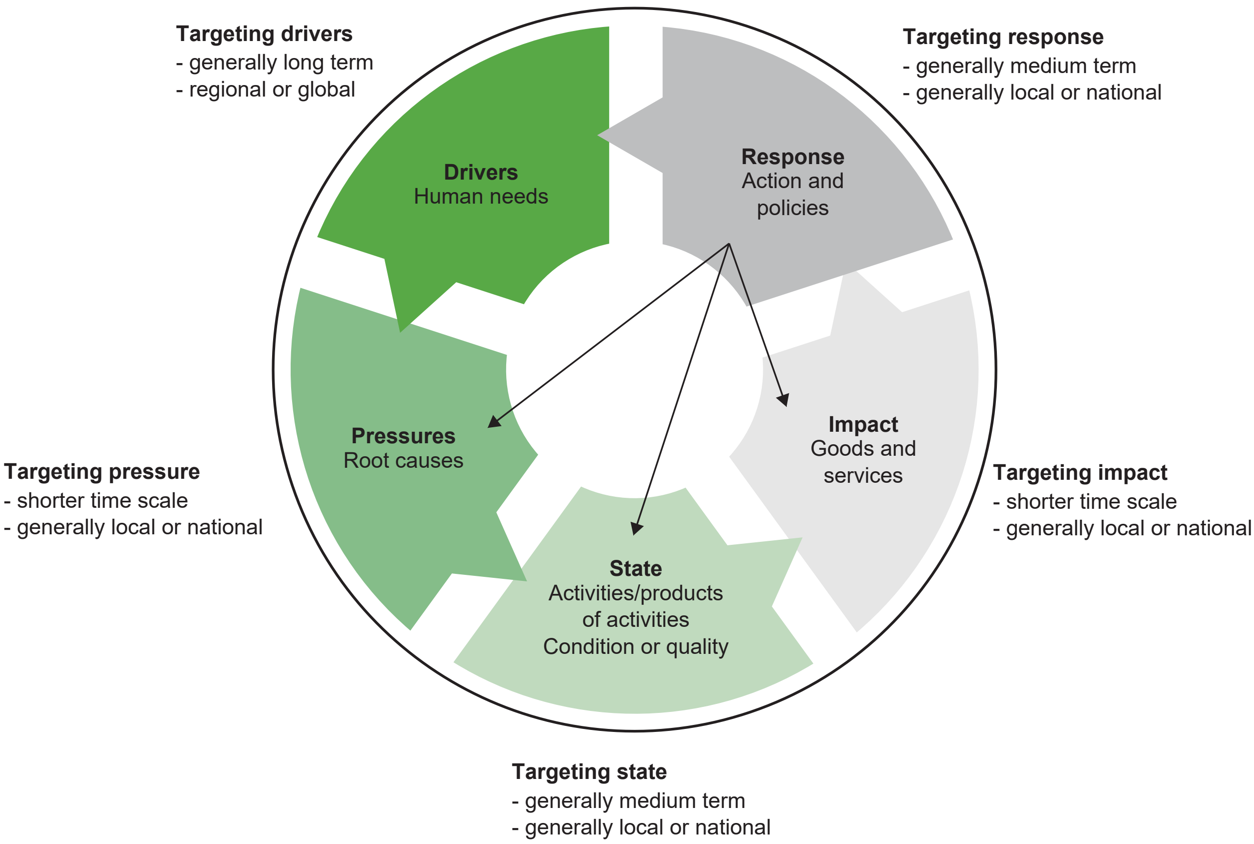
This Sixth SOER was prepared under the overall supervision of ASOEN with the assistance and coordination by the ASEAN Secretariat. The report was prepared by the Institute for Global Environmental Strategies (IGES), Japan, as the implementing agency. A Task Force comprising representatives of all AMS reviewed the report drafts and provided feedback and guidance. The Government of Japan through its Japan-ASEAN Integration Fund (JAIF) provided financial support for the preparation and publication of this report.

1.2 Methodology

The methodology of SOER6 follows that of the Global Environment Outlook and similar integrated environmental assessments. The SOER6 will consider ASOEN Working Group Action Plans and the ASEAN Socio-Cultural Community (ASCC) Blueprint 2025 as well as other relevant sectoral plans/strategies, to ensure linkage with existing ASEAN policies/plans and the associated monitoring and reporting.

The overall methodology follows the commonly accepted Drivers-Pressures-State-Impacts-Response (DPSIR) methodology developed by the OECD and used for the Global Environment Outlook (GEO) and other similar assessments as explained below in Figure 1.1. In addition, target impacts may include cumulative and reversible/irreversible ones, and target responses may endeavour to simultaneously achieve economic and social as well as environmental objectives in a synergistic manner along the lines of a "triple bottom line." In general, environmental issues have been increasingly impacted by economic activities, so dedicated commitments, policies and other measures for environmental protection and conservation should be strengthened.

Figure 1.1 DPSIR framework



Source: (UNEP 2017b)

Each chapter on specific environmental issues (Chapters 3-7) as well as Chapter 10 on the circular economy, uses the DPSIR framework directly, addressing key regional environmental issues/pressures and their drivers, economic and social impacts, and responses, especially priority areas of intervention, strategic guidance, and investment plans. The rest of the chapters do not use DPSIR because they focus on specific kinds of responses. Resource use and the circular economy with extended producer responsibility (EPR) are highlighted because they are closely linked to other environmental issues.

The overall approach to data and sources is similar to the approach used in previous ASEAN State of the Environment reports. Generally, SOER6 presents a broad regional perspective and does not provide detailed information on each AMS. Some topics have two or three detailed country cases while others present data for several AMS in a table, although data are not available for some topics. Data are mainly based on publicly available sources, although unpublished official data from AMS are included in some cases. Sources are indicated for all data used in this report.

1.3 Report structure

This report is structured as follows. Chapter 2 explains the driving forces of environmental issues in more detail. Chapters 3-7 focus on key regional environmental issues: climate change and air pollution (Chapter 3), nature conservation and biodiversity (Chapter 4), water resource management (Chapter 5), coastal and marine environment (Chapter 6), and chemicals and waste (Chapter 7). The rest of the chapters focus on different approaches and options for responses to these environmental issues. Chapter 8 focuses on cities, which need to manage their own responses to these environmental issues as well as implement responses from the national and regional levels; cities not only suffer from major environmental impacts, but they are also key sources of the drivers of environmental impacts. Education for Sustainable Development (ESD), addressed in Chapter 9, is an important overarching response to all types of environmental issues. The circular economy is a key response approach for linking the environment and the economy, making the economy more sustainable, which is discussed in Chapter 10. The SDGs, discussed in Chapter 11, are a holistic and integrated approach to sustainable development which can show more concretely how measures to address the drivers and pressures of environmental problems can generate a wide range of economic and social development benefits. Chapter 12 surveys the broad and extensive range of ASEAN's international cooperation on the environment. Chapter 13 synthesizes the outlook and possible response options, and then Chapter 14 concludes.

Chapter 2
Driving Forces

Main Messages

- Many environmental responses tackle the impacts that appear at the end of a long chain of logic, such as premature deaths from air pollution, but they rarely address the underlying “drivers” of change.
- In the ASEAN region, these drivers include economic strategies that are geared towards creating an ASEAN economic community, continued population growth and demographic changes, the expected bounce from a post-COVID-19 recovery, ASEAN’s global links through international trade, infrastructure development, technological change under the Fourth Industrial Revolution, global climate change, and biodiversity loss.
- Responding to these drivers is usually not seen as the responsibility of the region’s environmental agencies, but an effective understanding of how they contribute to the ASEAN State of the Environment and the necessary level of multiple-sectoral cooperation towards joint environmental goals is crucial.
- To address the drivers, environmental and social management will need to become far more cross-sectoral, going beyond the simple mandates of environmental ministries and authorities.

2.1 Introduction

As indicated above, the overall methodology of the State of the Environment Report (SOER6) is to follow the commonly accepted Drivers-Pressures-State-Impacts-Response (DPSIR) methodology developed for the Global Environment Outlook. To illustrate the chain of logic behind DPSIR, consider the following simple example. Population growth (D) increases consumption of goods (P) which increases the volume of solid waste (S) which causes plastic leakage to marine litter and impacts on marine biota (I), leading to governments deciding to ban the use of plastic bags (R). Of course, this simple equation can be disrupted at any point and other factors may lead to the observed impacts. For example, population policies might constrain population growth, manufacturers may voluntarily produce goods that are easily recycled, or waste management might be improved so there is no leakage of plastic waste to marine litter.

Driving forces, or “drivers” for short, are the structural factors ultimately underpinning changes in the environment, many of which may be under minimal or no control of ASEAN countries and usually not under the control of environmental agencies. The state of the environment in the ASEAN region is fundamentally driven by the interplay of global, regional, national, and local forces, which are at times both synergistic and antagonistic and have uncertain long-term outcomes. The environment in ASEAN countries is affected by various global trends such as the global COVID-19 pandemic, mass extinction of biological diversity, international trade agreements, human trafficking and migration, and geopolitics. At the regional level, ASEAN’s structural framework itself, including a broad range of regional integration and connectivity measures while recognizing a policy of non-interference in national issues has some influence on the environment. At the national level, significant demographic changes, such as an ageing society; national and private sector development plans, including foreign direct investment; information and communication technology; infrastructure development; and education and health systems plus increasing public awareness and demands for better living conditions are important drivers of environmental change in the region.

2.2 ASEAN Community Vision 2025

At the highest policy level, ASEAN is driven by an image of an integrated, cohesive economic and social community, in many ways similar to the European Union. The 2007 ASEAN Charter provides for “One Vision, One Identity and One Caring and Sharing Community” (Chua and Lim 2017). Since 2009, ASEAN integration has been driven by the Roadmap for an ASEAN Community (i.e., political, security, economic, and socio-cultural “blueprints”), the Initiative for ASEAN Integration, the Master Plan on ASEAN Connectivity, and leading to creation of the ASEAN Community in 2015 (ASEAN Secretariat 2015b). The ASEAN Community Vision 2025 highlights the region’s comprehensive approach to future security, with “a highly integrated and cohesive regional economy that supports sustained high economic growth” and enhanced connectivity, and promotion of a high quality of life and sustainable development. In relation to the environment, Vision 2025 promotes “social development and environmental protection through effective mechanisms” (ASEAN Secretariat 2015c). The extent to which this Vision drives national policies across the ASEAN region to align with Vision 2025 will influence future environmental outcomes, although those outcomes currently remain uncertain.

2.3 Population demographics and urbanization

From 1980 to 2019, ASEAN’s population grew from 355.2 million to 655.9 million, an average increase of 1.3% per annum (ASEAN Secretariat 2019b) and is currently estimated at 667.37 million (Table 2.1). The almost doubling of population over 40 years is partly due to increasing membership of ASEAN (Brunei Darussalam in 1984, Viet Nam in 1995, Lao PDR in 1997, Myanmar in 1997, and Cambodia in 1999). The projected increase in population by 2035 is to 741.21 million, a 12.8% increase over 2019 (ASEAN 2013). The population growth rate has been declining consistently from over 2% to around 1% currently.

Table 2.1 Population statistics for AMS

Country	Population 2011 (million)	Population 2021 (million) (est.)	Population 2035 (million) (est.)	Total fertility rate 2005	Total fertility rate 2019
BRN	0.39	0.46	0.56	2.0	1.8
KHM	14.41	15.84	18.10	4.1	2.6
IDN	241.99	272.25	291.69	2.3	2.3
LAO	6.35	7.37	8.09	4.5	2.7
MYS	29.06	33.36	39.89	2.8	1.8
MMR	49.52	53.55	55.93	2.5	2.5
PHL	94.70	110.43	135.86	3.3	2.7

SGP	5.18	5.84	6.52	1.3	1.1
THA	67.52	69.95	76.52	1.7	1.3
VNM	87.86	98.32	106.04	1.9	2.1
ASEAN	596.98	667.37	741.21		

Source: (ASEAN Secretariat 2019b; ASEAN 2013; Statista 2021d); Brunei Darussalam's total fertility rate in 2019 was provided by the Department of Economic Planning and Statistics.

There has also been a shift in the age structure of the population, with the working age group (i.e., 15-64 years) increasing from 53.0% to 59.6% over 2000-2019, and the aged group (65 and beyond) increasing from 4.9% to 7.1% in 2019 (ASEAN Secretariat 2019b). The gender ratio varies slightly, with Brunei Darussalam having the lowest female ratio (46.8%) and Myanmar the highest (52%). The increased working age group suggests that there may also be a concomitant increase in consumption, causing increased energy demand and waste generation. The ageing population is a particular concern in Thailand, where 12.5% of the population in 2019 was over 65 years of age.

The ASEAN population is also becoming more urbanized. More than 50% of ASEAN people live in urban areas and an additional 70 million are projected to live in ASEAN cities by 2025, making sustainable and inclusive urbanization a key driver of the ASEAN Community Vision 2025 (ASEAN Secretariat 2021n). The ASEAN Sustainable Urbanisation Strategy (ASEAN Secretariat 2018b) and the ASEAN Smart Cities Network (ASEAN Secretariat 2018a) are providing a platform for cities to work together for smart and sustainable urban development. The ASEAN Sustainable Urbanisation Strategy is an initiative of the Master Plan on ASEAN Connectivity (MPAC) 2025 which makes it a key priority for progress on the Master Plan. The rapid pace of urbanization is expected to see waste volumes, for example, increase by 150% from 1995 levels by 2025.

The demographic changes in the ASEAN region will influence a wide range of consumption and production factors, such as household formation rates, education demands, health services, homes for the elderly, availability of workers, and migrant workforces, among others. A common result of demographic change is the hollowing out of rural areas with young people increasingly flocking to urban centres, leaving behind an ageing farm workforce, inadequate investment in sustainable agriculture, and increased reliance on imported food. Depending on the mix of these factors in each ASEAN country there will be different environmental implications.

2.4 Economic drivers

Economic growth and the structure of the region's economy drives many of the environmental impacts noted later in this report based on the consumption patterns and production processes. Some production processes and consumption patterns are resource intensive and unsustainable, so there is a need to shift to more sustainable production and consumption (SCP).

The ASEAN economy is currently the fifth largest globally, with about a 3.5% share and a gross domestic product (GDP) estimated at US$ 3 trillion (ASEAN Secretariat 2019d). ASEAN has a 7.2% share in global trade in goods (4th) and 6.8% in services (4th) as well as being an attractive destination for foreign direct investment (US$ 154.7 billion or 11.9% global share in 2018). Outward investment (US$ 69.6 billion) is 6.9% of the global share (ASEAN Secretariat 2019d).

Among the ASEAN countries, Indonesia (34.9%) and Thailand (16.9%) have the largest share of the ASEAN economy (Table 2.2). Until 2019, all ASEAN economies (except for Brunei Darussalam) have grown steadily, with good recent performances of Cambodia, Indonesia, Viet Nam, and Malaysia notable.

Table 2.2 Gross domestic product (2010-2018) of AMS and total share in ASEAN

AMS	Nominal GDP (US$ billion)			Share of ASEAN GDP (%)		
	2010	2015	2018	2010	2015	2018
BRN	13.7	12.9	13.6	0.7	0.5	0.5
KHM	11.2	18.1	24.6	0.6	0.7	0.8
IDN	710.1	855.0	1 041.6	36.8	34.8	34.9
LAO	6.8	14.4	18.1	0.3	0.6	0.6
MYS	250.8	299.5	358.4	13.0	12.2	12.0
MMR	41.0	59.8	77.3	2.1	2.4	2.6
PHL	200.0	292.5	342.7	10.4	11.9	11.5
SGP	239.8	308.0	364.1	12.4	12.5	12.2
THA	341.5	401.7	505.1	17.7	16.4	16.9
VNM	116.3	193.6	241.0	6.0	7.9	8.1
ASEAN	1 931.2	2 455.6	2 986.4	100	100	100

Source: (ASEAN Secretariat 2019d)

The sectoral components of the ASEAN economy are shown in Table 2.3, with the services sector dominant and growing. The ageing population and increasing urbanization will continue to put pressure on the agriculture sector, while industry appears to be relatively stable (ASEAN Secretariat 2019d).

Table 2.3 Sectoral composition of the ASEAN economy

Sector	2010	2011	2012	2013	2014	2015	2016	2017	2018
Agriculture (%)	12.0	11.9	11.5	11.6	11.5	11.1	10.7	10.5	10.3
Industry (%)	37.7	37.1	36.9	37.5	37.4	37.1	37.0	35.8	36.6
Services (%)	48.7	40.5	50.2	40.4	49.7	40.2	49.5	49.7	50.1
Balance (%)	1.6	10.5	1.4	10.5	1.4	11.6	2.8	4.0	3.0
Total (US$ million)	1 931	2 251	2 392	2 502	2 534	2 456	2 581	2 785	2 986

Source: (ASEAN Secretariat 2019d)

The global COVID-19 pandemic in 2020-2021, however, has disrupted economic growth in all AMS (Table 2.4). The Asian Development Bank (ADB) projects that the post-COVID-19 recovery will be very strong, although the pandemic was far from over in 2021 (J. Williams and Voas 2021). The nature of the recovery will be an important driver of future environmental changes in the ASEAN region (ASEAN Secretariat 2020).

Table 2.4 Economic growth and inflation (2019-2022) in AMS

AMS	GDP (%)				Inflation (%)			
	2019	**2020**	**2021**	**2022**	**2019**	**2020**	**2021**	**2022 (est.)**
BRN	8.9	1.2	2.5	3.0	-0.4	1.9	0.7	0.7
KHM	7.1	-3.1	4.0	5.5	1.9	2.9	3.1	3.0
IDN	5.0	-2.1	4.5	5.0	2.8	2.0	2.4	2.8
LAO	4.7	-0.5	4.0	4.5	3.3	5.1	4.5	5.0
MYS	4.3	-5.6	6.0	5.7	0.7	-1.1	1.8	2.0
MMR	6.8	3.3	-9.8	N/A	8.6	5.7	6.2	N/A
PHL	6.1	-9.6	4.5	5.5	2.5	2.6	4.1	3.5
SGP	1.3	-5.4	6.0	4.1	0.6	-0.2	1.0	1.2
THA	2.3	-6.1	3.0	4.5	0.7	-0.8	1.1	1.0
VNM	7.0	2.9	6.7	7.0	2.8	3.2	3.8	4.0

Source: (J. Williams and Voas 2021)

2.5 Global pandemic and post-COVID-19 economic recovery

There is some evidence that the COVID-19 pandemic has had some positive environmental impacts, such as improved air quality (Wetchayont, Hayasaka, and Khatri 2021) and some negative impacts such as increased waste production (including plastic packaging and personal protective equipment) (Sarkodie and Owusu 2021), mainly due to movement restrictions or lockdowns. Working from home for a large percentage of workers, as well as increased unemployment and home schooling, has seen a rapid increase in home delivery services, virtual meetings, increased demand for electronic equipment, but also a significant reduction in air travel.

Historical evidence from previous pandemics suggests that economic activities and pent-up consumption demand (e.g., for tourism travel) will rebound quickly, thus driving environmental pressures post-COVID, but probably not immediately back to pre-pandemic trends (Ma, Rogers, and Zhou 2020). Early signs of such a rebound are evident in China and Viet Nam, while the resurgence of COVID-19 in 2021 halted recovery in most ASEAN countries (J. Williams and Voas 2021). Delayed vaccination is likely to further depress economic activity in 2021 and 2022. While the post-pandemic recovery is a driver of future trends, pandemic countermeasures may need to continue indefinitely as new variants or even new pandemics appear.

In the Asia-Pacific region, there has been considerable discussion about rebuilding societies to become more sustainable, resilient, and inclusive through overcoming COVID-19 (IGES 2020). The Institute for Global Environmental Strategies (IGES) employs an analytical framework consisting of three components: (i) targeted actions to address immediate public health and environmental challenges -- managing medical waste, promoting sustainable workstyles and lifestyles, etc.; (ii) policy reforms and stimulus spending that results in the reorientation of development – i.e., green recovery; and (iii) redesigns of systems and institutions to accelerate just transitions (i.e. leaving no one behind) (IGES 2020).

The 2021 Asian Development Outlook contains a specific theme on “financing a green and inclusive recovery” which suggests that the investment needed is much more than can be met by the public sector, necessitating mobilization of private green finance (J. Williams and Voas 2021). Issuance of green bonds is associated with improved company environmental performance by 30% after two years. Governments, however, need to use a range of policy options to nurture social and green finance, with the most effective being “regulations that enforce common standards for impact measurement and information disclosure” (J. Williams and Voas 2021). The Platform for Redesign 2020 outlines the specific measures that multiple countries, including several AMS, intend to take for a green and inclusive recovery (Ministry of the Environment Japan 2021c). While an economic rebound appears likely, ASEAN countries should endeavour to make their economic recovery packages as “green” as possible.

Over the past decades, ASEAN has made significant progress in reducing poverty, from 34.3% at 2000 to just 3.3% by 2018 (ASEAN 2021). There is also a concern that COVID-19 will reverse some of the region’s recent gains in reducing poverty (Pennington 2021). About 24 million people who could have been expected to escape poverty and 11 million who may fall into poverty was the projected worst case for 2020. Weak social protections, inadequate health insurance, and loss of employment (especially in the tourism industry) suggest that the pandemic will have lasting poverty implications for the region. Green recovery packages will help to reduce poverty while simultaneously promoting environmental sustainability.

The ASEAN Comprehensive Recovery Framework Implementation Plan contains five broad strategies (i) enhancing health systems; (ii) strengthening human security; (iii) maximising the potential of the intra-ASEAN market and broader economic integration; (iv) accelerating inclusive digital transformation; and (v) advancing towards a more sustainable and resilient future (ASEAN Secretariat 2020). The latter strategy covers (i) the transition to a green and circular economy; (ii) reducing marine debris pollution; (iii) green jobs policy; (iv) transition to sustainable energy; (v) green infrastructure and smart green cities; (vi) sustainable financing and responsible investment; (vii) sustainable agriculture and food value chains; and (viii) strengthening disaster management.

2.6 International trade and economic integration

ASEAN countries are members of a range of trade and economic partnership agreements. The newest one is the Regional Comprehensive Economic Partnership (RCEP) which AMS joined in November 2020, along with Australia, Japan, New Zealand, China, and Republic of Korea, creating the world's largest trade bloc (31% of global GDP). In addition, India can access the partnership via a fast-track procedure (J. Williams and Voas 2021). ASEAN is also a core member of the Asia-Pacific Economic Cooperation (APEC). Some ASEAN countries belong to the ASEAN Free Trade Area and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), which also involves Canada, Chile, Peru, and Mexico, as well as other bilateral and multilateral free trade agreements with other countries, such as the Greater Mekong Subregion (GMS) economic cooperation and the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC).

ASEAN economic integration globally and among ASEAN countries currently shows insufficient attention to environmentally sound or "green" integration, although multiple opportunities exist for further greening (IGES 2015).

For example, the RCEP agreement has 20 chapters, but relatively little in relation to the environmental implications (RCEP Secretariat 2020b). RCEP is intended to boost sustainable competition and productivity and provide a rulebook for regional supply chains. Flexible arrangements are provided for Cambodia, Lao PDR, Myanmar, and Viet Nam. Chapter 5 deals with sanitary and phytosanitary measures, emphasizing capacity building and technical support in this important area. The institutional structure for implementation of RCEP also includes one of four committees dedicated to sustainable growth.

The ASEAN Free Trade Agreement also has no treatment of environmental issues associated with trade (ASEAN Free Trade Area Council 1992). The ASEAN-China Free Trade Agreement was signed in 2002 as a framework agreement to lead to the ASEAN-China Free Trade Area by January 2010 (ASEAN Secretariat 2002b). The Agreement on Trade in Goods was signed in November 2004, the Agreement on Trade in Services in January 2018, and an Investment Agreement in 2009. For the ASEAN-Indian Free Trade Area, the Framework Agreement was signed in 2003, Trade in Goods Agreement in 2010, and the Trade in Services Agreement and Investment Agreement signed in 2014 (ASEAN Secretariat 2009). The ASEAN-ROK Joint Declaration on Comprehensive Cooperation Partnership Agreement was signed in 2004, with the Framework Agreement on Comprehensive Economic Cooperation signed in 2005 (ASEAN Secretariat 2019d). The Framework Agreement is supported by the ASEAN-Korea Economic Cooperation Fund, established in 2008. Areas of cooperation include science and technology, agriculture, fisheries, livestock, plantation commodities and forestry, environmental industry, and natural resources. The ASEAN-Japan Framework for Comprehensive Economic Partnership signed in 2003 also provides for economic cooperation in agriculture, forestry, fisheries, and environment.

As all these free trade agreements are intended to increase global and regional trade, the increased volume of trade in goods and services will have significant environmental implications. The challenge is to use these free trade agreements to facilitate increased trade in environmental goods and services. ASEAN is a strong supporter of an open trading regime, with the share of trade in output reaching 94.3% of the regional GDP in 2018 (ASEAN Secretariat 2019d). ASEAN has set a target of doubling intra-ASEAN trade between 2017 and 2025. As a highly integrated, cohesive economy, there is ample opportunity for increased trade in environmental goods and services. In 2015, ASEAN adopted a Green Logistics Vision and Action Plan, followed by the Best Practices on Green Logistics in 2018 to reduce GHGs and other air pollutants throughout the supply chains (ASEAN Secretariat 2019d). The balance between environmentally sound goods and services, and those that cause environmental harm will be an important future determinant of environmental conditions in the AMS.

The effects of economic integration on the environment are complex, including both positive and negative ones (Chandra 2009). To enhance the positive impacts and reduce the negative ones, trade and economic cooperation agreements should include stronger environmental safeguards, and their environmental impacts should be assessed (Chandra 2009). The potential for conflict somewhere in the global supply chains, as evidenced by the recent conflict in Ukraine, can disrupt global trade patterns, causing ripple effects through the ASEAN region.

In the long run, as ASEAN economies become more integrated, the trade effects of environmental policies may increase, generating pressures towards greater harmonization of national environmental policies, similar to the EU. Harmonization should be in the direction of stronger policies in line with ASEAN commitments (on environmental sustainability, SDGs, MEAs, etc.).

2.7 Infrastructure development

The ADB estimated Asia's infrastructure financing gap at US$ 459 billion per year (or 2.4% of developing Asia's regional GDP), needing US$ 1.34 trillion per year from 2016 to 2030, but currently spending about US$ 881 billion per year (Ra and Li 2018). For Southeast Asia, the 2016-2030 investment needs are US$ 2,759 billion (i.e., US$ 184 billion per year or 5% of projected GDP) (ADB

2017b). When adjusted for the costs of climate mitigation and climate proofing (i.e., adaptation), the Southeast Asian investment needs expand to US$ 3,147 billion or US$ 210 billion per year. The two largest sectors are power and transport, 56% and 32% respectively, with telecommunications (8.7%) and water and sanitation (3.1%) significantly smaller (ADB 2017b). For Southeast Asia (7 countries), the climate-adjusted investment gap is US$ 102 billion per year (4.1% of GDP) compared to 2015 current investment of US$ 55 billion.

The Master Plan on ASEAN Connectivity 2025 highlights the priorities of (i) sustainable infrastructure; (ii) digital innovation; (iii) seamless logistics; (iv) regulatory excellence; and (v) people mobility (ASEAN Secretariat 2016d). The Master Plan proposed a "rolling priority pipeline list of potential ASEAN infrastructure projects and sources of funds". While 39 initiatives in the 2010 Master Plan were completed, 52 uncompleted initiatives were rolled over to the 2025 Master Plan. At least US$ 110 billion per year is required for ASEAN's infrastructure needs, about 2-6 times as great as historic expenditure (ASEAN Secretariat 2016d). Funding sources will include the private sector, bond market, infrastructure banks, and the ASEAN Infrastructure Fund.

The ASEAN Infrastructure Fund, established in 2011, has a total portfolio size of US$ 3 billion and is ASEAN's largest financing initiative by AMS (ADB 2019). Under the Fund, an ASEAN Catalytic Green Finance Facility was created in 2019 to finance projects on sustainable transport, renewable energy, and climate-adapted water and sanitation facilities. The Facility aims to mobilize US$ 1 billion in a 3-year pilot phase, with US$ 75 million from the Infrastructure Fund, US$ 300 million from ADB, US$ 336 million from KfW, € 150 million from the European Investment Bank and € 150 million from Agence Française de Développement (ADB 2020a). The Facility is designed to not only accelerate investment in green infrastructure, but also to crowd in private sector capital, technologies, and management.

A particular environmental concern relates to the impacts of hydropower development, especially in the Greater Mekong Subregion (i.e., Lao PDR, Cambodia, Viet Nam, Myanmar, Thailand, and the southern part of China). With funding from China, Malaysia, and Thailand, land-linked Lao PDR aspires to become the "battery of Asia" (Bonnema et al. 2020). Hydropower development threatens freshwater biodiversity, sedimentation, and saline intrusion in the river deltas, as well as human livelihoods, such as in Tonle Sap. Hydropower dams can also be a source of greenhouse gases.

Other ambitious infrastructure projects designed to improve connectivity across the ASEAN region include the ASEAN Highway Network and Singapore-Kunming Rail Link (ASEAN Secretariat 2016d), ASEAN power grid (Ahmed et al. 2017), trans-ASEAN gas pipeline (ASCOPE, n.d.), the Isthmus of Kra Canal (Clark 2020b) (now proposed to be replaced by a land bridge), the Australia-ASEAN Power Link (Department of Industry Science Energy and Resources 2021), and parts of the Chinese Belt and Road Initiative (BRI 2021).

The national priorities for infrastructure in each AMS, have many common elements—transportation (roads, railways, seaports, airports), energy, urban infrastructure, information and communication technology (ICT), among others (Table 2.5). It should be acknowledged, however, that most of the national socio-economic development plans also indicate an emerging pivot towards sustainable development and clear recognition of the importance of SDGs (Rodlauer, Nolan, and Keen 2018). The extent to which infrastructure will be made greener, however, remains uncertain.

Table 2.5 Priority infrastructure plans in AMS

AMS	National Infrastructure Plans	Source
BRN	Education, public utilities, health services, communication, electricity, roads, sanitation, ports, water supply, drainage	Eleventh National Development Plan (2018-2023)
KHM	Transport, urban infrastructure, water resources and irrigation, electricity, information and communication technology, digital economy, railways, logistics, maritime transport and ports, airports	National Strategic Development Plan (2019-2023)
IDN	Water supply, irrigation, inter-modal transportation, telecommunications, energy supply, housing, marine infrastructure	Long-Term National Development Plan (2005-2025)
LAO	Rural roads and bridges, industrial zones, transmission lines and power stations, education, health and sanitation, irrigation, telecommunications, security, railway, airports	8th Five-Year National Socio-Economic Development Plan (2016-2020)
MYS	Transport, communications, electricity and smart grids, water and sewerage, rail, airports, digital access, logistics, Pan-Borneo highway, high speed broadband, Sarawak Corridor of Renewable Energy, flood mitigation, ports	Eleventh Malaysia Plan (2016-2020)
MMR	Electricity, roads, ports, ID card system, digital government, railways, telecommunications, water and sanitation, and urban infrastructure.	Myanmar Sustainable Development Plan (2018-2030).
PHL	“Build build build” programme increasing infrastructure spending to 5.5% in 2021 and 4.3% in 2022. Transport, electricity, broadband, decongestion of urban areas, digital transformation, ICT, disaster resilient infrastructure.	Updated Philippines Development Plan (2017-2022)
SGP	Floating solar energy, low energy buildings, electricity charging stations, cycling network, rail, green spaces, smart LED lights, centralized cooling system, carbon capture and storage, coastal defences, and sustainable food solutions.	Singapore Green Plan 2030 Urban Redevelopment Authority (URA) Long-Term Plan and Master Plan
THA	Domestic infrastructure networks connecting economic corridors, logistics, ICT, energy, public transport, traffic management, waste management, highways and bridges, fast rail, urban infrastructure, airport expansion.	Twelfth National Economic and Social Development Plan (2017-2021)
VNM	Transportation, electricity distribution, water, irrigation, ICT, highways, railroad, inland and coastal waterways, airports, traffic management, coastal protection, industrial parks and economic zones, marine infrastructure, seaports, wastewater, flood protection.	Five-Year Socio-Economic Development Plan (2016-2020)

2.8 Global dynamics and technological change

One of the global megatrends is the Fourth Industrial Revolution (4IR) which involves transformational changes in all aspects of modern living and emphasis on new technologies (e.g., big data, artificial intelligence, augmented reality, crypto-currencies, nano-technology, and the Internet of Things). These new technologies are intended to combine physical, digital, and biological domains to boost economic growth (ASEAN Secretariat 2019d). AMS have considerable potential to capitalize on the 4IR, as currently the digital economy is only 7% of regional GDP compared to 35% in the US. While 4IR could add US$ 1 trillion to the regional economy by 2025, it would also have major implications for employment losses due to automation and the increasing use of robots in manufacturing, retailing, services, and healthcare (ASEAN Secretariat 2021i).

In 2017, the ASEAN Economic Ministers Meeting tasked the ASEAN Secretariat to conduct an assessment of AMS readiness for 4IR. The assessment covered innovation and technology, human capital, regulatory frameworks, infrastructure and connectivity, and inclusive and sustainable growth. Singapore, Malaysia and Thailand were ranked as having strong readiness for the future; Indonesia with a strong economic base but facing risks; Brunei Darussalam and Philippines with high potential; and Viet Nam, Cambodia, Lao PDR and Myanmar in the nascent category (ASEAN Secretariat 2019d). The environmental implications of the 4IR on ASEAN countries, however, remain to be seen.

2.9 Global climate change

Meanwhile, global impacts of environmental damage – climate change and biodiversity loss – are now driving current and future environmental conditions in ASEAN. Environmental damage in these two areas has become so severe that they have become “drivers” in the DPSIR framework, not just “impacts” as they were considered previously. In other words, climate disruption and biodiversity damage are now affecting the other drivers like the economy and population growth. These topics are addressed in more detail in chapters 3 and 4, respectively. While the ASEAN region contributes to these drivers, they are essentially global problems over which ASEAN countries have important, but limited, control, and face disproportionate impacts from them vis-à-vis other regions.

To set the context for Chapter 3, a brief outline of the scale of the global climate change issue is included here, as climate change is a driver for all countries and all sectors. The Intergovernmental Panel on Climate Change (IPCC) has recently finalized its sixth assessment. In the fifth assessment report (AR5) the headline finding was “warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen” (IPCC 2013). The sixth assessment report (AR6) provided additional modelling results and new analysis, confirming that “it is unequivocal that human influence has warmed the atmosphere, ocean, and land” (IPCC 2021a). In 2019, atmospheric carbon dioxide levels were the highest in at least 2 million years, while concentrations of methane and nitrous oxides were the highest in at least 800,000 years. There is also increased likelihood of compound extreme events, such as concurrent heatwaves and droughts, dangerous fire weather, and flooding. Southeast Asia is experiencing hot extremes and increased heavy precipitation. Five new emissions scenarios in AR6 and results of the Coupled Model Intercomparison Project Phase 6 (CMIP6) show that temperature increases over 2081-2100 are very likely to be higher by 1.0-1.8°C (SSP1-1.9) to 3.3-5.7°C (SSP5-8.5), compared to 1850-1900, although other models often yield more extreme results.

In the longer-term, sea level rise is committed to rise for centuries to millennia due to continue deep-ocean warming and ice sheet melt and will remain elevated for thousands of years (IPCC 2021). Climate change is also expected to drive extreme weather events, altered river flows, wildfires, and haze, and possibly human migration patterns, which in turn will have significant implications for all future socio-economic conditions in ASEAN (Overland 2017). The severe economic damage will increasingly threaten not only loss of jobs and livelihoods, but also loss of lives from climate-related disasters.

The ASEAN joint statement on climate change to the UNFCCC 25th Conference of the Parties (COP 25) expressed “grave concern” about the impacts of climate change (ASEAN 2019a). These concerns were reiterated in the ASEAN Joint Statement on Climate Change to COP 26 in 2021, including the disproportionate and continuing increase in losses and damages experienced by developing countries. AMS have also affirmed their commitment to the UNFCCC and the Paris Agreement and intention to implement measures to combat climate change under the ASEAN Socio-Cultural Community Blueprint 2025. At least 124 countries have pledged net-zero GHG emissions by 2050 (including four AMS: Cambodia, Lao PDR, Myanmar and Singapore) (Wallach 2021). Indonesia aims for net-zero emissions by 2060 or sooner (Republic of Indonesia 2022). As most countries will be expected to increase their ambition and aim for net-zero emissions by 2050, complementary actions will need to be drafted and implemented by AMS. The extent to which AMS increase their climate ambition for the next Conference of the Parties (COP 28) will have major implications for the economies, society, and the environment.

2.10 Global biodiversity loss

Biodiversity loss will have negative economic, health, and environmental impacts. Hence, it is now considered a “driver” and not just an impact of global change. While it is clear that we depend on nature for a wide range of ecosystem services, nature is now under a planet-wide threat of overexploitation and damage, leading to the sixth mass extinction of species (IPBES 2019). Loss of biological diversity is no longer an environmental impact alone but is driving the planet to an unsustainable state. Biodiversity loss has become one of the major tipping points of the planetary boundaries (Steffen et al. 2015). Multiple human drivers have contributed to most ecosystems and biodiversity experiencing rapid decline. Around 1 million species (25% of animal and plant groups) are threatened with extinction, possibly within decades, a rate of extinction much higher than the past 10 million years. Local breeds and varieties of domesticated animals and plants are disappearing, undermining global food security. The drivers behind this biodiversity loss include (i) land and sea usage changes; (ii) direct overexploitation of species; (iii) climate change; (iv) pollution; and (v) alien invasive species (IPBES 2019). To protect nature, transformative changes are needed across all social and economic dimensions.

The Kunming-Montreal Global Biodiversity Framework (KMGBF) adopted by Parties to the Convention on Biological Diversity (CBD), and which included contributions from ASEAN, is seen as a stepping stone towards the “2050 Vision” of living in harmony with nature, and the Framework was adopted at the 15th Meeting of the Conference of Parties to the Convention on Biological Diversity in 2022 (CBD 2022; CBD Secretariat 2021; ASEAN Centre for Biodiversity 2020). Among the 23 targets of the KMGBF, one of the targets seeks to protect 30% of the world’s oceans and land. Other key targets include (i) restoration of at least 30% of degraded water bodies and terrestrial ecosystems; (ii) reducing invasive alien species by at least 50%; (iii) reducing pollution from all sources; (iv) contributing to climate change mitigation and adaptation through ecosystem-based approaches; (v) ensuring equitable sharing of the benefits from genetic resources; (vi) reducing harmful incentives or subsidies by at least US$ 500 billion per year; and (vii) increasing funding to at least US$ 200 billion per year. All countries will be expected to plan for and to implement complementary actions and report on them prior to 2030. The extent of these complementary actions will have major implications for the future of biodiversity in the ASEAN region. The ASEAN Joint Statement to the 15th Meeting of the Conference of the Parties to the Convention on Biological Diversity called on all parties to “develop a realistic post-2020 global biodiversity framework to achieve the 2050 Vision of “Living in Harmony with Nature” and undertake transformative actions”.

2.11 Conclusions

The underlying drivers of environmental change, which have included population growth, urbanization, unfettered resource-intensive economic growth, infrastructure development, and technological change for many decades are now joined by multiple global crises of climate change, biodiversity loss, and a global pandemic. How ASEAN responds to these drivers will determine the future state of the environment in the region.

“ASEAN 2025: Forging Ahead Together” proposed a range of actions driving environmental protection in the region, including (i) marine environmental protection; (ii) protection of biodiversity; (iii) standards harmonization; (iv) good regulatory practices; (v) green development through clean energy and related technologies; (vi) food safety; (vii) improved forest management; (viii) sustainable agriculture; (ix) responsible tourism; (x) sustainable mineral development; (xi) control of transboundary pollution, hazardous substances and waste; (xii) environmental education; and (xiii) environmentally sustainable cities, among others (ASEAN Secretariat 2015a). In addition to these, AMS may wish to re-examine national economic and sector policies that may not align with ASEAN environmental objectives, as the drivers of environmental change are frequently outside the remit of national environmental agencies. The remainder of SOER6 will examine the current and prospective efforts by AMS to address these and other drivers.

Chapter 3
Climate Change and Air Pollution

Main Messages

- Climate change is already causing serious negative impacts in the region. In the future, extreme weather and sea level rise will cause mounting economic costs in terms of damage to health, infrastructure, and food security.
- ASEAN Member States (AMS) have a variety of policies and responses to climate change adaptation and disaster risk reduction, including international and regional cooperation. The region has made rapid progress in recognizing and addressing the climate change and disaster nexus, and the adaptation and mitigation nexus but more needs to be done. These responses should be further strengthened, including with additional financing.
- AMS should finish developing national and sub-national adaptation plans and then implement them. This will enable countries to streamline efforts and achieve synergistic responses that help to achieve multiple developmental goals. This calls for transformative changes in addition to incremental changes.
- Emissions of greenhouse gases (GHGs) and key air pollutants have continued to rise in ASEAN, and decoupling economic growth from them is an immense challenge.
- High levels of air pollution pose a substantial threat to the health and well-being of the 660 million people living in the AMS. Many air pollution sources also contribute to near- and long-term climate change.
- The main sources of air pollution and GHGs in AMS are similar: fossil-fuel energy, road transport, industry, construction, residential energy, waste management, agriculture, deforestation, and forest/land use fires.
- Many policies and measures simultaneously reduce emissions of both air pollutants and GHGs, delivering multiple benefits or co-benefits. Pursuing co-benefits is cost effective way to save money and lives while also mitigating climate change.
- Key responses to climate change and air pollution include replacement of outdated polluting industrial technologies, stronger emissions standards and their enforcement for stationary and mobile sources, acceleration of the transition to renewable energy, and improved energy efficiency.
- The ASEAN Plan of Action for Energy Cooperation (APAEC) 2016–2025 set a regional target of 32% reduction in energy intensity by 2025 relative to 2005 levels, and a 23% share for renewable energy share in the total primary energy supply by 2025. The energy intensity target is on track but the renewable energy target is not.
- Strengthened monitoring, modelling and research capacity on climate change and air pollution are also needed.
- Since most drivers and pressures are common for both climate change and air pollution, synergistic actions are needed that also promote sustainable development goals (SDGs).
- Transboundary cooperation fostered by the ASOEN working groups and other ASEAN bodies is needed to address climate change and improve air quality. Cooperation could focus on creating a regional renewable energy market including accelerating plans for the ASEAN power grid, harmonizing air quality standards and climate targets, (as well as their enforcement, as weak policy responses and enforcement in one country can have significant impacts in other AMS).
- Overall, transformative change (“shifting development pathways” according to the IPCC AR6) is needed in the face of such huge challenges, and incremental efforts and isolated approaches are not sufficient. AMS should strengthen their ambition for both mitigation and adaptation, and enhance their enhance their nationally determined contributions (NDCs), considering carbon pricing as a key tool.

3.1 Overview

While climate change has impacts well beyond the atmosphere, the GHGs responsible for climate change come from sources that can also contribute to air pollution. Further, in countries such as the United States, some GHGs are themselves regarded as air pollutants. The inverse relationship is also true: some air pollutants contribute to climate change. Most notably, black carbon particles that make up a portion of fine particulate matter are not only harmful to human health but absorb solar radiation and cause near-term warming.

Though the relationship between air pollution and climate change is complex, the frequent overlap between the sources of, and solutions to, air pollution and climate change suggests AMS would be wise to look at more integrated approaches to these problems. Doing so is likely to not only save time and money but yield other co-benefits ranging from improved health to lower medical costs to new jobs. Given these possible benefits, this chapter discusses climate change and air pollution together.

3.2 Climate change

As the ASEAN State of Climate Change report (ASCCR) was only recently completed, there is no intention to merely repeat those details but rather to lay out the logical chain from drivers to impacts and the potential for public and private responses to avoid, minimize, or offset those impacts (ASEAN Secretariat 2021g)[1].

3.2.1 Drivers

The energy sector and land use sector are two major GHG sources of the ASEAN region. As stated in the ASCCR, ASEAN's GHG emissions have continued to rise due to increasing energy-related carbon dioxide (CO_2) emissions and GHG emissions from Agriculture, Forestry, and other Land Use (AFOLU) or Land Use, Land Use Change and Forestry (LULUCF) (ASEAN Secretariat 2021g). In 2018, CO_2 emissions from fuel combustion and GHG emissions from LULUCF in ASEAN were 1,485 million tons of carbon dioxide equivalent ($MtCO_2eq$) and 965 $MtCO_2eq$, respectively. This means that changes in land use systems are a significant driver accounting for around two fifths of the total GHG emissions, while the energy sector remains the dominant driver. It should be noted that the uncertainty range of LULUCF emissions is very high and yearly fluctuations are non-negligible.

Population and economic growth are the deep-rooted drivers of climate change, given traditional economic structures based on fossil fuel combustion. In the time-series data between 1990-2018, a negative correlation between GDP per capita and energy-related CO_2 emissions per capita is observed only in a handful of AMS. In the others, economic growth and population growth require more energy, especially for heat and electric power (increasingly for air conditioning),

[1] In doing so, this section includes excerpted text from the ASCCR.

and this has mainly been provided by fossil fuels. In 2018, the main energy-related CO_2 emission sources in terms of sectors were (i) electricity and heat production; (ii) manufacturing industries and construction; and (iii) transport (ASEAN Secretariat 2021g). Although energy supply (electricity and heat production) is the dominant driver of climate change, on the demand side, industry, transport and residential sectors were the three largest consumers of total final energy in 2017 (ASEAN Centre for Energy 2020a). Hence, the industrial structure, mode of transportation, and energy performance of buildings collectively are the main drivers of climate change.

Table 3.1 Synergies and differences in drivers, impacts and responses between climate change and air pollution

	Climate Change	Air Pollution
Drivers	Similar: fossil-fuel energy, road transport, industry, construction, residential energy, waste management, agriculture, deforestation, and land use fires.	
State & Trends	High and increasing GHGs	High and increasing air pollution
Impacts (Rising economic costs)	• Extreme weather • Sea level rise • Loss and damage of biodiversity & natural resources • Food insecurity • Health impacts • Socio-economic losses	• Health damage (=> difficult to work, economic costs) • Deaths • Agricultural damage (=> food insecurity)*
Responses:	• There is a wide range of AMS responses to both air/climate • Many responses address both air and climate but synergies can be enhanced • Responses are insufficient but growing, a change in state/trends is yet to be seen • Capacity development in science, policy, technology, finance, human resources are needed • Responses fashioned on SDGs can promote integrated approaches; synergies increase cost effectiveness	

Regarding the energy sector, the ASEAN region is one of the fastest growing regions in the world for electricity demand, driven in part by increasing urbanization, the accompanying ownership of household appliances and air conditioners, and increasing overall production and consumption driven by steady economic growth (IEA 2020). Energy demand has grown by more than 6% per year for the past two decades. Four countries accounting for 80% of ASEAN's total energy demand are Indonesia (26%), Viet Nam (22%), Thailand (19%) and Malaysia (15%). ASEAN is one of the few regions where new coal-fired power plants are planned or under construction, while Lao PDR and Cambodia are aiming to utilize their hydropower potential, and others like the Philippines are planning to use natural gas as a bridging fuel. Indonesia and Viet Nam had planned to double their coal-fired power plants, adding 20-50 GW to the total, but they may be reconsidering these plans considering their new net-zero emissions pledges as required under the

Paris Agreement. ASEAN has an overall target of 23% of renewable energy by 2025, to be achieved partly through the ASEAN Power Grid and plans for regional power trading (e.g., Lao PDR-Thailand-Malaysia-Singapore Power Integration Project[2]) (IEA 2020).

The Asian Development Bank (ADB) noted that transport in Asia is becoming the largest GHG emitting sector accounting for 46% of global emissions by 2035 and 80% by 2050. Asia's share of global transport related GHG emissions is expected to grow to 31% by 2030 (ADB, n.d.). Registered road vehicles in ASEAN have increased from 62,483,000 in 2000 to 387,242,000 in 2018, a more than six-fold increase. As most AMS have yet to begin the transition to electric vehicles, the GHG emissions from this increasing vehicle fleet are locked in for at least the next decade.

Regarding renewable energy costs, the levelized cost of electricity (LCOE) of solar PV, biomass, onshore wind, offshore wind, and concentrated solar power (CSP) has declined between 2010 and 2018 (IRENA 2019). In the ASEAN region, LCOEs of solar PV, biomass, onshore wind, hydro, and geothermal were 0.09, 0.07, 0.13, 0.05, and 0.07 US$/kWh, respectively, in 2018 (IRENA 2020). Despite these cost reductions, AMS have been slow in deploying renewable energies to their full potential, and this transformation needs to be much faster. Modern biomass energy, especially biofuel, has been promoted in the transport sector in Indonesia, Malaysia, Philippines, Thailand, and Viet Nam through regulatory frameworks. Lao PDR in its latest NDC has announced that the share of biofuels will increase to 10% of the demand for transport fuels by 2025. Compared to biofuels for the industry sector, biomass energy from agricultural waste has attracted less attention, but an ASEAN-wide biomass energy strategy for 2030 for agricultural communities and rural development has been established (ASEAN Secretariat 2021h).

The forestry sector has potential to act as a carbon sink, but deforestation has been causing substantial GHG emissions in the region. The Global Forest Resource Assessment shows that South and Southeast Asia lost 30 million ha of forest cover between 1990 and 2020, while the total carbon stock was 41.5 billion tonnes, or 140 teragrams of carbon per hectare (tC/ha) in 2020 (FAO 2020a). Between 1990 and 2010, Southeast Asia's forest cover declined from 268 million ha to 236 million ha (Estoque et al. 2019a). If the average loss of 1.6 million ha/yr was to continue, possibly 40% of the region's biodiversity would be lost by 2100. Under a worst-case scenario, the region's forests would decline by 5.2 million ha by 2050 and the above ground forest carbon stock would decrease by 790 TgC; while under a best-case scenario the region could gain 19.6 million ha of forest and sequester 1,651 TgC (Estoque et al. 2019a)[3]. Indonesia is the key to the eventual outcome, since it accounts for 40.7% of the projected gain in forest cover (49.3% of carbon stock increase) under the best-case scenario and 47.5% of the decline in forest cover (55% of the carbon stock decline) under the worst-case scenario. Currently Indonesia aims to limit deforestation to between 325,000- 450,000 ha/yr, which would exceed the worst-case scenario, if continued to 2050 (Estoque et al. 2019b).

[2] The Lao PDR-Thailand-Malaysia-Singapore Power Integration Project was announced at the 38th ASEAN Ministers on Energy Meeting in 2020.

[3] 1 teragram (Tg) = 1 million tonnes

3.3.2 Pressures

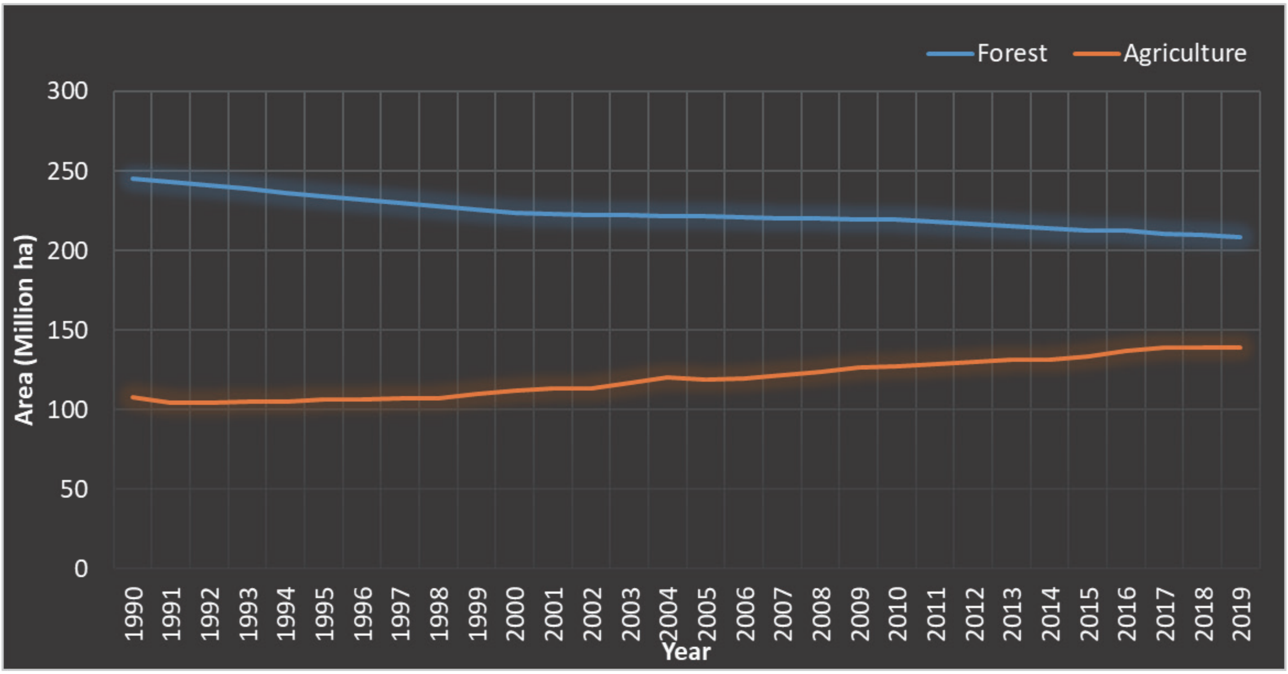
The AMS NDCs to the UNFCCC outline some of the pressures experienced by AMS in trying to accelerate GHG emission reductions absolutely or relative to baseline emissions, while achieving continued economic growth. For example, Indonesia's (2021) NDC indicates that a fundamental pressure is how to balance an annual economic growth rate of 5% to reduce poverty incidence below 4% by 2025, while simultaneously trying to reduce GHG emissions by 31.89% (unconditional) or 43.20% (conditional) by 2030. A further pressure is the fiscal drain caused by recurrent natural disasters, which limits public funds available for climate change mitigation and adaptation. Policy incoherence is a further pressure, exemplified by a mandatory policy to promote biodiesel (B30) by 2020, while simultaneously enhancing domestic oil production and construction of additional oil refineries (to reduce oil imports). Natural gas pipeline development to replace kerosene usage in households will continue while striving for 31% of renewable energy by 2050 (and 23% by 2025). Other pressures are also evident in the transport sector. Massive investment in infrastructure will not help to reduce transport related GHG emissions unless a substantial portion goes into mass transit systems. In the forestry sector, there is a moratorium on clearing primary forest and a plan to rehabilitate 2 million hectares (Mha) of peatland, while still acknowledging at least 325,000 ha/yr of deforestation.

Land degradation and land use changes

Land degradation in the ASEAN region includes deforestation, forest degradation, soil erosion (both water and wind erosion), soil salinity, soil acidity, loss of soil fertility, water logging, and declining groundwater tables (Shrestha 2011; Estoque et al. 2019a). Land use changes are prominent causes of land degradation in addition to poor management of soils, over exploitation, and excessive chemical inputs (Wijesinghe and Park 2017; Turkelboom, Poesen, and Trébuil 2008; Z. Zeng et al. 2018; C. L. Lim et al. 2017). As a significant proportion of terrestrial carbon is embedded in soil and vegetation, land degradation is a significant pressure on the ability of terrestrial ecosystems to sequester GHGs.

Most AMS have experienced rapid land use changes in the past three decades. Significant land swapping took place between forest and agricultural land (Figure 3.1). During 1990-2019, the region lost 36.6 Mha of forest land. Indonesia (-25.8 Mha), Myanmar (-10.35 Mha), and Cambodia (-2.78 Mha) lost the most forest land while Viet Nam (+5.2 Mha) and Thailand (+0.5 Mha) gained the most forest land in the past three decades because of sustained reforestation efforts and curbs on deforestation. During the same period, the area under agriculture increased by 31 Mha in the region.

Figure 3.1 Land swapping between forest and agricultural land from 1990-2019



Source: authors based on (FAO 2021)

Within agricultural land, the relative share of arable and permanent crops remained stable at about 60% and 40% respectively during 1961-2019. All AMS experienced expansion in agricultural land except possibly Brunei Darussalam (FAO 2021). The expansion of arable land was significant in Indonesia (8.3 Mha) and Thailand (6.4 Mha). The area under permanent crops expanded the most in Indonesia (17 Mha) and Malaysia (5.3 Mha). While most of these land use changes were driven by direct human interventions including expansion of agriculture and urbanization, the role of climate change (e.g., increased drought incidence) cannot be discounted.

Cultivation on slopes, especially through slash and burn techniques and not implementing soil conservation methods in some of the AMS, are also contributing to increased deforestation, forest degradation and soil erosion. As flat plain areas are crowded and land prices are higher, increased farming on hill slopes is expanding, contributing to land degradation (Mertz and Bruun 2017). Burning of forests to clear agricultural land is not only a source of GHG emissions, but also contributes to air pollution, loss of biodiversity, and soil erosion.

Excessive use of resources

The growing population and developmental needs are resulting in overuse of natural resources in the ASEAN region (Nevins and Peluso 2008; Nawaz, Azam, and Azhar 2019), which is causing concern in many governments in the region as these resources provide important inputs for economic growth and social development (Nawaz, Azam, and Azhar 2019). The region has experienced a rapid increase in demand for water during recent decades (Satoh et al. 2017), and most of the growth in water demand originated from the expansion of agriculture, urban areas, industrial growth and energy production (Hoang et al. 2019). Methane emissions from irrigated rice paddies and large water storage areas and nitrogen oxides from fertilizer use are significant GHGs in the ASEAN region.

AMS consumed an estimated 283 km^3/yr of water in 2010 (Satoh et al. 2017). It has been projected that the ASEAN region would need about 336–385 km^3/yr, of water by 2050, a 19-36% increase in water demand. Most of this demand is expected to come from population growth, industrial growth, energy demands, urbanization, and regional water competition. Currently, although the ASEAN region is doing well on some aspects of water security, it leads other regions on rural household water security and environmental water security. Meeting rural household water needs sustainably is a major challenge while addressing the already overexploited water resources in the region (ADB 2020). Increasing population, growing demand for water for agriculture, and industrial and domestic consumption in urban areas have been identified as some of the causal factors for drought intensification in the region (Miyan 2015). Increased incidence and severity of droughts due to climate change will exacerbate these pressures.

Southeast Asia is the primary supplier of hardwood timber in Asia and its timber exports are on continuous rise. The early increase in timber harvests were driven by domestic and regional demands (Yamaguchi 2021). In addition to the domestic demand for natural resources, global and regional demands are adding pressure for increased timber exports, including rising timber demand from Japan (Samejima 2019). These domestic and international demand factors have contributed to the overexploitation of forests in the region and the loss of potential carbon sequestration, especially in Indonesia, Malaysia, and Philippines (Samejima 2019).

The ASEAN region provides significant supply of minerals such as tin, nickel, and copper for which domestic, regional, and international demand is growing. Indonesia, Lao PDR, Philippines, Myanmar, and Cambodia are investing in expanding mineral exploitation, with significant environmental implications. In addition, production of cement, where Indonesia (91.4 Mt/year) and Viet Nam (63.05 Mt/year) are placed among the top 15 producers in the world, is also a source of significant environmental degradation and GHG emissions (USGS 2021; Global Cement 2021). Indonesia, in particular, is looking at the nickel-based industries as this would have synergistic impact on renewable energy and sustainable transport choices by boosting the electric vehicle (EV) industry. Cement output grew at 4.97% and 10.12% in Indonesia and Viet Nam, respectively, during 2016-2020 (Statista 2021b; 2021a). Cement production accounts for 1.63% and 11.6% of total GHG emissions in Indonesia and Viet Nam respectively (Government of Viet Nam 2020; Government of Indonesia 2021). With the growing economy and industrial production, cement production is projected to grow in the future with significant environmental implications, including increased GHG emissions.

3.2.3 State and trends

The ASCCR comprehensively outlined the current state and trends of climate change in the ASEAN region including GHG emissions, energy and economy, vulnerability to and impacts of climate change, climate change adaptation, and climate change mitigation. The key points on the trends in GHG emissions and the energy sector are as follows:

1. In 2018, ASEAN emitted more GHGs from fossil fuel combustion (1,485 MtCO_2eq) than from the LULUCF sector (965 MtCO_2eq);

2. The power sector is the largest direct source of GHG emissions in all AMS, except Cambodia (where the transport sector is the largest emitter);

3. From 1990 to 2018, energy intensity (Total Final Consumption of energy (TFC)/GDP) decreased while emission intensity (CO_2 emission/TFC) increased;

4. In 2019, renewable energy (only solar and wind) reached 13 GW in ASEAN; and

5. Based on the NDC targets to 2030, GHG emissions in the ASEAN region will likely continue increasing, with a projected emission range of 3,294–4,506 MtCO_2eq in 2030.

Similar to global trends, GHG emissions in ASEAN have been and will continue increasing toward 2030, even if NDC targets in all AMS are all met as planned. There is a clear gap in 2030 between projected emissions based on NDC targets and GHG emissions which would be consistent with realizing net-zero GHG emissions, which is necessary to achieve the long-term temperature goal enshrined by the Paris Agreement. Moreover, realizing a peaking of the region's GHG emissions as soon as possible after 2030, which is mentioned in the ASCCR as one of ASEAN's climate mitigation goals, is not promised in currently announced policy (ASEAN Secretariat 2021g). Decarbonization of the power sector is not happening to a sufficient degree, but rather dependence on fossil fuels has been increasing, as measured by emission intensity. Variable renewable energy sources such as solar and wind, which are key to decarbonization, are not sufficient even though the region has a very large potential and the costs for these renewable energies have decreased dramatically (IPCC 2022)[4]. Moreover, reductions in energy intensity measured by TFC/GDP do not necessarily guarantee improved energy efficiency (ASEAN Centre for Energy 2022). As the sectoral composition of the ASEAN economy shifts towards the service sector, the TFC/GDP energy intensity will decline because the service sector's energy consumption per unit of GDP is lower than that of the industry sector. Thus, the energy efficiency of each sector needs to be measured with “activity” metrics rather than GDP, such as value added, number of employees, floor area in the services sector, or passenger-kilometre and tonne-kilometre in the transportation sector (ASEAN Centre for Energy 2022).

Clearly the net-zero emissions goal by or around mid-century will require all AMS to peak their energy demand as soon as possible after 2030, avoid locking in high carbon energy sources, and then quickly reduce energy demand in all sectors. Considering the vital importance of the long-term net-zero emissions goal, stronger actions such as phasing-out or phasing-down coal-fired power plants and early retirement of unabated (i.e., without carbon dioxide capture and storage) fossil energy infrastructure are needed by 2030.

[4] See Figure SPM.3: Unit cost reductions and use in some rapidly changing mitigation technologies.

Hazards and climate change projections

The ASEAN region is highly vulnerable to natural hazards including storms, floods, droughts, landslides, and wildfires, which cause economic losses from damage to infrastructure, injuries, deaths, and related health costs. The extent to which these are due to climate change appears to be increasing. From 1902-2021, a total of 259,362 people were killed, and 13.83 million people were made homeless by 1,544 natural hazard events comprising storms, floods, droughts, landslides and wildfires (CRED/UC-Louvain 2021). Storms killed the most (218,779) followed by floods (24,855), droughts (9,348), landslides (6,051), and wildfires (329). A clear upward trend can be observed in the number of storm and flood events recorded in the region between 1902-2021 (Figure 3.2). The sub-regional trends could be different (see Table 3.2). For example, in the Philippines, only the severity of tropical cyclones was reported to have increased during 1951-2013 with no clear trend in the number of cyclones (Arias 2021). The Philippines experiences on average 20 cyclones every year (PAG-ASA 2022). Similarly, no clear historical trend can be found in the number of drought and wildfire events in the region. However, there is robust evidence for the increase in extreme precipitation in the region since 1950s (Seneviratne et al. 2021a). Extreme precipitation events were closely associated with the widespread riverine floods, landslides, and urban flooding episodes.

Table 3.2 Distribution of disaster events across AMS by hazard during the COVID-19 pandemic

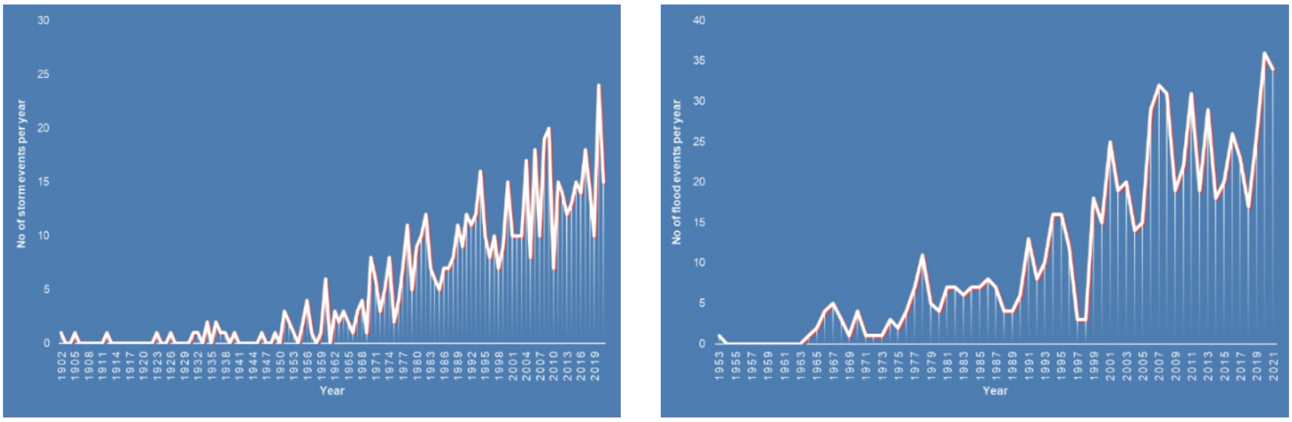
AMS	Drought	Landslide	Storm	Wind	Flood	Tsunami	Volcano	Earthquake	Total
BRN	-	-	-	-	-	-	-	-	-
KHM	1	-	8	11	11	-	-	-	31
IDN	12	135	6	134	888	-	4	11	1190
LAO	-	3	3	1	4	-	-	-	11
MYS	-	2	0	-	36	-	-	-	38
MMR	-	4	5	2	4	-	-	-	15
PHL	-	18	30	25	88	-	2	6	179
SGP	-	-	0	-	-	-	-	-	-
THA	-	12	39	36	56	-	-	-	143
VNM	-	12	18	14	29	-	-	-	83
Total	13	206	109	223	1116	-	6	17	1690

Source: reproduced from (AHA Centre 2022)

Recently, the increasing incidence of a multi-hazard nexus has been reported in several parts of the region that has serious consequences for climate change and disaster risk management. For example, the drought of 2020 was reported to be very severe due to the combined effects of water scarcity and saline water intrusion in the coastal areas that affected nearly 33,157 people and affected agriculture production in 460,000 ha in one single episode of the drought in Viet Nam

(IFRC 2020). The related economic costs (lost incomes and increased government spending on disaster relief), as well as health damage/ costs, and lost jobs are a significant burden on the economy and society. Attribution of disaster events due to climate change is an emerging science but there is insufficient research using this approach in the ASEAN region.

Figure 3.2 Number of storms (left) and floods (right) recorded in the ASEAN region between 1902-2021



Source: (CRED/UC-Louvain 2021)

Climate change will have serious consequences for the region. The region is projected to experience significant increases in mean and extreme temperatures, although the increase is expected to be relatively smaller than the global average (Arias et al. 2021). Under the representative concentration pathway (RCP) 2.6 scenario, the region is projected to warm by 1.2 ± 0.4°C during the 21st century, or 3°C to 5°C under the RCP 8.5 scenario (Gutiérrez et al. 2021). Daily maximum temperature extremes may be more pronounced due to climate change with an associated decline in the cold extremes (Seneviratne et al. 2021a). This observation is consistent with the historical observed trends in temperatures in the region and it is consistent across all temperature scenarios.

The available climate change projections indicate that the region is likely to experience an increase in monsoon precipitation in the medium to long-term (medium confidence) (Arias et al. 2021). The increase in precipitation will be associated with increased riverine floods (medium confidence) and associated economic damage. Climate change will also result in intensification of extreme precipitation events with some sub-regional differences (high confidence). Possible global warming of up to 4°C would increase the meteorological droughts in the region (medium confidence), as well as associated aggravating factors such as increasing frequency of extreme El Niño episodes. The number of tropical cyclones may decline with an associated increase in extreme precipitation events and increased number of intense cyclone events.

3.2.4 Impacts

While many of the climate response targets aim at future dates of 2030 or 2050, climate change impacts are happening now, even though the global temperature has increased by only 1.09°C so far compared to pre-industrial times. The main impacts in the ASEAN region are (i) sea level rise, coastal inundation, storm surges, and saline intrusion into groundwater and river deltas; (ii) increased extreme weather events such as heatwaves and droughts; (iii) extreme precipitation, landslides, and flooding; (iv) impacts on crop productivity; (v) increased forest fire incidence; (vi) coral bleaching and death; and (vii) increased severity of windstorms and cyclones (IPCC 2021b).

These impacts will impose substantial economic costs and endanger human health and well-being. Many climate impacts will cause extensive damage to infrastructure and housing, and many people could be displaced from their jobs as a result of climate related disasters. Treatment of health impacts in hospitals will also be costly. Climate refugees could cause political instability (ASEAN Secretariat 2021g).

The ASCCR includes some examples of the projected impacts. For example, sea level rise by 2050 could cause economic impacts ranging from US$ 62 billion (Brunei Darussalam) to US$ 8.6 trillion (Viet Nam). Heatwaves and increased mosquito-borne diseases like malaria and dengue could have major impacts on health.

The high intensity rainfall events associated with climate change can exacerbate soil erosion especially on hill slopes and in areas with sparse vegetation in the Laos–Viet Nam transnational Upper Ca River Watershed (Giang, Giang, and Toshiki 2017). Countries such as Myanmar, Philippines and Indonesia are reported to be highly vulnerable to climate change driven soil erosion under the shared socio-economic pathway (SSP5)-RCP8.5 scenario until 2070 (Borrelli et al. 2020). Soil erosion will reduce agricultural productivity and threaten food security.

The land use changes dominated by deforestation and expansion of agriculture and urbanization in the region have been directly attributed to the significant increase in global GHG emissions (Canadell et al. 2021). Persistent biomass burning in Southeast Asia is a prominent contributor of potent GHGs. Land use changes were also attributed to the recent decline in monsoon rainfall in the region (Douville et al. 2021).

3.2.5 Responses

Recognizing that climate change impacts are already occurring with more severe impacts locked-in due to the long-lived nature of GHGs in the atmosphere (like CO_2), AMS are actively planning and implementing a wide variety of mitigation and adaptation responses at all levels, from the central governments to private firms and individuals. These measures have been documented in NDCs, National Adaptation Programmes of Action (NAPAs), National Adaptation Plans (NAPs), and various adaptation strategies, local adaptation plans, and sector plans.

Mitigation of GHG emissions

Efforts to mitigate climate change (SDG 13: Climate action) are closely interlinked with other SDGs such as SDG 7 (Ensure access to affordable, reliable, sustainable, and modern energy for all), SDG 8 (Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, and decoupling economic growth from environmental degradation), SDG 9 (Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation), SDG 11 (Make cities and human settlements inclusive, safe, resilient and sustainable) including air pollution prevention, and SDG 15 (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss). The 6th ASEAN Energy Outlook (AEO6) (ACE, 2020a) quantitatively presented GHG emission projections until 2040 under several scenarios including one where SDG 7 is achieved: (i) ensuring universal access to affordable, reliable and modern energy services; (ii) increasing substantially the share of renewable energy in the global energy mix; and (iii) doubling the global rate of improvement in energy efficiency. AEO6 further estimated the number of jobs that would be created by promoting renewable energy and reducing social costs of fossil energy while also increasing investment in the power sector. This indicates that the clean energy transition will incur some economic costs but will also generate socio-economic and environmental benefits and influence the achievement of the SDGs. Thus, it is vital to design and implement climate change mitigation policies to maximize synergies and reduce trade-offs among SDGs.

To achieve net-zero emissions, reduction in energy demand will be key, along with phasing out fossil fuels and promoting renewable energy. Reduced energy demand can be achieved through a circular economy approach in which material efficiency will be increased through reuse and recycling. Lifestyle changes may reduce energy demand by changing the patterns of leisure and work. For example, teleworking and online shopping through digitalization have changed the mode and patterns of transport. To achieve the long-term temperature goals of the Paris Agreement, AMS are preparing (i) long-term strategies (LTS) targeting after 2050; and (ii) NDCs for around 2030.

Singapore submitted its Long-Term Low Emissions Development Strategy (LEDS) to the UNFCCC in March 2020, which aspires to halve GHG emissions from their peak to 33 $MtCO_2eq$ by 2050, with a view to achieve net-zero emissions as soon as viable in the second half of the century. More recently, Singapore announced in October 2022 that it will raise its climate ambition to achieve net-zero emissions by 2050. In 2021, Indonesia and Thailand submitted their LTS to the UNFCCC with aspirational targets to achieve net-zero GHG emissions by 2060 for Indonesia, and carbon neutrality by 2050 and net-zero GHG emissions by 2065 for Thailand. These three AMS have developed official LTS, and their NDC targets and sectoral and cross-sectoral plans are expected to be in line with the LTS.

All AMS have converted their initial nationally determined contributions (INDCs) into NDCs. Brunei Darussalam, Cambodia, Singapore, Thailand, and Viet Nam updated their NDCs in 2020, Indonesia, Lao PDR, Malaysia, Myanmar, and Myanmar in 2021. Based on these updated NDCs, aggregate GHG emissions in ASEAN are likely to increase until 2030 within the range of 3,294–4,506 $MtCO_2eq$ according to the ASCCR. The estimated GHG emissions reductions depend on assumptions about possible international financial support and the level of ambition of the measures in the AFOLU/LULUCF sector. The expected contribution of the AFOLU/LULUCF sector to total GHG emission reductions is especially large in Cambodia, Lao PDR, and Myanmar, depending on successfully preventing deforestation and increasing forest cover and carbon sinks, stronger collaboration across institutions and policies, as well as mobilization of financial support by the public and private sectors. Singapore further updated its NDC in 2022.

The priority mitigation sectors for AMS include energy, transport, industry, forestry and land use, and waste (ASEAN Secretariat 2021g). For the energy sector, priority actions include (i) energy efficiency; (ii) renewable energy; and (iii) trans-border energy interconnection between AMS. Additionally, coal phase out/down and early retirement of unabated fossil energy infrastructure in the power sector need to be prioritized. Transport priorities include mass transit systems, biofuels, and promotion of electric vehicles. Forestry and land use priorities include afforestation, preventing deforestation and forest degradation, peatland restoration, and sustainable forest management. Waste sector priorities are diversion of waste from landfills and promotion of recycling. The ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025 has key regional strategies for (i)-(iii), and its key strategies for (iii) include the ASEAN Power Grid expansion and Trans-ASEAN Gas Pipeline development (ASEAN Centre for Energy 2020b). In the AFOLU/LULUCF sector, ASEAN's specific strategies include the Vision and Strategic Plan for ASEAN Cooperation in Food, Agriculture and Forestry (SP-FAF) 2016–2025 with action programmes to promote climate smart/friendly agriculture, land use and fisheries based on nature-based solutions (NbS), and the Regional Action Plan for the ASEAN Heritage Parks (AHP) 2016–2020 with seven goals, strategic actions and specific activities which contribute to GHG emission reductions (ASEAN Centre for Biodiversity 2016).

Eight AMS have set their GHG emission reduction targets relative to business-as-usual (BAU) emissions, while Singapore has set an absolute emission limitation target, and Malaysia has set GHG intensity reduction targets. The coverage of GHGs and sectoral GHG projections differ across AMS' NDC targets. These differences and the uncertainty of the ASEAN region's forest sequestration projections, make it difficult to estimate an ASEAN-wide absolute GHG reduction target in a bottom-up fashion. Nevertheless, updated NDCs by Lao PDR and Myanmar set relative GHG emissions reduction targets based on improved projection of BAU emissions, making it easier to develop a harmonized regional mitigation target or roadmap. For the energy sector, the APAEC 2016–2025 set a target of 32% reduction in energy intensity by 2025 relative to 2005 levels, and a 23% share for renewable energy share in the total primary energy supply by 2025. ASEAN is on track to reach the energy intensity target achieving 21% energy intensity reduction in the energy sector, surpassing its aspirational target. However, stronger effort is needed to reach the renewable energy target, with only a 14.3% share of renewable energy in 2017. The renewable energy target of 23% will be an important near-term milestone for smoother transition toward decarbonization. ASCCR analyzed the gap between AMS' collective mitigation targets and what would be needed to achieve the 1.5°C target or net-zero target (ASEAN Secretariat 2021g).

Innovative economic instruments that would help AMS achieve mitigation targets with lower costs, such as explicit carbon pricing, emission trading scheme (ETS) or a carbon tax, have been officially introduced in some AMS such as Singapore (economy-wide carbon tax) and Indonesia (ETS in the power sector). Other AMS such as Philippines, Thailand and Viet Nam have carbon crediting mechanisms and/or tax schemes with some impact on mitigation (ASEAN Secretariat 2021g). To realise a cost-effective transition to net-zero emissions, increasing the number of countries that introduce carbon pricing and increasing the level of the carbon price over time are essential.

Adaptation

Adaptation actions by AMS can be categorized as (i) integrating climate change into national development plans; (ii) national policies on disaster risk management (DRM) and climate change adaptation (CCA); (iii) identifying focal agencies for disaster risk management and climate change adaptation; (iv) creation of national climate change committees and/or climate change agencies; (v) strengthening meteorological data systems; and (vi) funding for disaster risk management.

Some AMS have also implemented DRM laws and management plans, downscaled climate change projections, vulnerability and risk assessments, and funding arrangements for climate change adaptation. At the time this report was prepared, only Indonesia and Singapore had submitted National Adaptation Communications to the UNFCCC. However, most other AMS have included some discussion of adaptation, including nature-based solutions (NbS), in their NDCs or national communications.

AMS have prioritized key sectors for adaptation interventions in various official documents including their Adaptation Plans, National Communications, NDCs, and Adaptation Strategies. There are no uniform criteria across AMS to describe how these sectors were prioritized nationally. However, some criteria that became apparent from reading these official documents include climate change vulnerability, the significance of these vulnerabilities and impacts on the national economy, their significance to societal wellbeing, and their significance to various development goals. These key sectors were mostly identified without assigning relative priority among them.

Prominent sectors related to adaptation include health, biodiversity, forestry, food and agriculture, and water resources (Table 3.3). Countries such as Cambodia have identified the livelihood implications of climate change impacts as a separate priority. Though urban areas were not identified as a separate key sector by countries such as the Philippines, Myanmar, Malaysia, and Brunei Darussalam, their national communications did emphasize urban areas and identified interventions to address urban vulnerabilities. Countries such as Myanmar, Cambodia, Indonesia, Viet Nam, Philippines, Lao PDR, Thailand, and Malaysia derive immense benefits from fisheries, but the focus on fisheries as a priority sector has been minimal. All countries recognized the impact of climate change on tourism in their national communications.

Table 3.3 Key sectors for climate change interventions identified by AMS

	Food & Agriculture	Water resources	Health	Forest(ry) & biodiversity	Urban	Coastal & Marine	Energy	Industry & infrastructure	Fisheries	Livelihoods & poverty	Tourism	Transport
Brunei	■	■	■	■			■		■			■
Cambodia	■	■	■	■	■	■	■	■		■	■	
Indonesia	■	■	■	■	■		■	■	■			
Lao PDR	■	■	■	■	■		■					■
Malaysia	■	■	■	■		■	■	■				
Myanmar	■	■	■	■		■						
Philippines	■	■	■	■		■						
Singapore	■	■	■	■	■	■	■	■				■
Thailand	■	■	■	■	■						■	
Viet Nam	■	■	■	■	■	■	■		■		■	■

Source: Adapted from (ASEAN Secretariat 2021g)

The AMS have made significant progress on addressing CCA and disaster risk reduction (DRR) issues through strengthening institutions which enabled them to integrate these priorities into various policies and plans. Some commonalities can be found in how ASEAN countries designed institutional mechanisms for CCA and DRR. It is beyond the scope of this report to assess the effectiveness of these institutional interventions across the region since they were developed based on national circumstances, but it is possible to get a general impression from the disaster impacts in the region. Most countries have DRM laws and policies and have established focal departments/ministries/agencies to address disaster risks. This helped them to make a significant progress in addressing disaster risks in a cross-cutting manner across all other ministries and departments. Disaster risk insurance has been receiving increasing attention in the region especially agricultural insurance, while interest in other kinds of insurance such as flood insurance for assets is rising more gradually. There are also regional insurance initiatives such as the Southeast Asia Disaster Risk Insurance Facility (SEADRIF).

The institutional and policy setups for climate change adaptation have benefited from the region's DRM experiences. Substantial progress has been made in terms of CCA policies, and adaptation plans have been rapidly drawn up. The NAPAs formed the basis for identifying and implementing priority adaptation actions in many countries. NAPAs were submitted by Lao PDR and Cambodia. The AMS have submitted national communications that also outlined adaptation priorities for these countries. No NAPs and/or adaptation communications have been submitted so far.

Risk assessments are an important part of both DRR and CCA. The disaster risk assessments are at an advanced stage in the region with most countries having conducted them at least at the national level and in most cases even at the sub-national levels. However, the disaster risk assessments that integrate climate change are still being developed. Some improvements have been made in specific hazard areas such as flood risk assessments, drought risk assessments, and landslide risk assessments in which some countries were able to integrate climate change projections and further able to downscale these efforts to the community level. Major bottlenecks in this area are the lack of quality data, quality climate projections, and technical human resources. As a result, the progress in downscaling climate change projections has been minimal in several countries. Sectoral level climate change risk assessments have yet to be developed in most countries, and this is hampering climate risk mitigation at the sector level.

Table 3.4 Current status of climate change adaptation and disaster risk reduction in AMS

Item	Brunei	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam
1. Laws, regulations and policies										
Recognise CC in National Dev. Plans	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
DRM policy	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
DRM law	Implemented	Implemented	Implemented	Under planning	Under planning	Implemented	Implemented	Implemented	Implemented	Implemented
DRM plan	Under planning	Implemented	Implemented	Under planning	Under planning	Implemented	Implemented	Implemented	Implemented	Implemented
Focal agency for DRM	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
National DRM committee	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Sub-national DRM institutions	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
CCA policy	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
CCA plan (National Adaptation Plans)	Under planning	Under planning	Under planning	Under planning	Under planning	Under planning	Under planning	Under planning	Under planning	Under planning
Focal agency for CCA	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
National CC Committee	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
DRR and CCA integration in policies	Under planning	Under planning	Under planning	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Guidelines for DRR and CCA integration	Under planning				Under planning		Under planning	Under planning		
2. Risk assessments										
Disaster data systems	Under planning	Implemented	Implemented	Under planning	Under planning	Under planning	Implemented	Under planning	Implemented	Implemented
Meteorological data systems	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Downscaled CC projections			Implemented		Implemented		Implemented	Implemented	Implemented	Implemented
Risk maps with CC impacts		Implemented			Under planning				Under planning	Implemented
3. Financial mechanisms										
Funding for DRM	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
Funding for CCA	Under planning	Under planning	Implemented	Under planning	Under planning	Under planning	Implemented	Implemented	Under planning	Under planning

actions are fully implemented; not fully implemented and under planning; no actions taken yet or not relevant.

Source: authors

Monitoring and evaluation (M&E) are important parts of implementing adaptation actions. However, since there has been no significant development in M&E frameworks that countries can use that are comparable across the countries in the region, it is a challenge to assess how effective these adaptation actions have been on the ground. One area where some AMS have made progress is in financial tracking of climate expenditures, and this work has continuously been upscaled in the region.

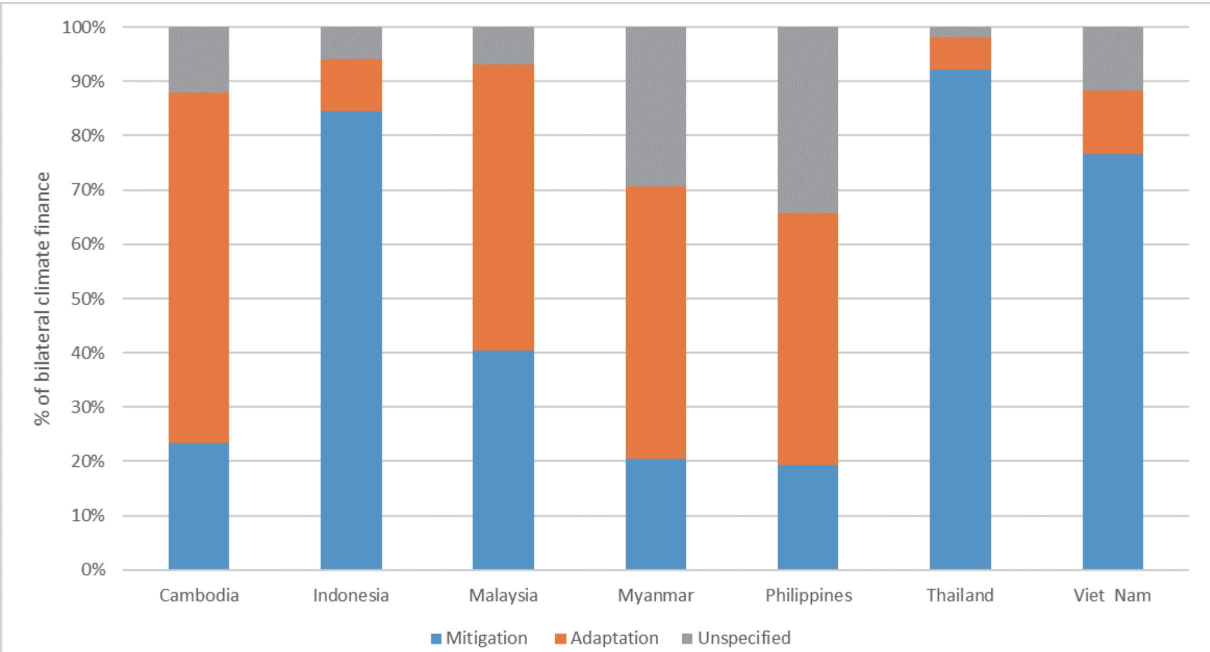
Another area that needs progress is measures related to loss and damage. Countries are pursuing several areas, including setting up a disaster impacts database (e.g., DesInventar), building ASEAN's financial resilience against climate shocks and disasters (e.g., SEADRIF), research into key knowledge gaps on climate impacts and projecting future losses and damages, and assessing options to avert, minimize and address loss and damage. While some progress can be seen in the disaster impacts database, progress in other areas is ongoing.

Gender and vulnerable groups are prominent focuses in most adaptation strategies in the region. It has been widely recognized that disasters and climate change have severe implications for gender equality, women's empowerment, and child protection, and that specific measures are required to address these impacts. This recognition could be clearly seen in the ASEAN joint statement at COP 26, which highlighted the need to implement actions such as promoting NbS, promoting intergenerational approaches that address issues of gender and vulnerable groups, and the need to focus on coastal ecosystems, especially in relation to vulnerable groups. The statement reiterated ASEAN's commitment to implementing the Lima Work Programme on Gender and its Gender Action Plan. While these commitments are beneficial, it is not clear how these commitments will translate into actions by AMS which are often challenged by capacity constraints (i.e., financial and human resources mostly). Agriculture plays an important role in adaptation and mitigation in the region. Since women make up a significant share of ASEAN's agricultural work force, strengthening actions to support women and vulnerable groups would go a long way towards making agriculture more climate resilient. The disaster risk management community is at the forefront in addressing these issues and ensuring their importance to adaptation becomes more widely recognized.

Adaptation is also a technological challenge for the region. Technology needs assessments have yet to be completed for major sectors. Some prominent technologies being pursued as part of climate change adaptation strategies in the region include water balance systems, early warning systems, climate-smart agriculture, disease surveillance, and integrated water resource development. There is strong institutional support at the regional level through the Committee on Science and Technology, and the Plan of Action on Science, Technology, and Innovation (APASTI) 2016-2025 which can play a vital role in technical cooperation in the ASEAN region (ASEAN Secretariat 2017b). These measures are expected to enhance the technical cooperation in the region in the years to come.

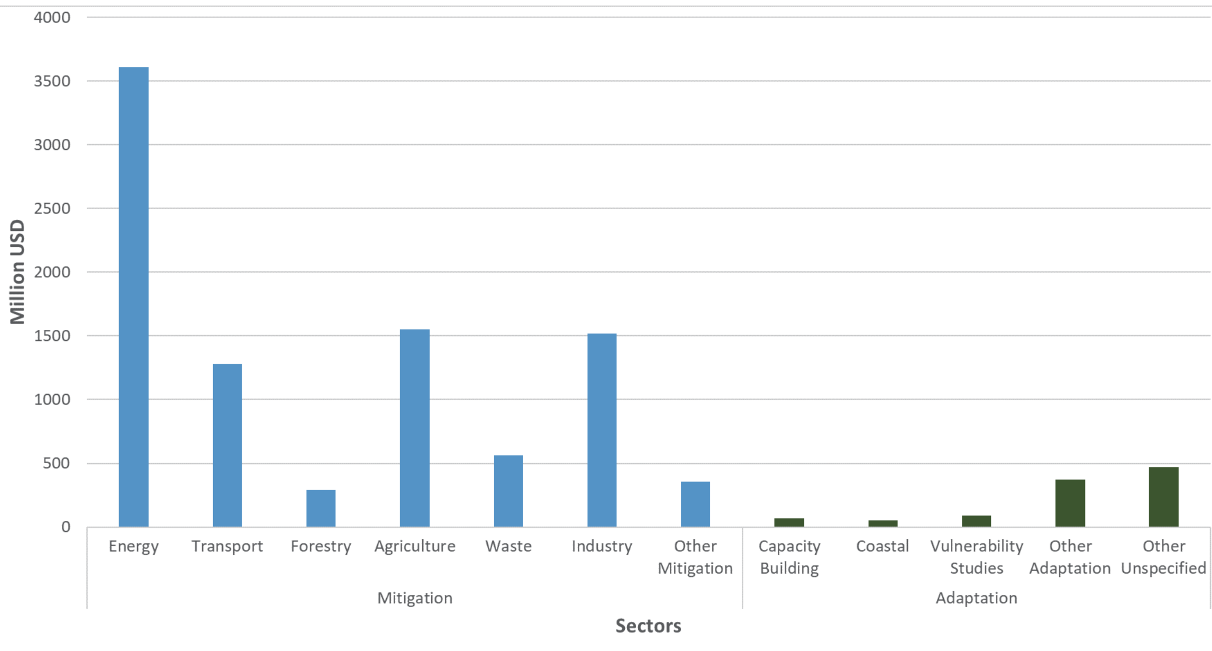
Financing is a major limitation for many countries in the region to scale up climate change adaptation measures. AMS are increasingly willing to invest their national finances in adaptation funding, and there is a growing engagement of corporations through corporate social responsibility (CSR) initiatives. International financing has been increasing partly due to continuous capacity building measures to access these resources. As a result, AMS have been able to obtain funding from the Green Climate Fund (GCF), Green Technology Fund, Adaptation Fund (AF), the Least Developed Country (LDC) Fund, and Global Environment Facility (GEF) Trust Fund. During the fourth to sixth national communications, the AMS received US$ 3.95 billion in bilateral climate finance (Figure 3.3 and Figure 3.4) (UNFCCC 2020). According to the Organization for Economic Cooperation and Development (OECD), ASEAN countries (except Brunei and Singapore) received a total of US$ 56 billion or 10.56% of total climate finance provided to developing countries between 2000 and 2019. There is a large disparity in terms of how this funding is allocated between adaptation and mitigation measures, however, as 74% of this funding was allocated to climate change mitigation, while adaptation received only 15%. Bilateral adaptation finance mostly supported vulnerability assessments (Figure 3.4). One of the challenges for AMS has been to balance adaptation financing and development financing.

Figure 3.3 Bilateral climate finance for mitigation and adaptation in AMS



Source: (UNFCCC 2020)

Figure 3.4 Bilateral finance for various sectors of mitigation and adaptation



Source: (UNFCCC 2020)

Regional Actions

ASEAN is a vibrant region in terms of regional cooperation on climate change and this cooperation has been increasing. Cooperation efforts are included in the ASCC Blueprint 2009 and 2025. The Blueprints have helped countries to reach a common understanding of climate change, and regional cooperation has resulted in several projects and programmes being implemented to address the adaptation needs of the AMS. These actions include organizing training events, regional science and policy dialogues, studies and conferences, sharing information between countries, organizing information exchange forums, and implementing projects to address specific issues (e.g., a project on "Rehabilitation and Sustainable Use of Peatland Forests in Southeast Asia"). These cooperation actions have received extensive support from Australia, Canada, China, European Union, Republic of Korea, Japan, the United States, and the United Kingdom, among others.

The ASEAN Working Group on Climate Change (AWGCC) Action Plan 2016–2025 (AAP) has further enhanced the resolve of the countries to cooperate, as the plan supports capacity building programmes and technical exchanges regarding eight core themes: (i) climate change adaptation and resilience; (ii) long-term planning and assessment of NDCs; (iii) climate change mitigation; (iv) climate modelling and assessment; (v) measurement, reporting and verification and stocktake of GHG emissions; (vi) climate financing and markets; (viii) cross-sectoral coordination; and (viii) technology transfer. Some of the expected benefits from these projects and activities include: (i) strengthening AMS capacity for implementing NDCs; and (ii) building AMS capacity on carbon pricing and laying the foundation for possible cooperation on carbon pricing at the regional level.

3.3 Air pollution

Few environmental issues pose a greater threat to the health and well-being of more than 667 million people in ASEAN than air pollution (see Table 2.1 for population data and related trends). Similar to elsewhere in this report, this section moves from drivers to state to pressures to identify how this threat can be managed and minimized. The section also presents untapped opportunities to achieve co-benefits from integrating air pollution and climate policies in ASEAN.

3.3.1 Drivers

Air pollution in the ASEAN region is the product of several broad sets of forces that frequently overlap with the drivers of climate change: (i) urbanization strategies that rely heavily on petrol and diesel powered vehicles; (ii) fossil-fuel based energy systems that lock-in resource intensive growth; (iii) economic policies promoting fast-paced industrialization; (iv) agriculture systems that have become increasingly reliant on industrial fertilizers; and (v) changing production and consumption patterns that place new strains on energy, food systems and waste management

(CCAC, UNEP, and APCAP 2019). Several other important air pollution sources in ASEAN that are drivers themselves and are related to the forces listed above include the construction of roads and infrastructure, residential energy use, rice cultivation, waste management, and land and forest clearing practices.

3.3.2 Pressures

The pressures that cause air pollution in ASEAN often differ in urban and rural areas. This section divides those pressures into urban and rural categories, although the interaction between urban and rural emissions is attracting growing interest.

In urban areas, air pollution pressures stem chiefly from the rapid increase in fossil fuel combustion in energy, industry, and transport. As for energy and industrial sources, oil- and coal-fired thermal power stations emit high levels of air pollutants and GHGs. This is especially the case because power plants and large industries often depend on outdated and inefficient technologies. With energy demand growing quickly, power producers are reluctant to “prematurely” retire outdated polluting plants. In addition, small industries scattered in populated areas often rely on older equipment for coal or biomass combustion. The lack of, or limitations on, emission controls in these smaller industries increase risk of exposure and adverse health effects.

In the transport sector, demand for motorized transport is rising rapidly. This demand is not always met by automobiles. Rather, in many ASEAN cities, emissions come from motorcycles that are more affordable and convenient in navigating narrow and congested roads. For example, in 2016, Viet Nam had 49 million motorcycles (492 motorcycles per 1,000 residents). In 2015, Hanoi had 5 million motorcycles while Ho Chi Minh City had 6.8 million (J. H. Park 2018). Unfortunately, this mode of transport, which grew by 7.2% per year from 2010-2016 and makes up over 90% of the urban vehicle fleets, not only contributes to poor air quality generally but exposes riders to higher emission concentrations while on the road (Phuc and Oanh 2022; Tang et al. 2020).

A related concern in the transport sector is imported second-hand vehicles, reconditioned motors, and poorly maintained vehicles (Li and Crawford-Brown 2011). These older or poorly functioning vehicles generate high level of emissions of sulphur oxides (SOx), nitrogen oxides (NOx), volatile organic compounds (VOCs) and particulate matter (PM), often exposing poorer communities and roadside workers or vendors to poor air quality and threats to their health (Li and Crawford-Brown 2011). In addition, NOx and VOCs are important precursors for the formation of tropospheric/surface ozone (O_3), a toxic and phytotoxic and a strong GHG. VOCs, NOx, SOx and ammonia (NH_3, from the agricultural sector) are precursors for the formation of secondary particles in the atmosphere (Li and Crawford-Brown 2011).

A related pressure stems from increased vehicle use and construction. In many parts of urban ASEAN, road dust resuspended due to vehicle movement on silty surfaces of paved and unpaved roads (and dust from construction activities) are significant contributors to PM pollution. Intensive construction and reconstruction activities of roads, houses, and infrastructure in urban areas add to high levels of PM emissions (Prasertsin and Nathapindhu 2020; Srithawirat and Latif 2015).

A pressure that is both urban and, to some extent, rural is the rapidly escalating waste volumes that have grown due to urbanization and increasing disposable income. Unsanitary landfills—often no more than open dumping sites—are an increasing concern in this regard. Landfills are frequently a source of methane and other VOC emissions and when the waste is burned, large amounts of fine PM and other toxic air pollutants, including dioxins and polycyclic aromatic hydrocarbons, are released. People living near these landfills also complain about unacceptable levels of odours, which, in turn, impacts their health (World Bank Group 2019). In Yangon and Mandalay, for example, air pollution and waste management are major concerns. Residential waste burning occurs not only at dumpsites but also frequently in backyards in many parts of ASEAN which releases a large amount of toxic air pollution in crowded areas, especially in the booming peri-urban areas where the coverage of waste collection is insufficient.

Outside of urban areas, one of the most health-damaging pressures is a continued reliance on biomass and coal for residential cooking. The continuing dependence on biomass and coal contributes to both indoor and ambient air pollution as the particulates eventually disperse outside homes and enclosures (Huy, Winijkul, and Kim Oanh 2021).

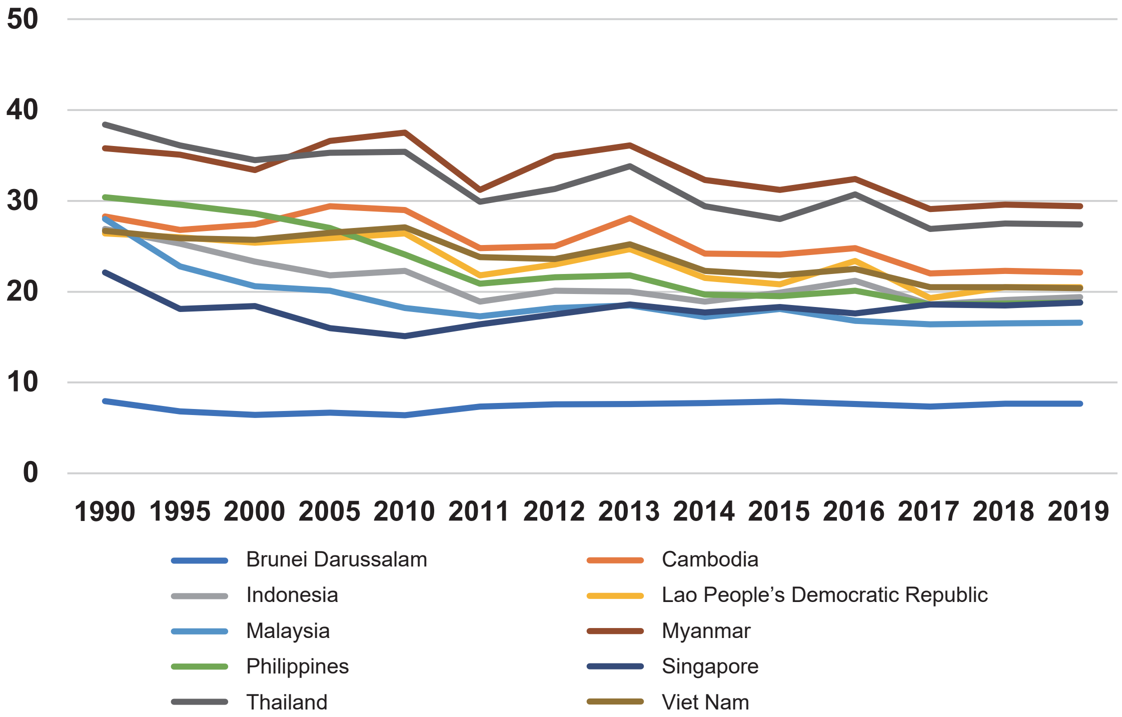
Another pressure in rural areas involves changes in the agriculture and forestry sectors, where increased productivity is often prioritized over sustainable use (Jones 2006). Much of the agriculture land in AMS is converted from former forested land—particularly for oil palm and rubber plantations. Uncontrolled forest fires are frequently used to clear forests; the associated emissions from this practice is a cause of transboundary haze episodes (Jones 2006). To a significant extent, traditional shifting cultivation in upland areas of several AMS also leads to haze pollution (Jones 2006).

Other pressures in rural areas involve paddy rice cultivation and fertilizer use. Rice cultivation creates large areas of anoxic standing water with anaerobic methane (CH_4) emissions that is converted into tropospheric ozone. The growing use of nitrogen-based fertilizers that break down in the atmosphere are also a source of pollution in the region. For example, pressure to increase production to meet rising demands for domestic consumption and export leads farmers in the agrarian ASEAN areas grow two or three rice crops per year, leaving only a short period between consecutive cycles for land preparation (Oanh et al. 2019). Therefore, open burning of rice straw is used to quickly clear the surface biomass for land preparation. Emissions from open field burning of residues from annual crops, such as rice straw, maize and sugarcane, are major contributors to poor air quality (Kim Oanh et al. 2018).

3.3.3 State and trends

There are both promising and concerning trends regarding the state and trends of air quality in the ASEAN region. One promising trend is a modest reduction in average annual population-weighted concentrations of $PM_{2.5}$ (the fine fraction of PM with aerodynamic diameters ≤2.5 μm) in ASEAN since 1990. As illustrated in Figure 3.5, those concentrations have fallen by approximately 30% over nearly 30 years in many countries in the region (Health Effects Institute 2020a). Despite this encouraging improvement, annual ambient concentrations of $PM_{2.5}$ in most ASEAN countries are four times the current (and recently strengthened) World Health Organisation (WHO) guideline values of 5 μg/m^3 (annual mean) (WHO 2021a).

Figure 3.5 Southeast Asia: average annual population weighted $PM_{2.5}$ µg/m^3

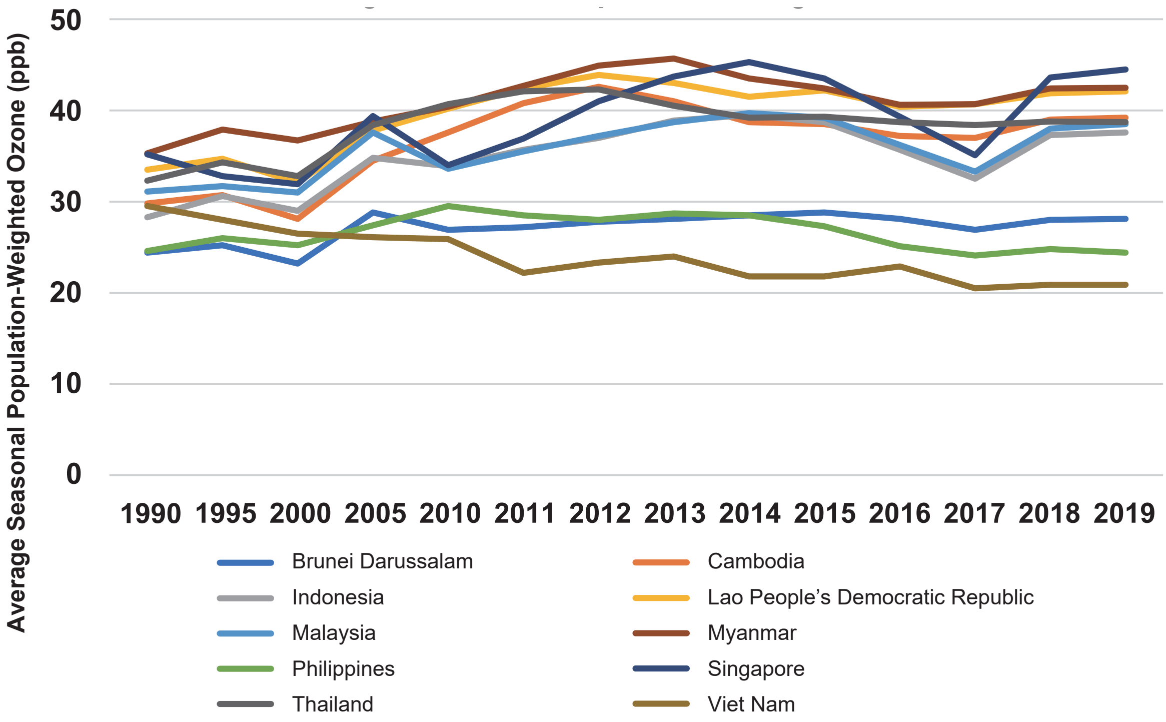


Source: (Health Effects Institute 2020b)

Another consideration is the high seasonality of air pollution levels given the monsoon-driven climate in the region. In many parts of the ASEAN region, daily and monthly levels of air pollution are higher in the dry season than in the wet season. Accordingly, annual averages can obscure spikes in dangerous pollution levels over short timeframes.

An additional concerning trend involves tropospheric ozone pollution. Ambient ozone has increased by around 20% between 1990 and 2019 in many countries in ASEAN (See Figure 3.6) (Health Effects Institute 2020b). Ozone is a secondary pollutant formed in the air from the photochemical reactions of the precursors of NOx and VOCs (including methane) in the presence of sunlight. Ozone air quality is managed by controlling the emissions of precursors with specific strategies tailored to concerned areas.

Figure 3.6 Southeast Asia: average seasonal population-weighted concentrations of ozone



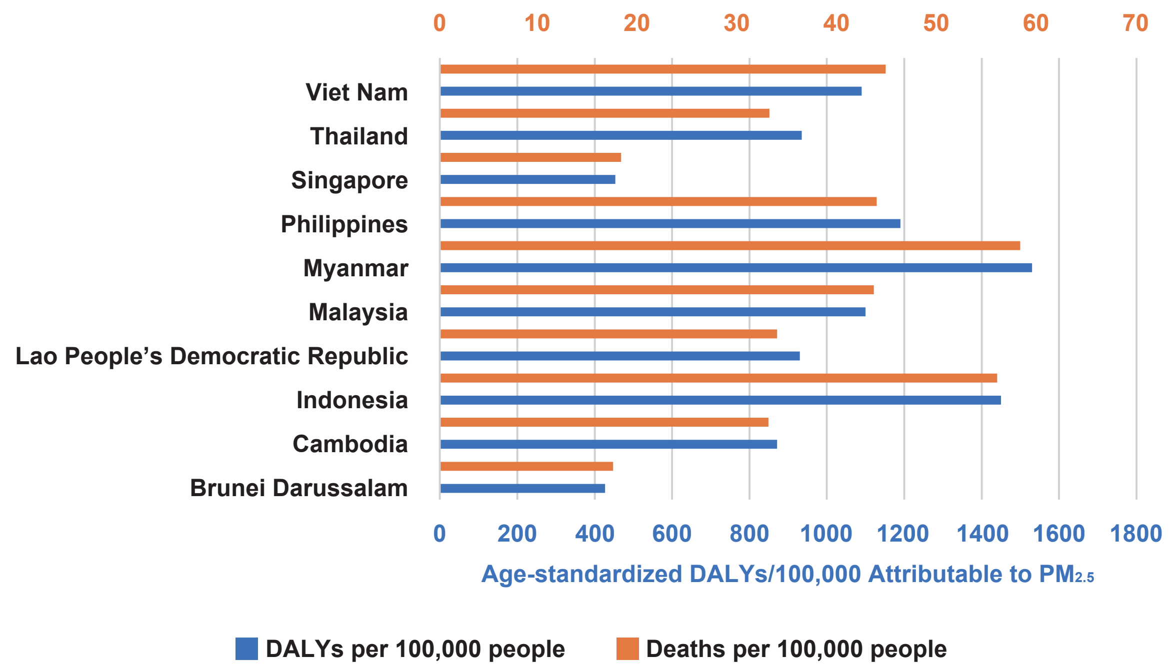
Source: (Health Effects Institute 2020b)

A final notable point is that, though there appears to be some broad-based similarities in trends in air quality from the above figures, there is also variation across the region. For instance, the Philippines has experienced the most significant reduction in fine particulate concentrations in the region (see Figure 3.5). In addition, there are significant differences between rural and urban regions in trends in air quality due to both variations in the main sources (especially fire and non-fire related emissions) and the relative effectiveness of interventions (H. H. Lee et al. 2018). Finally, even within cities, there are variations in concentrations and trends (Alas et al. 2018).

3.3.4 Impacts

Air pollution is already having severe impacts in the ASEAN region. The most debilitating effects are on the health and well-being of exposed populations. Those impacts are vividly illustrated in Figure 3.7. Figure 3.7 demonstrates that countries in the region suffered between 17 to 58 deaths per 100,000 people from fine particulate pollution in 2019. The Figure also suggests that the number of disability adjusted life years (DALYs)—a broader metric that accounts for the years of an unhealthy life—ranged from 400 to 1500 per 100,000 people in the region in 2019. While most countries in ASEAN are below the global averages for both deaths (52) and DALYs (1500) from fine particulates, they are frequently above regions such as Western Europe in terms of deaths (11) and DALYs (284). Perhaps more troubling is that some projections suggest that these impacts will continue to rise; according to the ASEAN Parliamentarians for Human Rights, air pollution is expected to kill more than 650,000 people in ASEAN by 2040 (ASEAN Parliamentarians for Human Rights 2021).

Figure 3.7 Age-standardized disability-adjusted life years (DALYs) and deaths per 100,000 attributable to $PM_{2.5}$ in 2019



Source: (Health Effects Institute 2020b)

These overarching figures may nonetheless overshadow differences within the region. For example, Indonesian citizens in the most polluted areas could expect to live up to 2.5 years longer with significant reductions in air pollution (Greenstone and Fan 2019). Meanwhile in Myanmar, in 2017, 45,000 deaths were attributed to air pollution, double the average mortality risk in Southeast Asia (World Bank Group 2019).

Air pollution also negatively impacts other development issues in ASEAN. For example, air pollution lowers labour productivity which in turn reduces socioeconomic output. In addition, air pollution can reduce crop yields because many air pollutants are phytotoxic (e.g., ozone, SO_2, NO_2, etc). Atmospheric deposition of acidic compounds associated with NOx and SOx emitted from fossil fuel combustion—in both wet (acid rain) and dry deposition forms—acidifies and alters soil and water bodies, degrading ecosystems in the process.

There are also important social dimensions to these impacts. For instance, air pollution was responsible for 12% of deaths among men but 14% among women in Southeast Asia in 2019 (Health Effects Institute 2020b). These effects also overlap with lifestyle patterns. In most regions, women and children tend to bear the brunt of the adverse effects of poor indoor air pollution because they spend relatively more time indoors (UNEP ROAP, UNICEF EAPRO, and AIT 2021).

3.3.5 Responses

National air quality standards have gradually strengthened in the ASEAN region, but they are often still weaker than WHO recommended guidelines (Elder 2015a). Stronger air quality standards and improved enforcement have significant socioeconomic benefits and could help to overcome export barriers in countries with higher air quality standards (Saikawa 2013). As shown in Table 3.4, there is considerable scope for strengthening and harmonization of air quality standards across ASEAN. Fortunately, some of these standards have been strengthened since 2015. For instance, Myanmar adopted 2005 WHO guideline for standards in 2020 (EANET, n.d.) as well as National Environmental Quality (Emission) Guidelines in 2015 that are now being used as a reference of standards for emissions by different sectors in monitoring and EIA processes. The extent to which these standards are attained or enforced is not clear, and more research on enforcement is needed.

At the national levels, AMS have formulated and implemented clean air measures addressing key emission sources especially focusing on transport (progressively stronger vehicle emission (Euro) standards, improvement of fuel quality and expansion of mass transit), electric power plants and industry (emission standards, and emission controls) and open burning (restrictions and alternatives to burning). There have also been several good practice examples in the region that could achieve significant reductions in air pollution if implemented at scale. For example, in the Philippines, bike lanes and electric vehicles are helping to create sustainable forms of mobility while also reducing emissions.

Table 3.5 Air quality standards in ASEAN Member States (μg/m³)

Pollutant	BRN	KHM	IDN	LAO	MYS	MMR	PHL	SGP	THA	VNM
$PM_{2.5}$ 24-hr	37.5	-	65	-	35	25	50	37.5	37.5	50
$PM_{2.5}$ Annual	-	50 (proposed)	15	-	15	10	25	12	15	25
PM_{10} 24-hr	50	-	150	120	100	50	150	50	120	100
PM_{10} annual	-	25 (proposed)	50	50	40	20	60	20	50	50
TSP 1-hr	-	-	-	-	-	-	-	-	-	300
TSP 24-hr	-	-	230 (SPM)	330	-	-	230	-	330	200
TSP Annual	-	100	90 (SPM)	100	-	-	90	-	100	140
SO_2 1-hr	-	500	900	780	250	900 (10 minutes)	-	-	780 (=0.3 ppm)	350
SO_2 24-hr	50	300	365	300	80	20	180	50	314.4 (=0.12 ppm)	125
SO_2 Annual	-	100	60	100	-	-	80	-	104.8 (-0.04 ppm)	50
NO_2 1-hr	100	300	400	320	280	200	-	200	319.6 (=0.17 ppm)	200
NO_2 24-hr	-	100	150	-	70	-	150	-	-	-
NO_2 annual	-	-	100	-	-	40	-	40	56.4 (=0.03 ppm)	40
O_3 1-hr	-	200	235	200	180	-	140	-	200	-
O_3 8-hr	100	-	-	-	100	100	60	100	140	120
O_3 annual	-	-	50							
CO 1-hr	30	20	30	-	120	-	35	30	34.2	30
CO 8-hr	10	20	-	30	35	-	10	10	10.3	10
Pb Annual	-	-	1	10.26	10	-	1	-	-	0.5

Sources: (Elder 2015a; EANET 2019; National Environment Agency Singapore 2022a). Brunei Darussalam's air quality standards were provided by the Department of Environment, Parks and Recreation, Ministry of Development (unpublished). Thailand's air quality standards for PM2.5 are available at (National News Bureau of Thailand 2022).

Notes: The table was updated as of 2021, although the enforcement dates of these standards differ. The standards in this table are not necessarily fully comparable and some are derived from unpublished sources.

The report “Air Pollution in Asia and the Pacific: Science-based Solutions” (UNEP 2019b) provides a comprehensive scientific assessment of air pollution solutions in Asia and the Pacific region. The report outlines 25 policy and technology clean air measures (Figure 3.8) that could help achieve ambient PM2.5 levels that could meet the 2015 WHO guidelines for PM2.5 for one billion people in Asia by 2030. These measures would also deliver benefits for public health, economic development, and the climate. The 25 measures are grouped into three categories:

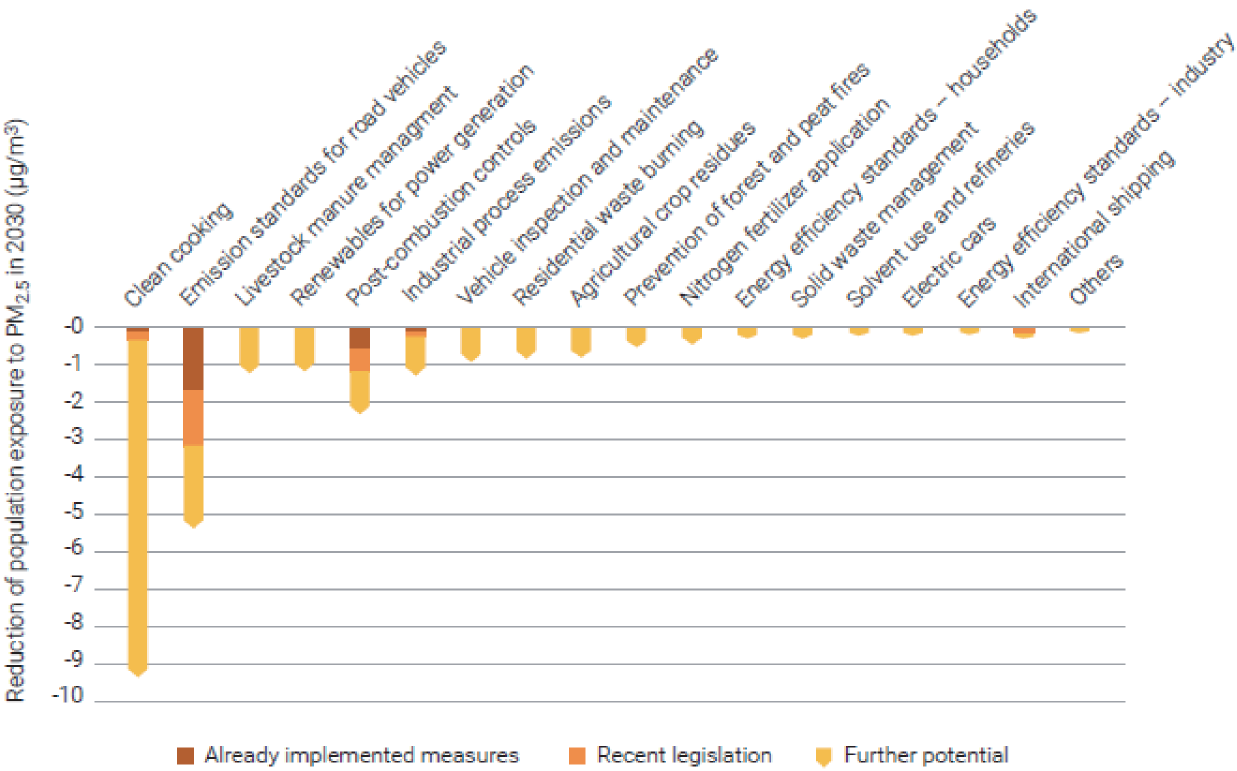
- Conventional emission control measures are those that have proved effective in the past for Asian conditions and are currently being implemented. These include, for example, end-of-pipe measures to control SO_2, NOx and PM emissions at power stations and in industry, inspection and maintenance (I&M) for vehicles, road dust and construction dust control.

- Next-stage air-quality measures are those that address the remaining priority emission sources in Asia. These are still not major components of many clean air policies in Asia, so are not yet popularly applied. Implementation of these additional measures would further improve air quality. For example, imposing a ban on open burning of crop residue and household solid waste, livestock manure management, improving energy efficiency in households, among others.

- Measures contributing to development priority goals are those addressing the economic and social development, energy or agricultural policies, or urban management, e.g., to achieve SDGs 6, 7, 11 and 13, but simultaneously provide environmental quality co-benefits. These measures often focus on clean energy and climate change mitigation (SDG 13), which can also bring in substantial co-benefits for air quality and human health. For example, promotion of electric cars, renewable energies, clean cooking, and laser levelling of rice paddies.

In the transport sector, the adoption of EURO 4 or higher vehicle standards (along with accompanying improvements in fuel quality), construction of mass transit systems, and promotion of electric vehicles will lead to cleaner air and reduced GHG emissions. In the waste sector, improved landfills and wastewater management systems can help to reduce methane emissions and black carbon particles from solid waste open burning. In the agriculture sector, sustainable rice management, including laser levelling and precision nitrogen fertilizer placement, can reduce methane and NOx emissions. For ruminant livestock, there may be opportunities to alter feed mixes (e.g., with seaweed) and improve manure management (CCAC, UNEP, and APCAP 2019).

Figure 3.8 Impacts on population-weighted exposure to $PM_{2.5}$ in 2030 from implementation of 25 clean air measures, ranked by further potential



Source: (CCAC, UNEP, and APCAP 2019)

At the regional level, there have also been efforts to curb pollution. Most notably, the ASEAN Agreement on Transboundary Haze Pollution was signed in 2002 and called for the establishment of the ASEAN Coordinating Centre for Transboundary Haze Pollution Control (ASEAN Secretariat 2016a). This agreement stemmed from the 1997 Regional Haze Action Plan and the 1995 ASEAN Cooperation Plan on Transboundary Pollution. The Agreement provides for AMS to "coordinate national action for preventing and monitoring transboundary haze pollution, through exchange of information, consultation, research, and monitoring". It also provides the legal backing for AMS to jointly combat land and/or forest fires (including coal seam, peat, and plantation fires) and the resulting haze. All 10 AMS have ratified the ASEAN Haze Agreement (see also section 12.3.4 for more details).

AMS are also members of various other regional and international cooperation frameworks related to air pollution. Eight AMS are members of the Acid Deposition Monitoring Network in East Asia (EANET) which focuses on acid deposition and strengthening air pollution and acid deposition monitoring systems. Activities also include data management, technical assistance, capacity building, and research. Five AMS are members of the Asia Pacific Clean Air Partnership (APCAP), whose secretariat is United Nations Environment Programme (UNEP), which has a broader focus, aiming to improve overall coordination in the region, knowledge sharing, and capacity building (UNEP, n.d.). The Asia Co-benefits Partnership (ACP) promotes the concept of co-benefits (Asian Co-benefits Partnership Secretariat, n.d.). The basic idea is that actions to mitigate climate change also provide other developmental benefits (i.e., co-benefits) such as clean air. Likewise, many of the actions to control air pollution emissions also reduce GHG emissions, thereby delivering climate change co-benefits. If this concept could become widely understood by AMS governments, it would encourage them to put more effort into climate mitigation measures. Five countries in ASEAN have joined the Climate and Clean Air Coalition (CCAC), which focuses on short lived climate pollutants (SCLPs), especially black carbon particles, methane, hydrofluorocarbons (HFCs), and tropospheric O_3. This framework is also based on the idea of co-benefits, since these SCLPs are both climate and air pollutants (CCAC, n.d.).

Table 3.6 ASEAN membership in international and regional air pollution cooperation frameworks and related initiatives

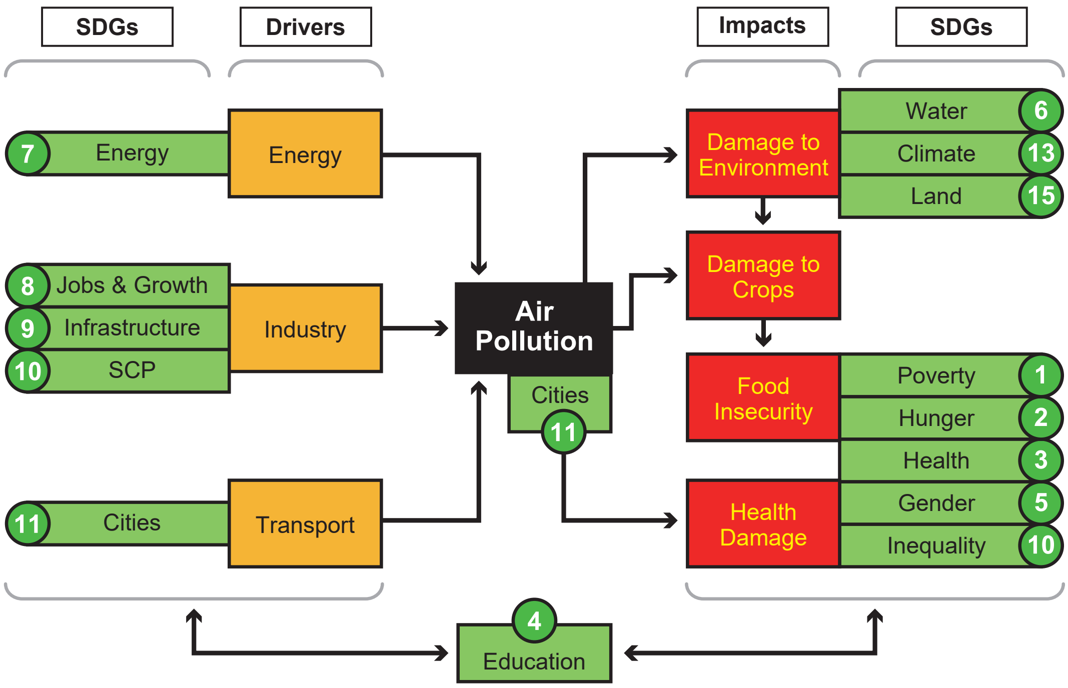
	Brunei Darussalam	Cambodia	Indonesia	Lao PDR	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam
EANET		√	√	√	√	√	√		√	√
APCAP		√			√		√	√	√	
Asian Co-benefits Partnership*			√						√	
ASEAN Haze Agreement	√	√	√	√	√	√	√	√	√	√
CCAC		√		√			√		√	√

* Note: represented in the Advisory Group

ASEAN is also engaged in several other regional initiatives that could help improve air quality. These include two reports that are financed by the Climate Change and Clean Air Coalition: Clean Air Solutions for ASEAN and Cooling and HFC Lifecycle Management Assessment in ASEAN. Additional activities include Clean Air for Sustainable ASEAN (CASA), which is supported by the Republic of Korea, and the Air Quality Improvement Program in ASEAN which is supported the French Development Agency.

SDGs can also be used to strengthen air quality management, as the SDGs provide a way to think about air pollution in an integrated manner (see Figure 3.9). Although air pollution is not a focus of any headline goals, it is included directly in three SDG targets (3.9, 11.6, 12.4) and indirectly in six others (6.3, 6.6, 9.4, 11.2, 13.2, 15.1). Figure 3.9 illustrates the SDGs which provide solutions to the drivers of air pollution and highlights the SDGs which benefit from reducing air pollution. In addition to SDG 7 on renewable energy and energy efficiency and SDG 11 on sustainable transport, also emphasized are the importance of education for sustainable development (SDG 4), sustainable (SDG 12) production and consumption, resource efficiency and sustainable upgrading of industry (SDGs 8 and 9). Target 8.4 on decoupling economic growth from environmental degradation may be the most important one. SDGs also show that human health and the health of ecosystems are not the only benefits of reduced air pollution, which include reduced crop damage and food insecurity, as well as reduced poverty and inequality. SDGs also enable us to consider measures to reduce air pollution as opportunities for industrial upgrading (SDG 9) and creating decent jobs (SDG 8).

Figure 3.9 Relation of SDGs to air pollution's drivers and impacts



Source: (Elder and Zusman 2016)

Much more needs to be done to tackle the chronic problem of air pollution in AMS. The World Bank identified priority responses for Myanmar, which also still apply to other AMS, as follows: (i) a systematic assessment of pollutant levels and sources; (ii) provision of low-cost air monitoring sensors and training in their use; (iii) an air pollution inventory for key cities; (iv) based on robust air quality modelling, cost-effective policies and investments identified; and (v) achievable air quality targets in air quality management plans at all levels (World Bank Group 2019).

3.4 Way forward

This chapter has focused on air pollution and climate change challenges in ASEAN. Moving forward AMS would be well advised to adopt integrated co-benefits solutions to these twin challenges. A growing body of research on co-benefits employs models that show, for instance, demand and supply-side reforms to the energy sector would generate health improvements that more than offset the costs of achieving 2 degrees C targets in Asia (Hanaoka and Masui 2018). It is critical that both air pollution and climate policies reflect this expanding evidence base.

In a similar way, it would be helpful if more integrated air pollution and climate policies also incorporate linkages with a broader range of development priorities. These could include synergies with food security, employment, and equity goals. There is also a growing body of evidence that renewable energy would provide significant numbers of jobs. For example, one study showed that in countries such as Viet Nam, investments in solar and wind could create 5.3 jobs per average installed megawatt (MW) capacity—a figure four times the number of jobs from coal power between 2015 and 2030 (M. A. Nguyen, Helgenberger, and Suryadi 2021).

While achieving co-benefits and synergies will be critical, relevant policies may also need to account for trade-offs, as sometimes actions aimed at achieving one objective may undermine another. For example, the promotion of biofuels to reduce transport related air pollution and to replace oil imports may inadvertently cause additional deforestation and removal of an important GHG sink. There may also be possible job losses and related social dislocation as countries shift away from fossil fuels. In the above cases, integrated packages of policies and interventions that help limit trade-offs and/or compensate losers will help make progress that is truly sustainable.

In order to effectively implement co-benefit strategies, AMS will also need to strengthen the interface between science and policy, which is highlighted as one of prioritised actions by 2030 in the ASCCR (ASEAN Secretariat 2021g). Reforms that could help in this regard include encouraging governments to use integrated planning tools such as the Long-range Energy Alternative Planning–Integrated Benefits Calculator (Leap-IBC)—a tool that has been used to develop the Clean Air Plan of Cambodia that features an integrated approach (Royal Government of Cambodia 2021). The effectiveness of these tools will be enhanced by greater investment in monitoring and evaluation to develop multi-pollutant emissions inventories and to provide essential inputs for science-based policy responses. Modelling capacity for multiple pollutants in the ASEAN region needs strengthening, along with increased research and development (CCAC, UNEP, and APCAP 2019). Strengthened monitoring and evaluation is also needed for climate adaptation, along with development of harmonized adaptation metrics.

AMS would also need to adopt or enhance governance arrangements to ensure that they are capable of translating evidence on synergies and trade-offs into policies and actions. In this context, institutional mechanisms that strengthen coordination between and within agencies responsible for air pollution, climate change, health, transport, and related sectors (Amanuma et al. 2018; Zusman et al. 2021). Similar efforts could target enhancing vertical integration or coordination between national and local levels of decision making (Amanuma et al. 2018; Zusman et al. 2021). This multi-level coordination will be particularly important for scaling up locally effective solutions to problems with implications for air quality and climate change such as open burning (Amanuma et al. 2018; Zusman et al. 2021). Yet another set of similarly motivated reforms could focus on more explicitly indicating which public budgets achieve air pollution, climate, and health targets. Importantly, these efforts would not only concentrate on climate mitigation but also adaptation.

Many of the above efforts will also pay dividends at the regional level. As indicated for the disparate air quality standards in the ASEAN region, there is a continuing need for the relevant ASOEN working groups to reach consensus on a harmonized set of air quality standards, climate change goals and targets, as well as integrated air pollution and climate change solutions, thus contributing to the ASEAN region's expected further overall integration. To this end, an urgent next action will be developing a comprehensive regional plan on climate change that integrates not only air pollution prevention but also sustainable development. The AWGCC Action Plan 2016–2025 (AAP) provides an ample basis for this kind of integrated regional plan since the AAP has broad categories of actions with a long-term policy planning perspective.

Finally, transboundary cooperation is needed for climate change (including mitigation and adaptation) and air quality, as weak, incoherent policy responses, and poor enforcement in one country can have significant impacts in other AMS. Again, the role of the ASOEN working groups in fostering transboundary cooperation is paramount. In working on this cooperation, it is essential to focus on capturing the benefits of integrated responses. This, in turn, will help build confidence for greater cooperation.

The short-term improvement in air quality during COVID-19 lockdowns was seen around the world and is also evident in AMS countries, but the air pollution returned as soon as the restrictions loosened. This improvement, however, offers a glimpse of what is possible. Development and implementation of systematic emission reduction strategies as part of the aforementioned regional plan on climate change will yield clean air and other benefits for sustainable development in the ASEAN region.

Chapter 4
Biodiversity Conservation

Main Messages

- The ASEAN region is one of the most biodiverse in the world on land, in freshwater and in the ocean.
- Drivers that underlie pressures on biodiversity in AMS include economic incentives that promote consumption and, hence, land-use change. These drivers are challenges to achieving SDGs 14 and 15 on conserving marine and terrestrial biodiversity, the proposed post-2020 global biodiversity framework, and other international and national biodiversity goals.
- As in most parts of the world, the main pressures believed to be responsible for biodiversity loss in ASEAN are habitat loss, over-exploitation, climate change, invasive alien species, and pollution.
- ASEAN has 5,776 species known to be threatened and a further 29 have already gone extinct or are extinct in the wild (IUCN 2022). Agriculture and urbanization have replaced or altered about half of the region's ecosystems.
- ASEAN has achieved some progress towards safeguarding essential ecosystems and ecosystem services but, in general, progress toward international targets to conserve biodiversity has been insufficient.
- Regional and international transboundary agreements may help to conserve ASEAN's nature but there is also a role for regulatory instruments at the national level, such as additional protected areas and other effective area-based conservation measures (OECMs). ASEAN Heritage Parks have a key role to play in this regard.
- Continued increases in resource-use efficiency will reduce pressure on ecosystems, especially from agriculture.
- Natural capital should be valued in a way similar to mineral resources or agricultural produce. Economic incentives, such as payment for ecosystem services (PES) and development of ecotourism, can help to accomplish this.
- Nature-based solutions (NbS) to developmental challenges should be encouraged, which may benefit from enhanced participation by indigenous peoples and local communities in landscape management.

4.1 Introduction

The ASEAN region is one of the most biodiverse in the world. By early 2022, the International Union for the Conservation of Nature (IUCN) had evaluated the conservation status of 26,037 species (12,801 chordates, 4,474 non-chordates 8,749 plants, and 13 fungi) (IUCN 2022). The total number of species in the region is likely to be many times greater than the number evaluated - whenever researchers go looking, they find new species. In 2017, for example, 157 new vertebrates were discovered across Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam (WWF 2021b). Three of these were mammals, including a primate.

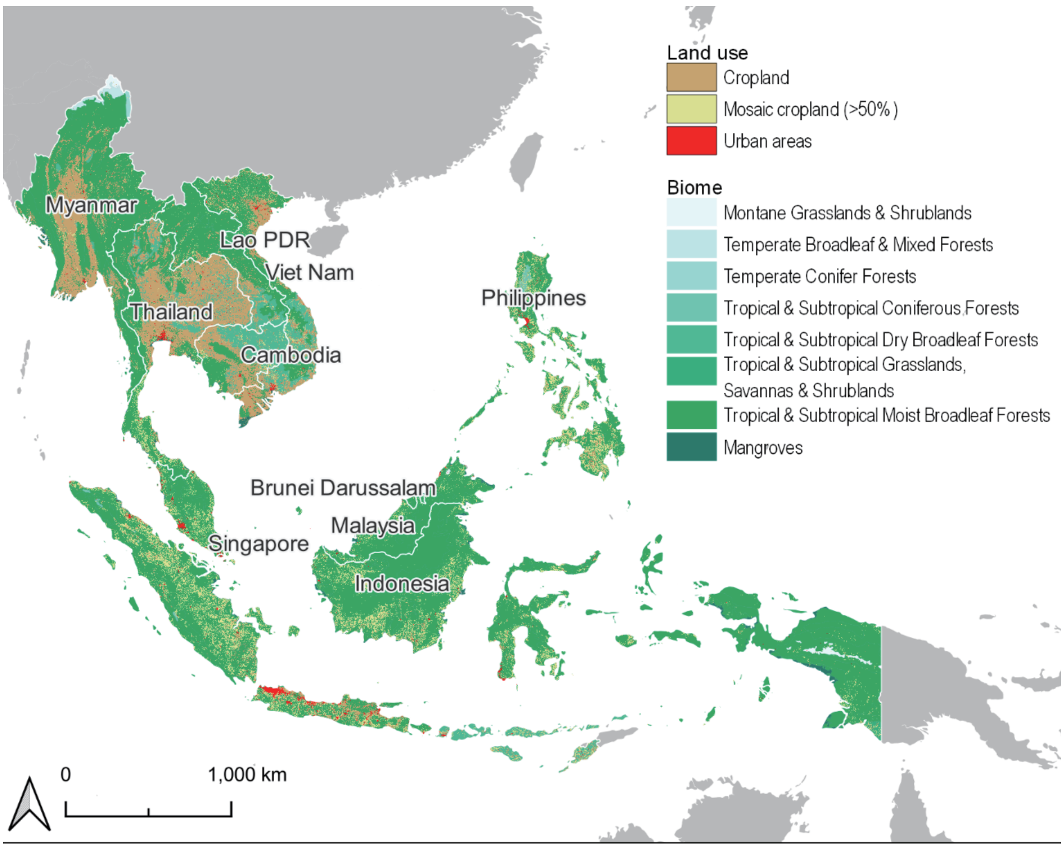
In 2020, another 69 species of vertebrates and 155 species of vascular plants were discovered across the same countries (WWF-Greater Mekong 2021). The number of invertebrates in a given area usually outnumbers vertebrates and plants by several times so, if invertebrates had been included in these surveys, the total new species would likely have been far higher. ASEAN Member States (AMS) are also home to at least 10,213 species that are endemic (IUCN 2022) – that is, they occur nowhere else in the world. It is, however, not known how much biodiversity is being lost to various pressures (see section 4.3). This chapter begins by describing the major ecosystems of which all these species form part. It then addresses the drivers and pressures affecting ASEAN's ecosystems and biodiversity, their current state and trends, the impacts of biodiversity loss on ecosystem services, and the region's conservation responses.

4.1.1 Major terrestrial ecosystems (biomes)

Prior to anthropogenic land change, almost 15% of the world's tropical forests were found in Southeast Asia (Dang et al. 2021). As discussed in section 4.3, a considerable proportion of forest and other major terrestrial ecosystems have been converted to agriculture and, to a lesser extent, urban areas. They now cover slightly under half of ASEAN's land area (FAO 2020a).

Figure 4.1 shows their current extent, and the extent to which agricultural expansion and urbanization have replaced them.

Figure 4.1 Major terrestrial biomes and anthropogenic land-use types of ASEAN



Sources: (Open Data Soft 2019; Dempsey 2021; Dinerstein et al. 2017; European Commission Copernicus Climate Change Service 2022)

As in many other tropical regions of the world, anthropogenic systems continue to displace ecosystems. The major terrestrial ecosystems in the region are described as follows:

Tropical and subtropical moist broadleaf forest is the most extensive ASEAN biome (WWF 2021a). These forests are dominated by semi-evergreen and evergreen broadleaf trees, and are characterized by high levels of biodiversity, especially in the various layers of forest canopy. The tropical and subtropical moist forests of the Indo-Malayan Archipelagos constitute the third largest area of tropical forest on Earth, after South America's Amazon Basin and Africa's Congo Basin. The climate is warm and wet year-round, and the resultant dense tree growth is punctuated by emergent trees that protrude above the canopy, while the forest floor is relatively sparse because limited light can reach it (Olson et al. 2001; WWF 2021a). Perhaps the most conspicuous species in these forests are primates, of which there are several species including the Sumatran and Bornean orangutan (Singleton et al. 2017; Ancrenaz et al. 2016). Underlying some of ASEAN's tropical and subtropical moist broadleaf forest is the world's largest concentration of tropical peat swamp, covering about 250,000 km^2, mostly in Indonesia (ASEAN Centre for Biodiversity 2017a). Peat soils are nutrient poor but have an unusually high capacity to store carbon.

Tropical and subtropical dry broadleaf forests in ASEAN are found in the Lesser Sunda islands, and parts of mainland Southeast Asia. During the long dry season, most trees lose their leaves, and the resulting sunlight enables the growth of a thick understorey. Although less biologically diverse than tropical and subtropical moist broadleaf forest, tropical and subtropical dry broadleaf forests are home to relatively high numbers of large vertebrates including the Asian elephant (C. Williams et al. 2020), various monkeys, large cats, parrots, rodents, and ground-dwelling birds (Olson et al. 2001; WWF 2021a).

Tropical and subtropical coniferous forests have relatively low rainfall and moderate variability in temperature. They are characterized by diverse conifer species, which form a thick canopy that blocks light to the forest floor. Nevertheless, shrubs and small trees that are adapted to these conditions compose a diverse understorey. In ASEAN, tropical and subtropical coniferous forests are found mostly in a small area of northern Sumatra in Indonesia, and on the island of Luzon in the Philippines (Olson et al. 2001; WWF 2021a).

Tropical and subtropical grasslands, savannas and shrublands in ASEAN are dominated by grasses, although scattered trees may be common. This biome is represented by only one ecoregion (a finer unit of measurement than biome) in ASEAN – the tropical savannas along the southern coast of New Guinea in Indonesia (Olson et al. 2001; WWF 2021a).

Temperate broadleaf and mixed forests

Temperate broadleaf and mixed forest, like temperate conifer forest, is limited in ASEAN to small pockets in the north of Myanmar, where temperatures are cooler than most of the region. They consist of deciduous trees that lose their leaves during winter, and mixed deciduous and conifer forest (Olson et al. 2001; WWF 2021a).

Temperate conifer forests

Temperate conifer forest, like temperate broadleaf and mixed forest, is limited in ASEAN to small pockets in the north of Myanmar, where temperatures are cooler than most of the region. As the name suggests they are dominated by coniferous trees, with an understory of herbaceous and shrub species (Olson et al. 2001; WWF 2021a).

Montane grasslands and shrublands in ASEAN are made up of scattered high-altitude meadow habitats in the north of Myanmar, along the Central Cordillera in Irian Jaya, Indonesia, and on Mt. Kinabalu and the Crocker Range and the surrounding upland areas in the Malaysian state of Sabah. The grassy and shrubby vegetation contrasts the forest surrounding it at lower altitudes (Olson et al. 2001; WWF 2021a).

Mangroves are ecosystems dominated by tree species that are adapted to growing in shallow seawater. Associated with these trees are various aquatic and salt-tolerant plants. Mangroves are nursery habitats for a diversity of aquatic animal species. They are found along the coastlines of most AMS (Olson et al. 2001; WWF 2021a), although much have been lost to anthropogenic activities (Friess et al. 2019).

4.1.2 Major freshwater ecosystems

The inland waters of ASEAN can be broadly divided into lentic and lotic ecosystems. The Mekong Delta, which is of central importance to mainland Southeast Asia, is an example of a network of both systems. Running through five AMS and supporting the livelihoods of about 65 million people, it is the largest inland fishery in the world (Ziv et al. 2012; IPBES 2018).

Lentic ecosystems are standing freshwater systems, such as lakes. They may also include human-made systems such as dams and water reservoirs, which tend to be less biodiverse. Tonle Sap Lake in Cambodia, which ranges in size from 2,700 km^2 to 10,360 km^2, depending on the time of year, is the largest ASEAN lake in terms of surface area (Editors of Encyclopaedia Britannica 2015). With an area of 1,103 km^2 and a maximum depth of 505 m, Lake Toba in Indonesia is the largest volcanic lake in the world (Moedjodo et al. 2006). Lake Lanao in the Philippines is one of the world's few ancient lakes[5], with resultant high levels of biodiversity and endemism (Species in Ancient Lakes 2012). Lake Matano in Indonesia is the deepest lake in ASEAN and one of the deepest in the world, at 590 m (Adhityatama et al. 2017; LakePedia 2021). Being geographically isolated, it is home to numerous endemic animal species (Sulastri et al. 2020).

Lotic ecosystems are flowing freshwater systems, such as streams and rivers. Larger ASEAN countries are crisscrossed with streams and rivers, fed by catchment areas. Mainland Southeast Asia is drained by five major river systems: the Irrawaddy, Salween, Chao Phraya, Mekong, and Red Rivers. The Mekong is the longest river of mainland Southeast Asia, flowing for about 2,400 km (Frederick et al. 2020). Riparian (riverbank) ecosystems, which typically flank lotic ecosystems, may be considered part of a lotic ecosystem, or part of the surrounding terrestrial ecosystem, or small-scale ecosystems in their own right.

[5] Ancient lakes: lakes that have consistently carried water for more than one million years.

4.1.3 Major marine ecosystems

The marine waters of the ASEAN region are warm and tropical, and dotted with thousands of islands. They are also among the most biodiverse in the world. All marine ecosystems can be divided into pelagic and benthic but, for ASEAN, seagrass beds and coral reefs are further distinguished here, due to their extent, ecological importance, and the unique threats that they face. Southeast Asia has disproportionate numbers of undescribed new marine species, although molecular genetic analysis could help to fill these knowledge gaps (United Nations 2021a).

Pelagic ecosystems describe everything in the open-ocean water column, as distinct from the substrate that underlies it. They account for a vast volume of habitat, although biodiversity is highest in near-surface layers. Within AMS' exclusive economic zones (EEZs), which include marginal basins such as the Sulu and Celebes Seas, the depth of these systems extends to over 5,000 m in places (Nishida and Nishikawa 2011). Light penetration decreases with depth and primary production, which is limited to the uppermost layers, feeds deeper layers (IUCN 2020). ASEAN's pelagic ecosystems are the source of most of its fishing harvest. The most commercially important pelagic species in Southeast Asia are tuna of various kinds, although the total quantity of unidentified fish (species data not available) exceeds the quantity of tuna (SEAFDEC 2018).

Benthic ecosystems in the marine context describe the sea bottom except, in the case of this report, where coral reefs and seagrass beds are specified. Benthic ecosystems underlie pelagic systems. Benthic organisms are attached to the sea bottom in some sense – either literally in the case of sessile organisms like anemones, corals, and sponges – or due to their dependence on the benthic habitat, like many bottom-dwelling fish species. The ecology of benthic systems, as with pelagic systems, is strongly affected by light, which in turn is dependent on depth. While less productive than the vast volume of pelagic systems, benthic systems are home to several commercially important species. In Southeast Asia, these include most molluscs, which accounted for 564,974 metric tonnes – just over 3% – of capture fisheries in 2018 (SEAFDEC 2018).

Seagrass beds are named after the world's only subtidal marine flowering plants (IUCN 2020). They have an underwater pollination system and rooting structures, which allow them to withstand the movement of water (UNEP-WCMC 2014). Forming so-called meadows, they affect the flow of water and ecological functions of the areas they dominate. Seagrasses provide habitat for small marine fauna such as juvenile fish and invertebrates, and the habitats they create typically have higher biodiversity than surrounding unvegetated soft sediments (IUCN 2020). They are found in all coastal AMS. Many areas described as being devoid of seagrass may simply not yet have been sufficiently mapped to detect them (McKenzie et al. 2020; Sudo and Nakaoka 2020). However, it is believed that seagrass meadows are continuing to decline in the region (United Nations 2021a).

Coral reefs are built over decades through the accumulation of calcium carbonate laid down by corals and other organisms. Other sessile organisms, including sponges, gorgonians and algae, add to the coral reefs' diversity and structural complexity (IUCN 2020). The three-dimensional structure of reefs provides a diversity of habitats and resources that support a variety of marine biota, many of them locally endemic. One-quarter of marine life is estimated to depend on reefs for food and/or shelter (IUCN 2020). The ASEAN region is one of the most important regions of the world for coral and the biodiversity it supports (IPBES 2018). The Coral Triangle area, stretching across six countries and located mostly in ASEAN (Indonesia, Philippines and Malaysia), is home to 76% of the world's known coral species and 37% of the world's total coral reef fish (ADB 2016) (see section 6.4.2 for more details on the Coral Triangle).

4.1.4 Anthropogenic systems

Agriculture and forestry are replacing an increasing proportion of ASEAN's original ecosystems. Rice constitutes the largest proportion of agricultural land in the region, at over 440,000 km^2 as of 2020 (FAO 2022). Other major crops include oil palm fruit (roughly 213,000 km^2), natural rubber (roughly 96,700 km^2), maize (roughly 94,600 km^2), fresh fruit and vegetables (primary production on over 86,700 km^2), and sugar crops (around 32,400 km^2) (FAO 2022). Notwithstanding the impacts of agriculture on the ecosystems it has replaced, the diversity of crop and livestock varieties is also an aspect of biodiversity, which is important for food security. Furthermore, agricultural areas may provide habitat for certain wild species, although generally to a lesser extent than original ecosystems.

Urban areas account for much less area than agriculture, at a total of about 123,000 km^2 as of 2010 (Center for International Earth Science Information Network (CIESIN) / Columbia University 2013) in ASEAN, although this proportion is growing. Urban areas are typically less habitable for wild species although some have adapted to these environments. A key feature of cities is the replacement of permeable with impermeable surfaces (e.g., asphalt, concrete), with consequent increases in water runoff and reflectance of radiation. These impermeable surfaces also prevent all but the most adaptable of plants from taking hold. Several ASEAN cities have made efforts to "bring nature back", for the sake of conservation and to enhance the quality of life for urban residents (ASEAN Centre for Biodiversity 2017a). For more information on the sustainability of ASEAN cities, see chapter 8.

Aquaculture is "the farming of aquatic organisms, including fish, molluscs, crustaceans, and aquatic plants" (Barg 1992). Global aquaculture production over the past 50 years has increased more than 50-fold, so that now more seafood is produced through aquaculture than is caught from the wild. Although aquaculture still requires inputs from wild-caught species for food, technological advances in aquaculture feeds, including plant-based feeds, mean that these inputs have become lower than their outputs for many farmed species (World Bank 2018; Naylor et al. 2021). In 2018, Southeast Asia's aquaculture production accounted for about 54% of the region's total fishery production in terms of volume, and 38% in terms of value. Production increased at about 2.6% per year from 2014 to 2018, partly due to a sudden rise in production in Myanmar and Viet Nam. Marine aquaculture, or mariculture, provided 47% of the region's total aquaculture production in 2018 in terms of weight, while brackish water aquaculture contributed 16%, and freshwater 37%. In terms of economic value, brackish water aquaculture contributed most at 44%, with freshwater contributing 41%, and marine 15% (SEAFDEC 2018). (See section 6.2.1 for more details on mariculture.)

4.2 Drivers

4.2.1 Demographic drivers

Populations in ASEAN are both growing and rapidly urbanizing. Urbanization is associated with a reduction in family size and increased resource use efficiency (Sanderson, Walston, and Robinson 2018). It is, however, also associated with wealth and an increased capacity for resource consumption. As major sinks for natural resources, cities can be practical points of entry for addressing the use of these resources including the goods and services provided by biodiversity and ecosystems. Apart from Singapore, which has consistently had an almost entirely urban population, the urban proportion of populations in ASEAN has been increasing since 1960 (World Bank 2021i). As urban populations increase and urban areas expand, natural areas and agricultural land are converted to environments that are less hospitable for most wild species. Over half of the urban expansion in Southeast Asia has been due to large-scale conversion of agricultural land (Güneralp et al. 2020).

As rural people move to cities, there may be reduced, or even, reversed land conversion around depopulating rural settlements. At the same time, however, urbanization increases the need for land in other areas that provide for those cities. For example, while rural communities may rely heavily on local wood for fuel, city dwellers may depend on electricity generated through large-scale energy generation by fossil fuels. In some AMS, urban population growth has outpaced land conversion, putting proportionally less pressure on surrounding ecosystems (Schneider et al. 2015). Urban density in large cities in Southeast Asia has remained more or less the same and land-use efficiency is high compared to small and medium cities in the region (Güneralp et al. 2020). Densely populated cities may therefore have proportionally less impact on nature.

4.2.2 Economic drivers

AMS collectively constitute the world's fifth largest economy, and have been experiencing rapid economic growth in the past few decades, despite a temporary decline in 2020 due to the onset of the COVID-19 pandemic (J. Williams and Voas 2021). While this growth has had some positive effects on biodiversity to the extent that it is tied to urbanization, as described earlier, it has also had significant adverse impacts, both directly and indirectly.

Incentives have increased to intensify economic activities such as the extraction of minerals for industrial purposes and agricultural intensification and/or expansion (ASEAN Centre for Biodiversity 2017a; IPBES 2018). ASEAN is a major source of minerals (Mélanie et al. 2005), and extractive activities for resources such as limestone and gravel have contributed to the direct loss of habitat (Hughes 2017). Extractive industries have also incentivized the fragmentation of habitat through the building of roads and other infrastructure necessary for supply chains (Hughes 2017). Besides the intensification of industry, global trade has also increased opportunities for the introduction of invasive species that may threaten indigenous species (IPBES 2018; ASEAN Centre for Biodiversity 2017a) (see section 4.3.4 for more details on invasive species).

Before the COVID-19 pandemic, tourism had been a major source of revenue for many AMS (ASEAN Secretariat 2015d; Greenview 2021). In alignment with ASEAN's goal of achieving more "inclusive", "green" and "knowledge-based" economic growth, the region's strategic tourism plan has begun emphasizing the need to promote sustainable tourism, recognizing that mismanaged tourism has led to negative environmental consequences (ASEAN Secretariat 2015d; ADB 2022b). Thus, it has been proposed to "ensure that recovery [of the tourism sector] is underpinned by principles of sustainability and inclusivity", for which the region is to create key performance indicators, such as "physical status of visited natural and cultural heritage sites", that account for the social and environmental impacts of tourism (ASEAN Secretariat 2020a; Greenview 2021). The degree to which this plan is implemented with the principles of sustainability in mind will likely influence the trends in pressures on biodiversity, including habitat loss and pollution (described in sections 4.3.1 and 4.3.3, respectively).

4.2.3 Sociocultural and technological drivers

Rising incomes have facilitated changes in consumption patterns in AMS (ASEAN Secretariat 2021d), which has increased demand for meat, including fish (FAO 2020b). This shift has created additional pressure on both land and marine resources (see section 4.3.2 for more details).

Technological innovation continues to improve agricultural productivity, but its misuse may contribute to the degradation of surrounding ecosystems, for example through the excessive use of nitrogenous fertilizer (United Nations 2021b) (see section 4.3.3 for more details). Such impacts are externalized when agriculture is subsidized. Similarly, technological advances facilitate the harvesting of resources like fish stocks. Aquaculture added to these challenges in the past through its reliance on capture fisheries for feed, but recent advances have increased efficiency to the point where aquaculture has potential to alleviate some of the pressure on capture fisheries (World Bank 2018; Naylor et al. 2021).

According to the *Regional Assessment Report on Biodiversity and Ecosystem Services for Asia and the Pacific*, the global UN biodiversity target of respecting and integrating traditional knowledge has seen progress in Southeast Asia, but with room for improvement (IPBES 2018). There has been increasing recognition in recent years that indigenous peoples and local communities, living close to nature, have amassed generational knowledge on sustainable management. For example, in Thailand, the Huay Hin Lad Nai community manages its local forest ecosystems and resources by shifting cultivation to enable the regeneration of wildlife and taking part in 'mix farming' or natural farming to avoid deforestation (Karki et al. 2017). Similarly, the Bajau people – a nomadic community living in the Philippines, Indonesia, and Malaysia – determine their daily consumption of giant clams based on their observations of population trends, opting for other marine species and avoiding eating juvenile clams in an effort to replenish depleting populations (Abd-Ebrah and Peters 2021).

However, such practices are being threatened by economic and political drivers (see section 4.2.4), which may exacerbate pressures such as habitat loss, over-exploitation, and pollution. Tourism and other economic incentives, for example, threaten begnas, a ritual for sustainable rice cultivation in which sacred landscapes are used for spiritual cleansing and observation of local fauna (Karki et al. 2017) in the northern Philippines.

4.2.4 Policies, governance systems, and institutions

Implementation of policies to conserve ecosystems and biodiversity remains a challenge in the ASEAN region. For example, in some parts of ASEAN, acquisition of land by corporations from local communities for industrial-scale agriculture is a source of local conflict and a challenge for ecosystem conservation (Sao 2021). This tension exists partially due to insufficient recognition of land rights for local communities which may be occupying and using the land without formal ownership titles, or clear documentation of their land ownership (Sao 2021). Moreover, transboundary environmental issues such as haze pollution and conservation of ecosystems, which transcend national borders, require strong concerted action among AMS. The impact of national level policies and governance, especially in ‘downstream’ countries, which are affected by activities outside of their jurisdiction, may be limited (IPBES 2018).

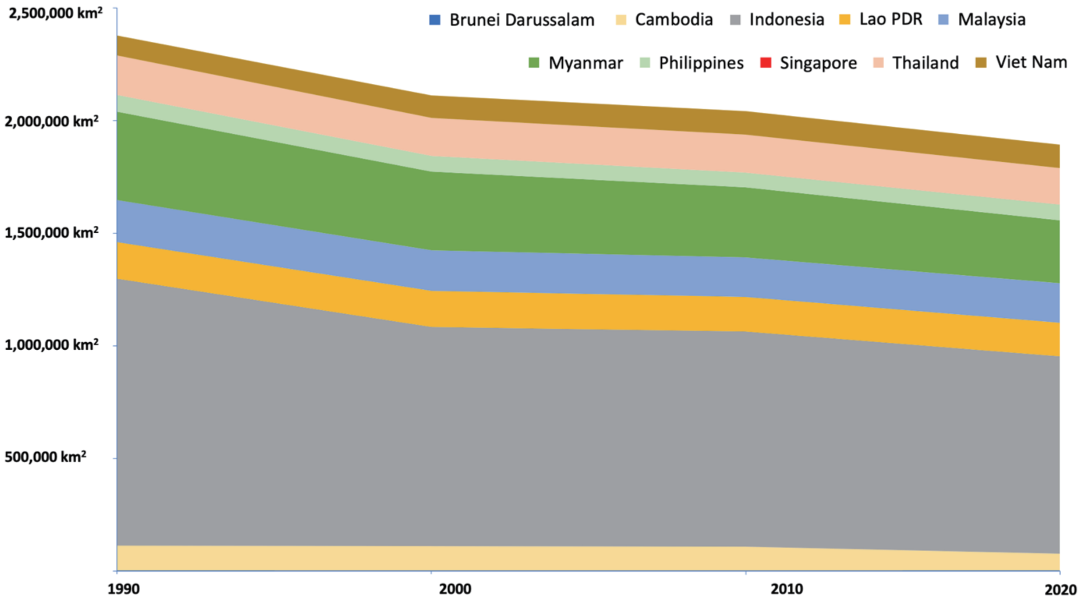
4.3 Pressures

According to the Regional Assessment Report on Biodiversity and Ecosystem Services for Asia and the Pacific, the global UN biodiversity target of reducing pressures on vulnerable ecosystems has seen an overall lack of significant progress in Southeast Asia during the second decade of the current millennium. Progress, albeit at an insufficient rate, was made towards sustainable management of marine living resources, agriculture, aquaculture, and forestry, and reducing pollution. No significant progress was made toward preventing and controlling invasive alien species or reducing pressure on vulnerable ecosystems; and habitat loss is worsening (IPBES 2018).

4.3.1 Habitat loss

As mentioned in sections 4.2.1 and 4.2.2, land-use change driven by economic and demographic factors is contributing to ecosystem loss in ASEAN. Naturally regenerating (i.e., not planted) tropical forests are being lost at a rate higher than in any other region of the world – more than 7.2% (about 148,000 km^2) from 2010 to 2020 and up from about 3.4% in the previous decade (FAO 2020a). This trend is illustrated for each AMS in Figure 4.2. Much of the loss has been peatland forest cover, mostly in Indonesia, which declined from 119,000 km^2 to 46,000 km^2 between 1990 and 2015 (Miettinen, Shi, and Liew 2016).

Figure 4.2 Change in area of naturally regenerating forest in ASEAN from 1990 to 2020



Source: (FAO 2020a). Note that Brunei Darussalam (directly below Cambodia) and Singapore (directly below Viet Nam) are not visible due to their much smaller values.

Mangroves, an important component of coastal ecosystems, are also under threat because of economic incentives for land conversion and land-use change driven by the expansion of activities such as aquaculture, rice cultivation, and palm oil production (IPBES 2018). In Southeast Asia including Timor Leste, more than 100,000 hectares of mangroves were lost between 2000 and 2012 (Richards and Friess 2016). In some AMS, such as the Philippines and Viet Nam, over 50% of mangrove ecosystems have already been lost and the rate of loss in some countries has been between 0.70% and 0.41% per year (Friess et al. 2019).

The impacts of land-use change are not limited to the ecosystems that are directly transformed. Evidence in the Cameron Highlands of Malaysia, for example, suggests that land clearing for agriculture and other purposes can also lead to runoff that worsens the quality of nearby rivers (Razali et al. 2018), thereby posing a threat to local aquatic biodiversity (see section 4.3.3 for more on pollution).

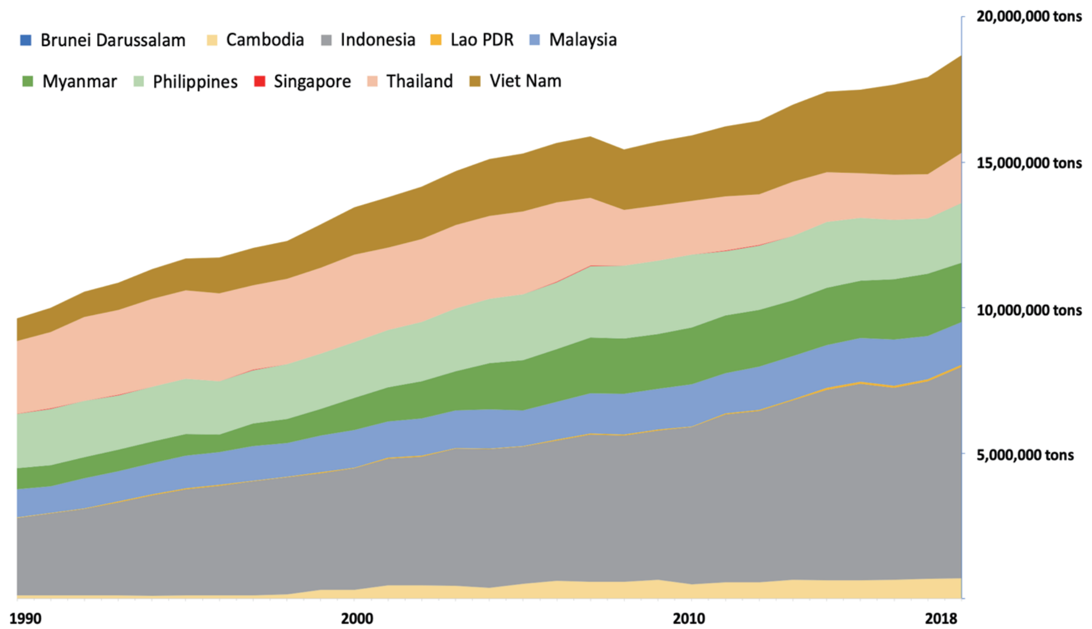
With respect to aquatic biodiversity, the rise in demand for water and other basic resources to sustain growing populations in the region has prompted the construction of more dams, which have led to significant changes in freshwater fish communities in some AMS (ASEAN Centre for Biodiversity 2017a). Seagrass meadows are also threatened by coastal development and sedimentation (Unsworth et al. 2018).

4.3.2 Overexploitation

Although an increasing number of governments and businesses are developing plans for more sustainable production and consumption, these are not being implemented on a scale that eliminates the negative impact of unsustainable human activities on biodiversity. While natural resources are generally being used more efficiently, the aggregate demand for resources continues to increase, and therefore the impacts of their use remain well above safe ecological limits (CBD Secretariat 2020).

The harvesting of wildlife to the point where stocks are diminished puts pressure on especially marine ecosystems in AMS. The proportion of wild fish (capture fisheries) stocks that are sustainably harvested has been in decline for decades (see Figure 4.3).

Figure 4.3 Marine capture fisheries production in ASEAN (in metric tonnnes), from 1990 to 2018



Source: (World Bank 2022b).

Note: capture fisheries excludes aquaculture. Brunei Darussalam (directly below Cambodia) and Singapore (directly below Viet Nam) are not visible or almost not visible due to their much smaller values.

In most AMS, over 20% of animal protein intake is fish (FAO 2020b), making it an important source of nutrition for the region. In recent years, there has been an increase in the number of coastal species being caught and eaten, especially in the Southeast Asian region (United Nations 2021a), despite an accompanying and dramatic increase in the volume of fish from aquaculture (FAO 2020b). Several AMS, including Viet Nam, Thailand, and Malaysia, have highlighted this issue in their recent national reports to the Convention on Biological Diversity, and have implemented policies targeting illegal, unreported, and unregulated (IUU) fishing, as well as overfishing (Ministry of Natural Resources and Environment of Viet Nam 2019; Government of Thailand 2019; Ministry of Natural Resources and Environment of Malaysia 2019) (see also section 4.6).

On land, more than 1,200 animal species in AMS are known to have been subject to hunting and trapping, almost half of which are classified as threatened (IUCN 2022). Some parts of ASEAN have among the world's highest rates of endemic terrestrial mammal species under threat from over-exploitation (Ripple et al. 2016). More than 570 plant species are also known to have been targeted for gathering, more than half of which are classified as threatened (IUCN 2022).

4.3.3 Pollution

The overuse of agricultural fertilizers has led to excess nitrogen and phosphorus leaching into lakes and other bodies of water, causing eutrophication (United Nations 2021b; IPBES 2018). Eutrophication threatens inland and coastal ecosystems, by stimulating the overgrowth of algae, and creating low-oxygen ‘dead zones’ where few species can survive (United Nations 2021b).

Although its impacts on biodiversity are less apparent than eutrophication, the potential of marine plastic pollution to negatively impact marine biodiversity has been recognized (IPBES 2018; ASEAN Secretariat 2019a) (see section 7.5.2). Another class of emerging pollutants of concern consists of antibiotics and other veterinary pharmaceuticals used in livestock production. While evidence in ASEAN is limited, research elsewhere has shown that some antibiotics alter microbial biodiversity (Johansson, Janmar, and Backhaus 2014), and the mixture of pharmaceuticals may have synergistic toxicological impacts on marine bacteria, crustaceans, and plant species (Drzymała and Kalka 2020) (see section 5.4.6 for related information).

Soil pollution impacts wildlife by exposing animals and plants to chemicals that are potentially harmful, including metals and polycyclic aromatic hydrocarbons (IPBES 2018). While primary literature in ASEAN is limited, heavy metals in soil have been associated with lower plant biodiversity in terrestrial ecosystems elsewhere (Hernández and Pastor 2008). Soil acidification, caused by the use of nitrogen fertilizers on soil and deposits from acid rain, can damage plant species and other organisms living in soil by creating unfavourable conditions for growth (Yadav et al. 2020). While further research in ASEAN is required, early evidence from the Philippines suggests that the contamination of soil with heavy metals leaching from electronic waste (e-waste) inhibits root growth of Allium cepa (Alam et al. 2019) (see sections 7.4.5 and 7.5.2 for more details regarding e-waste in ASEAN). By creating unfavourable conditions for some organisms, such soil pollution could cause structural changes to the ecosystem, ultimately lowering biodiversity (Yadav et al. 2020).

Though often overlooked, air pollution may also adversely affect biodiversity and ecosystems. While evidence in ASEAN remains limited, the air pollution caused by El Niño-associated wildfires in 2015 has been linked to lower acoustic diversity of birds (a proxy measure for biodiversity) in Singapore for 16 weeks post-event (B. P. Y. H. Lee, Davies, and Struebig 2017)

4.3.4 Invasive species

Invasive species are species that outcompete others to dominate an ecosystem. Most known invasive species are also alien species; that is, they are new to the ecosystem in question. The number of new invasive alien species has been increasing globally for most taxonomic groups (Seebens et al. 2017). Alien species may appear via a number of pathways, from deliberate introduction for an economic purpose, to unintentional transfer via cargo or ballast, or as contaminants of goods in transit (Seebens et al. 2017). As of 2018, Southeast Asia has not seen any significant progress on the prevention and control of invasive alien species (IPBES 2018).

Over 200 species introduced to the ASEAN region have become invasive, some resulting in significant ecological damage (ASEAN Centre for Biodiversity 2017a). Invasive species threaten especially indigenous species in freshwater ecosystems. For example, tilapia (Oreochromis mossambicus) from southern Africa, introduced into Lake Poso in Indonesia, has resulted in the loss of the duck-beak fish (Adrianichthys kruyti) and the sarasins minnow (Xenopoecilus sarasinorum) (ASEAN Centre for Biodiversity 2017a).

Other pressures may exacerbate the impacts of invasive species. Land-use change can create conditions for invasive species to thrive (ASEAN Centre for Biodiversity 2017a). For instance, the catclaw mimosa (Mimosa pigra), found in the Lower Mekong region, is capable of invading not only a range of natural ecosystems, but also modified habitats such as cleared and burned swamp forests and pastures (ASEAN Centre for Biodiversity 2017a). This species, highly adaptable and capable of spreading over long distances, has had significant ecological and economic impacts, damaging fields, hindering agricultural productivity and lowering biodiversity, even in protected areas (Global Invasive Species Database 2022).

Changes in climate may also affect the impact of invasive species or increase the likelihood that they will become invasive, as changes in temperature, humidity, precipitation and other environmental factors may favour these species (Seebens et al. 2017; IPBES 2018). Extreme weather events such as storms can also facilitate their spread (ASEAN Centre for Biodiversity 2017a).

4.3.5 Climate change

Climate change may directly and indirectly influence biodiversity through changes in temperature and other meteorological phenomena (Bellard et al. 2012). Changes in precipitation patterns and seasonality may impact water availability and, hence, biodiversity. For example, prolonged droughts that affect the connectivity of rivers could threaten the survival of some freshwater and terrestrial species (Parmesan et al. 2022).

The IPCC assesses with high confidence that global warming of 1.5ºC from pre-industrial levels could elicit up to a 90% decline in coral reefs around the world (IPCC 2018). This is particularly concerning for the region’s nearly 600 documented species of reef-building coral, home to over 2,000 fish species (Souter et al. 2020). In one case study in Indonesia, coral bleaching events have been linked to declines in income among fishing households, as well as decreased consumption of their own catch, suggesting how coral bleaching, often associated with El Niño events, impacts fish stocks (Chaijaroen 2019; World Bank Group and ADB 2021).

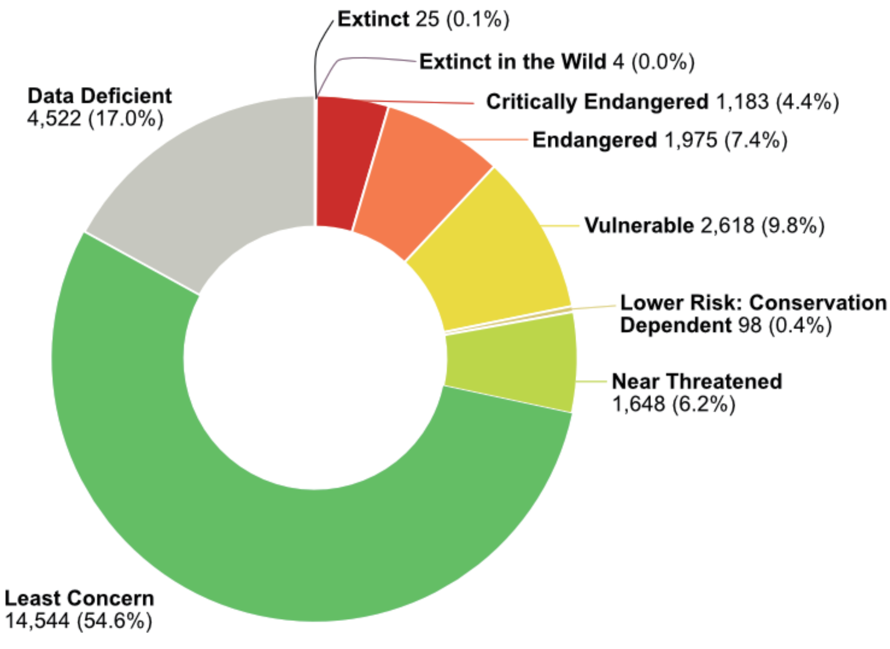
Extreme events, which may be exacerbated by climate change can also rapidly reshape ecosystems. Wildfires, for example, may cause significant habitat loss or change. Wildfires also impact biodiversity by threatening the survival of vegetation, degrading water supplies, and contributing to geographical shifts in biomes (Parmesan et al. 2022). The release of GHGs when forests burn may, furthermore, form a feedback loop by elevating the risk of future wildfires.

In some AMS, the sea-level rise expected to result from warmer oceans is expected to reduce the value of coastal ecosystems and ecosystem services (ASEAN Secretariat 2021g). These and other impacts could have disproportionate effects on indigenous peoples and local communities that depend directly on these ecosystem services for their livelihoods.

4.4 State and trends

Species richness in ASEAN is declining at a rate consistent with other tropical regions of the world due to pressures described in section 4.3. This has led to 5,805 (22%) of the 26,617 ASEAN species evaluated by IUCN being classified as extinct or threatened (see Figure 4.4). Of the threatened species, 1,183 are regarded as critically endangered, 1,975 endangered, and 2,618 vulnerable (IUCN 2022). A further 4,522 species were classified as data deficient. The actual status of data deficient species can be expected to roughly reflect the proportions of species with known status in each category. The 26,617 species surveyed by 2022 is considerably higher than the 11,377 in 2016, when the fifth ASEAN State of the Environment Report (SOER5) was published. The percentage of species found to be in each category, however, remains similar. According to a regional assessment, some progress has been achieved towards preventing species extinction, but at a rate insufficient to reach international targets (IPBES 2018). There are insufficient data to determine the degree to which genetic diversity is being maintained in ASEAN (IPBES 2018).

Figure 4.4 Extinction risk of species in ASEAN according to the International Union for Conservation of Nature (IUCN) Red List of Threatened Species in 2022



Source: (IUCN 2022)

According to an international assessment, at the level of ecosystems there were insufficient data to assess progress towards UN targets to restore ecosystems and enhance their resilience. Some progress, but at an insufficient rate, has been achieved towards global targets to make agriculture, aquaculture, and forestry sustainable (IPBES 2018).

4.4.1 Terrestrial biodiversity

As of 2021, Southeast Asia has made some progress toward SDG 15 (Life on Land) but insufficient to achieve the goal, based on the limited available data (UNESCAP 2021b). There has been slow progress on the conservation of terrestrial and freshwater ecosystems (SDG Target 15.1), sustainable forest management (Target 15.2), and conservation of mountain ecosystems (Target 15.4), and regression on addressing biodiversity loss (Target 15.5) in general (UNESCAP 2021b).

Among currently threatened terrestrial species in the ASEAN region is the yellow meranti (Shorea faguetiana) of Sabah, Malaysia, the tallest tropical tree in the world, which was recently discovered to reach 100 m in height (Shenkin et al. 2019). ASEAN trees under threat due to demand for timber include teak, trees from the dipterocarp family, and evergreen montane forests (ASEAN Centre for Biodiversity 2017a). Bruguiera hainesii is a species of mangrove with a total known population of only about 200 trees (Duke et al. 2010). Among the most threatened mammals are the Javan rhinoceros (Rhinoceros sondaicus), whose population was estimated at only 18 mature individuals in 2019, down from 46-66 in 2008 (Ellis and Talukdar 2020a). The Sumatran rhinoceros (Dicerorhinus sumatrensis) has an estimated population of 30 mature individuals, down from 220-275 in 2008 (Ellis and Talukdar 2020b).

Much of Southeast Asia's ecosystems have been transformed by agriculture. Although different forms of land transformation have different impacts on ecosystems and their biodiversity, the general trend is decreasing naturalness, as in other tropical regions of the world.

4.4.2 Freshwater biodiversity

Freshwater ecosystems are most impacted by habitat heterogeneity and fragmentation, land use change, climate change, eutrophication and invasive species (Faghihinia et al. 2021).

Among currently threatened freshwater species in the ASEAN region is the critically endangered giant carp (Catlocarpio siamensis), the largest member of the family Cyprinidae at up to 3 m and 300 kg (Binohlan and Torres, n.d.; Hogan 2011a); and the Mekong giant catfish (Pangasianodon gigas) – one of the largest freshwater fishes in the world, at up to 3 m and 350 kg (Cruz and Torres, n.d.; Hogan 2011b). Terniopsis ubonensis, known from a single population in Thailand, is the only freshwater plant classified as critically endangered in the region, but dozens more are data-deficient or not yet evaluated (Bignoli 2011). Endemic only to Taal Lake in the Philippines, the Bombon sardine (Sardinella tawilis) – the world's only freshwater sardine – was also classified as endangered in 2018 due to overfishing, habitat degradation, and the introduction of invasive species, and pollution (Santos et al. 2018).

The geographically isolated Lake Matano in South Sulawesi is the deepest lake In ASEAN, as well as being home to at least 60 endemic molluscs, 25 endemic fish, 10 endemic shrimps and three endemic crabs (Sulastri et al. 2020). However, endemic species in the lake are threatened by the hybrid flowerhorn, an invasive fish species documented to have proliferated since around 2010 (Sulastri et al. 2020).

4.4.3 Marine biodiversity

While there are significant data gaps, as of 2021 the Southeast Asian region has been regressing on SDG 14 (Life Below Water), driven mostly by worsening marine pollution (Target 14.1) and insufficient progress on conservation of coastal areas (Target 14.5) (UNESCAP 2021b). Data on other biodiversity-related targets, including marine and coastal ecosystems (Target 14.2), sustainable fishing (Target 14.4), and fisheries subsidies (Target 14.6), are unavailable (UNESCAP 2021b).

Among currently threatened marine species in the ASEAN region are ocean turf grass (Halophila beccarii), one of the oldest lineages of seagrasses, with high evolutionary value. As recently as 1997 one of only two known coelacanth species, the Indonesian coelacanth (Latimeria menadoensis), was discovered off the coast of Sulawesi (Iwata et al. 2019). It appears to be endemic to that area and has been classified as vulnerable.

Six of the world's seven marine turtle species are found in the Coral Triangle, which includes three AMS (WWF 2022). With the exception of one data-deficient species, all of these are categorized as threatened (SWOT n.d., n. accessed on 4 August 2022; Red List Standards and Petitions Subcommittee 1996; Mortimer and Donnelly 2008; Breu-Grobois and Plotkin 2008; Seminoff 2004; Casale and Tucker 2017; Wallace, Tiwari, and Girondot 2013).

4.5 Impacts

Impacts, in the context of this chapter, describe how the current state and trends of the region's biodiversity affect human wellbeing. Nature's capacity to benefit humankind has been described through the concept of ecosystem services – a framework that has been reworked and renamed over the past few decades (Daily 1997; TEEB 2010; Biodiversity.fi 2015; Pascual et al. 2017). The concept illustrates our reliance on nature, albeit in the broader context of increasing dependence on abiotic resources such as fossil fuel and renewable sources of energy (Lele 2020). Southeast Asia has been making progress towards Aichi Biodiversity Target 14, the UN target of safeguarding essential ecosystems and ecosystem services, but at an insufficient rate (IPBES 2018). It is thought that a Southeast Asian regional strategy could promote greater policy uptake of future ecosystem services assessments (Dang et al. 2021).

4.5.1 Provisioning services

Agricultural production is central to the economy of most AMS, and some agriculturally important species originate from the region. It is also possible that wild species could be domesticated in future if they are conserved. The largest agricultural output in ASEAN in 2020 was oil palm fruit, 369,421,481 tonnes of which was produced by the biggest AMS producers. This quantity was up considerably from 291,033,692 in 2016 (FAO 2022). Oil palm was followed by rice (189,005,463 tonnes, similar to the 189,142,072 tonnes produced in 2016); sugar cane (155,275,090 tonnes, down from 175,298,714 tonnes in 2016); rice milled equivalent (126,066,644 tonnes, down slightly from 126,156,709 tonnes);

and cassava (71,178,926 tonnes, down slightly from 74,999,706 tonnes in 2016) (FAO 2022). Fish catch was 18,694,200 tonnes in 2020, up from 17,661,881 tonnes in 2016, and eight times the figure for 1960 (World Bank 2022b).

Forestry also remains important but is threatened by the unsustainable clear-cutting of old-growth forest. Forests provide raw materials and energy resources in the form of wood and biomass. However, the majority of forest loss between 2002 and 2020 in ASEAN was to make way for agriculture.

At the same time, the harvesting of bushmeat is relied upon by millions of ASEAN people. Overall, ASEAN's provisioning services are being stretched to unsustainable levels. Other uses of biodiversity are less damaging, and nature's value as a source of medicine and other forms of technological innovation is increasingly being acknowledged. In 2021, Singapore launched an institute of biodiversity medicine (Singapore National Eye Centre 2021) to "leverage biodiversity such as natural ecosystems and flora to advance biological, health and pharmacological sciences".

4.5.2 Regulating services

Regulating services can include supporting services like habitat creation and maintenance, as well as the regulation of pollination and dispersal of seeds and other propagules; regulation of air quality, climate and ocean acidification; freshwater quantity, flow and timing; freshwater and coastal water quality; formation, protection and decontamination of soils and sediments; regulation of hazards and extreme events; and regulation of organisms detrimental to humans (IPBES 2018).

In some cases, available information indicates the need for ecosystem services, or their potential benefits. For example, in AMS, landslide risk may be an indication of the need for ecosystem restoration to stabilize slopes, possibly in combination with engineered solutions. Much sewage in AMS is not treated, so water-borne sewage poses serious risks to human health (see Chapter 5 for more details) in parts of the region. Ecosystems, especially riverine vegetation and wetlands can vastly improve water quality if they are kept healthy or restored to health.

Likewise, trees help to regulate local climate by providing shade in the rapidly growing cities of ASEAN. Urban parks and green spaces do the same, as well as sequestering carbon, helping to prevent erosion, and providing habitat for some species (see section 8.3.4 for the benefits of green space on human health and wellbeing). Wetlands, which are known to provide a disproportionately large amount of ecosystem services, are reducing in number and extent in the region. These shallow water areas provide diverse benefits, including but not limited to groundwater replenishment, storm protection, sequestration of carbon and other nutrients, and a habitat for many organisms. The Indo-Burma Region (comprising Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam), home to 35 "Ramsar sites" (or Wetlands of International Importance) is among the most threatened (IBRRI and IUCN 2020) (see section 4.6.1 for more details regarding the Ramsar Convention).

4.5.3 Cultural services

Experts consider biodiversity and ecosystem services to play a critical role in the cultural and spiritual fulfilment of the population of Asia and the Pacific (IPBES 2018). Although ASEAN is urbanizing rapidly, the region retains a wealth of indigenous and local knowledge, and many people still live in what urban dwellers might consider ‘wild’ environments. These traditional practices play a potentially important role in managing biodiversity and ecosystem services. In a review of studies of ecosystem services in ASEAN, however, only 21% assessed cultural services (Dang et al. 2021).

As lifestyles modernize, people typically become separated from nature. While this separation might be associated with enhancement of provisioning and regulating services (for example, food in a city is more diverse, and clean water is more accessible), cultural ecosystem services are more likely to be lost or degraded. Assessing such changes has revealed that cultural ecosystem services are dynamic and shift over time and within different contexts (McElwee et al. 2022). For example, in Viet Nam and the Philippines, sociocultural structures and the socioeconomic situation of farmers were found to have influenced farmers’ views on cultural services (Tekken et al. 2017). There is some urgency to better understand cultural ecosystem services and their value in the region, due to the rate at which they are being affected and changed as the region urbanizes.

In urban settings, parks and green space enable city dwellers interact with nature, providing spaces to exercise and interact with other community members. Evidence on the value of such spaces is accumulating, but research so far has looked mainly at the global north (Nor Hamzah et al. 2020).

4.6 Responses

AMS have implemented various policy and other responses to safeguard biodiversity and address some of the pressures and drivers mentioned above. These can be divided into legal and regulatory responses, social and cultural responses, economic and financial responses, and management responses.

4.6.1 Legal and regulatory responses

Regional Frameworks

Regional ASEAN agreements aim to address transboundary environmental issues, especially in cases where the source of the issue falls outside the national jurisdiction of the affected country. For instance, to tackle a couple of the pressures on biodiversity (namely, pollution and wildfires), under the ASEAN Agreement on Transboundary Haze Pollution (2002), signatories are expected to “prevent and control activities related to land and/or forest fires that may lead to transboundary haze pollution”, including open burning and land clearing by fire (ASEAN Secretariat 2002a). Aside from helping to reduce air pollution in the region, the agreement may encourage the preventive measure of conserving habitats.

Some regional agreements are limited to

concerned AMS around shared resources. An example is the Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (1995), which was signed by Cambodia, Lao PDR, Thailand, and Viet Nam. Article 7 of this agreement reads, "Where one or more States is notified with proper and valid evidence that it is causing substantial damage to one or more riparians from the use of and/or discharge to water of the Mekong River, that State or States shall cease immediately the alleged cause of harm until such cause of harm is determined..." (Mekong River Commission 1995, 4). The same agreement also outlines an institutional framework that stipulates the establishment of the Mekong River Commission, which includes a Council that has decision-making authority on matters related to the implementation of this agreement (Mekong River Commission 1995; 2017).

In addition to multilateral agreements, the direction of biodiversity conservation in the region is charted by key strategic plans. For example, the ASEAN Working Group on Nature Conservation and Biodiversity (AWGNCB), one of seven subsidiary bodies of the ASEAN Senior Officials on the Environment (ASOEN), is currently implementing its Action Plan for the decade of 2016-2025 (see Table 12.1 in Chapter 12 for more information). Under its Action Plan, it aims to (1) "ensure that by 2025, ASEAN's biodiversity is valued, conserved, restored, wisely used and delivers benefits essential for its people" and (2) "promote natural resiliency and use of integrated ecosystem-based approaches (to climate change adaptation and disaster risk reduction)" (ASEAN Secretariat 2016c).

Prioritized by AWGNCB in its Action Plan, the ASEAN Centre for Biodiversity (ACB) is an intergovernmental organization established in 2005 through the Establishment Agreement of ACB to coordinate regional action to "intensify biodiversity conservation" (ASEAN Centre for Biodiversity 2022a). The Establishment Agreement of ACB (2005) has been ratified by all AMS (ASEAN Centre for Biodiversity 2022a). ACB has a number of flagship activities to support its mission, including but not limited to the ASEAN Clearing-House Mechanism, the ASEAN Biodiversity Outlook (a publication that assesses the region's progress on biodiversity conservation), and the ASEAN Heritage Parks (AHP) programme (see section 4.6.4 for more details on the AHP programme).

The Regional Action Plan for ASEAN Heritage Parks (2016-2020) guides the implementation of the AHP programme to be in alignment with progress on the Aichi Biodiversity Targets and the SDGs (particularly SDGs 14 and 15). The Plan builds on the achievements of its predecessor, the first Regional Action Plan for ASEAN Heritage Parks and Other Protected Areas, by strengthening and adding goals relevant to improvements in scientific knowledge and technologies and communication (ASEAN Centre for Biodiversity 2016; ASEAN Centre for Biodiversity et al. 2008). The Plan stipulates seven goals, as follows (ASEAN Centre for Biodiversity 2016, 3–4):

1. Strengthen national and regional systems of AHP management to ensure integration into global network and contribution to globally agreed goals

2. Strengthen national and regional networks and collaboration

3. Enhance capacity of AHP managers and staff and other stakeholders to ensure effective management of AHPs

4. Ensure that scientific knowledge and technologies are improved, widely shared, transferred and applied for the effective management of the AHPs

5. Promote equity and benefit sharing

6. Ensure sufficient financial resources and promote sustainable financing

7. Strengthen communication and promotion strategies

Under these goals, there is a series of strategic actions to be implemented by AHPs and the ASEAN Centre for Biodiversity.

To address significant gaps in the taxonomic classification of ASEAN species, AMS are guided by the Global Taxonomy Initiative (GTI) Regional Action Plan for Southeast Asia (2017-2025) (ASEAN Centre for Biodiversity 2017a). This comprehensive action plan, the successor of the first GTI Regional Action Plan for South East Asia 2010-2015, aligns with Agenda 2030 and is organized into four goals (capacity building to address taxonomic needs, establishment and maintenance of infrastructure for data/specimen collection, improved systems for accessing data, and assistance for AMS to generate information for decision-making on biodiversity conservation). Each of these goals are broken down into objectives, strategic actions, and time-bound specific actions (ASEAN Centre for Biodiversity 2017a).

ASEAN does not have a regional mechanism for addressing the large-scale acquisition of land by corporate entities. Some AMS do, however, have national and subnational mechanisms to address land rights disputes and have introduced land titling programmes (Sao 2021). Indonesia, for example, introduced a social forestry programme in 2015 to address inequities and prioritize indigenous peoples and forest farmer groups in the redistribution of 12.7 million hectares of state forests (Sao 2021; World Bank 2021g). Under this programme, indigenous peoples and local communities are granted licenses to manage forest resources sustainably (World Bank 2021g).

Global Frameworks

With respect to global conventions relevant to biodiversity, all AMS are Parties to the CBD. All have also submitted national biodiversity strategies and action plans and their latest (sixth) national reports to the CBD (see Table 4.1). Moving toward the adoption of the Kunming-Montreal Global Biodiversity Framework at the second part of the 15th meeting of the Conference of the Parties to the CBD (CBD COP 15) in late 2022, ASEAN released a joint statement calling for a number of transformative actions, including “conserving and restoring prioritized ecosystems”; “mainstreaming biodiversity” across sectors; “strengthening measures to address current and future pandemics” and integrating the One Health approach; enhancing implementation of climate change mitigation actions, and “synergizing efforts to implement the SDGs targets and relevant multilateral environmental agreements”, among other actions (ASEAN 2021b, 4–5).

All AMS are also Party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2021) and the United Nations Convention to Combat Desertification (UNCCD 2021).

All but Brunei Darussalam and Singapore are Party to the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention) (Ramsar Convention Secretariat 2021b). A key commitment of the Ramsar Convention is to identify and place suitable wetlands onto the List of Wetlands of International Importance. These Ramsar sites are present in eight AMS and increased in number from 44 in 2016 (1,044,671 ha) to 52 in 2021 (1,286,308 ha), reflecting a growth in area of 241,637 ha. Designation is considered to promote conservation of these sites (Ramsar Convention Secretariat 2021a).

All but three AMS are Member States of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES); Brunei Darussalam, Lao PDR and Singapore are Observers (IPBES Secretariat 2021, n. accessed on 28 December 2021.). Myanmar joined in 2019, after the last ASEAN SOER. Among AMS, only the Philippines is Party to the Convention on the Conservation of Migratory Species of Wild Animals (CMS Secretariat 2021).

Table 4.1 AMS membership and participation in intergovernmental environmental agreements

AMS	NBSAPs developed	Sixth national report	Nagoya Protocol ratification	Cartagena Protocol ratification	CITES Party	UNCCD Party	Ramsar Party	IPBES Member State
BRN	Version 1 (2015)	Submitted	-	-	1990	2002	-	Observer
KHM	Version 2 (2016)	Submitted	2015	2003	1997	1997	1999	2012
IDN	Version 3 (2017)	Submitted	2013	2005	1979	1998	1992	2012
LAO	Version 2 (2016)	Submitted	2012	2004	2004	1996	2010	Observer
MYS	Version 2 (2016)	Submitted	2018	2003	1978	1997	1995	Unknown
MMR	Version 2 (2016)	Submitted	2014	2008	1997	1997	2005	2019
PHL	Version 3 (2016)	Submitted	2015	2007	1981	2000	1994	2012
SGP	Version 4 (2019)	Submitted	-	-	1987	1999	-	Observer
THA	Version 3 (2008)	Submitted	Signed in 2012	2006	1983	2001	1998	2012
VNM	Version 3 (2015)	Submitted	2014	2004	1994	1998	1989	2014

Source: (CBD Secretariat 2022b; 2022c; 2022a; CITES 2021; UNCCD 2021; Ramsar Convention Secretariat 2021b; IPBES Secretariat 2021). Years indicate when the relevant agreement was ratified.

Some AMS have national action plans and strategies to address the introduction and spread of invasive species in their respective countries, which may include establishing a list of priority species for control, regulating trade of biological materials, and implementing control measures such as the application of chemicals (ASEAN Centre for Biodiversity 2017a).

4.6.2 Social and cultural responses

Some, but insufficient, progress has been made by Southeast Asia towards the UN goal of integrating biodiversity values into development and poverty reduction strategies and planning processes and national accounting by 2020 (IPBES 2018).

The ASEAN Regionally Important Agro-Ecological Heritage Systems (ARIAHS) programme is a regional platform under development to give recognition to agricultural heritage systems based on indigenous knowledge regarding sustainable farming (ASEAN Centre for Biodiversity 2017a). This programme will localize the FAO's criteria for Globally Important Agricultural Heritage Sites for ASEAN and aims to promote landscape approaches, as well as practices such as crop rotation and growing diverse crops (ASEAN Centre for Biodiversity 2017a). By highlighting good practices and systems within the ASEAN region, countries are incentivized to value and preserve these practices.

Overall progress toward Aichi Biodiversity Target 1, the UN target on increasing awareness of biodiversity was considered to be static in Southeast Asia, while there has been some, albeit insufficient, progress toward Aichi Biodiversity Target 19, the UN target on improving, sharing and applying knowledge (IPBES 2018). (See Chapter 9 for more details on environmental education in ASEAN.)

4.6.3 Economic and financial responses

While mobilization of finance is critical to conserve biodiversity, significant progress is needed to increase financial resources from all sources in Southeast Asia (IPBES 2018).

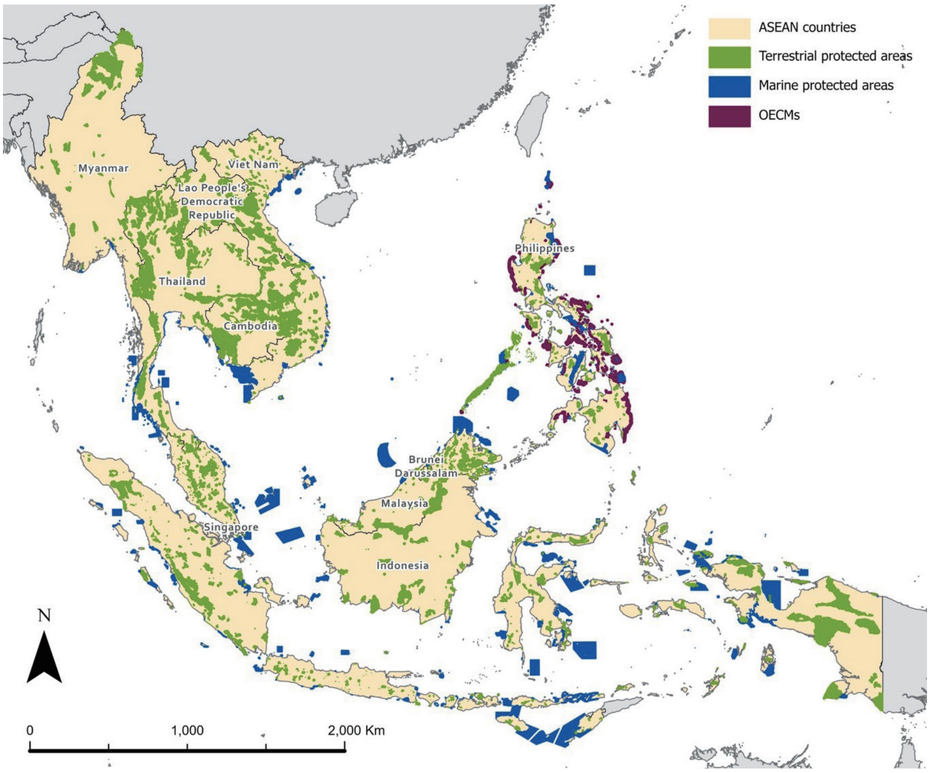
Ecotourism is one approach that can marry sustainable management of ecosystem services and economic activity, and results in increased awareness among tourists. In 2016, AMS agreed to cooperate on establishing ecotourism sites across the region in the Pakse Declaration on ASEAN Roadmap for Strategic Development of Ecotourism Clusters and Tourism Corridors (ASEAN Ministers of Tourism 2016). This strategy aims to create new value by linking ecotourism sites across countries by major roads and other transport infrastructure, supporting the ecotourism industry in respective AMS and generating new green employment opportunities locally (ASEAN Ministers of Tourism 2016). While the COVID-19 pandemic has inflicted significant damage on the tourism sector, the 2021 Phnom Penh Declaration on a More Sustainable, Inclusive, and Resilient ASEAN Tourism and Post-COVID-19 Recovery Plan for ASEAN Tourism (ASEAN Secretariat 2021k; Greenview 2021) has emphasized ecotourism as a key approach toward realizing more sustainable forms of tourism in the post-pandemic era. In early 2022, the ASEAN Tourism Ministers announced the reopening of ASEAN borders to tourism, while highlighting ASEAN's shift in "policy focus towards a resilient, competitive, resource efficient, inclusive and carbon-neutral tourism sector" (ASEAN Ministers of Tourism 2022, 4).

Payment for ecosystem services (PES) involves payments from beneficiaries of ecosystem services to the rightful providers or managers, in recognition that they are using and conserving natural capital (UNESCAP 2009). Given that payments are, in principle, contingent on service delivery, this can incentivize the conservation and/or sustainable use of ecological resources (UNESCAP 2009). Among AMS, Viet Nam has a national policy on PES, originally intended for water resources (ASEAN Centre for Biodiversity 2017a). For example, a PES scheme being implemented in Hoa Binh Province for forestry allows hydropower plants, water supply companies, and other users to compensate people and organizations who own and protect forested land (Tran, Zeller, and Suhardiman 2016). Meanwhile in Indonesia, a PES scheme has been used to compensate farmers for taking steps to prevent soil erosion (Squires 2014). The benefits of PES programmes to biodiversity conservation depend on issues such as property rights and the extent to which the quality of 'service' can be measured at appropriate scales, which is necessary for enabling payments to be made based on service delivery and thereby incentivize the effective management of ecosystem services (Tran, Zeller, and Suhardiman 2016; Van Noordwijk et al. 2012).

4.6.4 Management responses

By April 2022, ASEAN had a total of 2,202 terrestrial and marine protected areas (see Figure 4.5), 408 of them with management effectiveness evaluations. This accounted for 607,459 km^2, or 13.6%, of ASEAN land area and 259,439 km^2, or 2.7%, of the marine and coastal area (UNEP-WCMC and IUCN 2022). These figures fall short of the 17% terrestrial and 10% marine targets set by Parties to the Convention on Biological Diversity in 2010 (CBD Secretariat 2010) (see section 6.6.3 for more discussion on marine protected areas in ASEAN). Future targets, as laid out in the Kunming-Montreal Global Biodiversity Framework (CBD Secretariat 2021) are even more ambitious. Achieving them may be aided by the inclusion of less formally protected "other effective area-based conservation measures" (OECMs). OECMs are intended to augment protected areas, which alone cannot be relied upon to preserve species and ecosystems (CBD Secretariat 2018). OECMs may include biodiversity friendly agriculture, "socio-ecological production landscape and seascapes" (SEPLS) (Natori et al. 2018), and areas that are sustainably governed and managed by indigenous peoples and local communities (CBD Secretariat 2018). All 178 ASEAN OECMs declared so far are in the Philippines.

Figure 4.5 Terrestrial and marine protected areas, and other effective area-based conservation measures (OECMs) in ASEAN



Source: (UNEP-WCMC and IUCN 2022)

ASEAN Heritage Parks (AHP), a flagship programme adopted by AMS in 1984, designates protected terrestrial and marine natural areas across the region with the aim of maintaining the ecosystem services these areas provide (ASEAN Centre for Biodiversity 2016; JAIF Management Team 2020). AHPs are found all over the region, totalling 51 as of 2022. Given the comparatively few marine AHPs, and as stipulated by the Regional Action Plan for ASEAN Heritage Parks (2016-2020), in 2016 the ASEAN Centre for Biodiversity revised selection criteria to facilitate the declaration of an additional four marine AHPs from 2017 to 2019 (ASEAN Centre for Biodiversity 2019). Other strategic actions on the Action Plan, such as data collection and management, capacity building, and institutional harmonization with CBD Protocols, have also seen progress (ASEAN Centre for Biodiversity 2019). At the time of writing this report, the AHP Regional Action Plan for 2023-2030 is being compiled by ACB.

At a different scale, Singapore has led the development of an index to measure cities' biodiversity conservation efforts, known as the City Biodiversity Index or the Singapore Index on Cities' Biodiversity (Chan et al. 2021). This index has been used as a basis for biodiversity management in cities around the world, including some ASEAN cities.

As part of efforts to promote AHP programme implementation, ACB led a capacity-building project in 2015 for staff managing AHPs to improve data management and enhance awareness-raising and outreach (JAIF Management Team 2020). In one AHP site, AHP programme managers conducted education and awareness-raising and involved local community leaders in a Special Park Committee. This helped to build cooperation between local stakeholders and increased the willingness of local community members to become directly involved in the management of the AHP (JAIF Management Team 2020).

In an example of collaborative marine ecosystems management, Indonesia, Malaysia, and the Philippines are among the members of the Coral Triangle Initiative for Coral Reefs, Fisheries, and Food Security (CTI-CFF). CTI is founded on "people-centred biodiversity conservation", prioritizing actions that address both biodiversity loss and poverty in the region (CTI-CFF Secretariat 2019). Since its inception in 2007, the regional organization has strengthened its capacity, establishing a regional secretariat in 2015 (CTI-CFF Secretariat 2022a). CTI works with various stakeholders including multilateral financial institutions, non-governmental organizations and non-member governments to develop, finance, and implement conservation activities (IPBES 2018).

4.7 Way forward

In considering how to improve the state of ASEAN's biodiversity, this chapter concludes with some broad recommendations and a look back over the pressures, drivers, and responses that they are aimed at addressing. Most AMS are losing habitat to agriculture and urbanization, while the overexploitation of wild species exacerbates those impacts. Pollution on land, in the oceans, and in the air have lessened to some extent but continue to threaten ASEAN's biodiversity and the quality of life of its people, while marine plastics pose a relatively new threat. The threat of invasive species is increasingly recognized, and holds special significance for much of oceanic ASEAN, because islands are particularly vulnerable to biological invasions. Climate change, meanwhile, has the potential to exacerbate other drivers of biodiversity loss, as well as presenting its own challenges to conservation. These drivers are challenges to achieving SDGs 14 and 15 on conserving marine and terrestrial biodiversity, the Kunming-Montreal Global Biodiversity Framework, and other international and national biodiversity goals.

The human populations of all ASEAN countries are expected to begin shrinking over the next few decades, with estimates of the tipping point varying from the 2020s for Thailand, to the 2070s for Cambodia (United Nations Department of Economic and Social Affairs Population Division 2022; Our World In Data 2021b). In the meantime, the region's economy continues to grow, despite shrinking for most AMS in the year following the outbreak of COVID-19 (J. Williams and Voas 2021). As the economy grows, so do individual incomes, thereby raising levels of resource consumption. Improved technology also accompanies these changes and may be considered a challenge to managing biodiversity because it facilitates development. However, if certain technology and innovation are embraced and enhanced to benefit biodiversity, ASEAN can look forward to improvements such as those brought on by aquaculture (SDG target 14.7) and agricultural efficiency. At the same time as looking forward, with technological innovation, ASEAN would benefit from continued recognition of traditional and local knowledge to inform the wise management of biodiversity. Managing biodiversity loss will require careful consideration of which policies can achieve the most objectives at the lowest cost across development objectives (synergies) and a clear understanding of how actions that benefit one may be to the detriment of another (trade-offs) so that those decisions can minimize harm.

Global agreements like the CBD provide some guidance on how to conserve biodiversity.

Regional agreements that specify the relationships between AMS specifically, and are tailored to their unique challenges may, however, be better able to enhance transboundary cooperation in the region. Enhancing enforcement of such regional frameworks as those mentioned in section 4.6.1 is necessary.

Education (SDG 4), including education and awareness-raising on the importance and benefits of conservation, is one of the most fundamental ways in which AMS can continue to improve their responses to ecological challenges. At the same time, nature needs to be seen to work for people, by identifying and implementing solutions that benefit both nature and people (SDG target 15.9) including “nature-based solutions” that use natural systems as the basis for addressing development challenges.

Funding for nature (SDG targets 15.a and 15.b) is generally in short supply in developing countries and the case for increased funding is a familiar one, especially because it is in developing countries that biodiversity is most at risk. At the same time, progress may depend on ownership and responsibility being assumed by the people who live closest to, and benefit most from, ASEAN’s biodiversity. A custodial approach presents opportunities for the involvement of indigenous peoples and local communities, for ecotourism, for home-grown innovation in the management of nature, and for other opportunities to invest in natural capital.

As discussed in section 4.6.4, ASEAN has fallen somewhat short of global protected area targets, which are now even more ambitious as the CBD’s Strategic Plan for Biodiversity 2011-2020 and its Aichi Biodiversity Targets were succeeded by the Kunming-Montreal Global Biodiversity Framework in late 2022. However, a relatively new tool to achieve this goal has become available: “other effective area-based conservation measures” (OECMs), which are areas that can achieve conservation outcomes without formal protection. The quality of both protected areas and OECMs will, however, determine their conservation success as much as their quantity. AHPs may also benefit from expansion through the addition of OECMs across political boundaries.

A final word on the way forward relates to the COVID-19 pandemic, which has dominated so much of people's lives, public discourse and policy over the couple of years preceding the publication of this report. In several studies, the spill over of zoonotic disease from wild species to human beings has been associated with the destruction of natural habitat. Policymakers and other decision-makers are, however, advised to evaluate any future cases of spill over individually and in context. Sending the message that habitat transformation will necessarily endanger human health may backfire because, in some cases, it may even be necessary for human health (Mader et al. 2022). Whether the topic is zoonotic disease or biodiversity conservation more broadly, perhaps more than anything else, ASEAN decision-makers need continued and expanded research to inform biodiversity policy and management.

Chapter 5
Water Resources Management

Main Messages

- Remarkable progress has been made to improve access to safe and clean drinking water over the last 20 years; however, water degradation caused by poor sanitation and hygiene services, low water-use efficiency for agriculture, and lack of appropriate domestic wastewater treatment systems are still common challenges observed in many ASEAN Member States (AMS).
- Consequently, water security is under significant pressure in many ASEAN countries, both in terms of water quality and quantity. In addition, the complexity of climate change impacts and water-related disasters will gradually lead to increased vulnerability and water security risk in the region.
- Industrial pollution, nutrient pollution from agricultural run-off, and untreated domestic wastewater discharge are major threats to ambient water quality, damaging ecosystem services, and threatening human health.
- Other major challenges affecting regional water security are a lack of regular water quality monitoring, ineffective data management and reporting systems, a lack of practical technical guidelines at the city/provincial/local, ineffective inter-sectoral coordination mechanisms and institutional collaboration between water-related sectors and other stakeholders, as well as among national, subnational and basin levels (e.g., unsustainable development of hydropower plants in upstream regions).
- Improved water governance and enforcement capacity of institutions at national and local levels, as well as enhanced cross-sector coordination and collaborative partnerships on vertical and horizontal dimensions, are critical for effective implementation of sustainable water resources management in the region.
- The UN Sustainable Development Goal 6 (SDG 6) of ensuring water and sanitation can provide a good framework to encourage a more comprehensive and holistic approach to enhance regional water security. Due to its strong interlinkages with other sustainable development goals (e.g., food and energy security, poverty reduction, sustainable consumption and production, and economic growth), it is clearly that achievement and progress towards the eight targets of SDG 6 will strongly support progress on the other SDGs. Progress on SDG 6 will help the ASEAN region to improve its ability to safeguard sustainable access to sufficient quantities of water of acceptable quality to sustain livelihoods, human well-being, and socioeconomic development, protect against water-borne pollution and water-related disasters, and sustain ecosystems.

5.1 Introduction

Water security plays a vital role in sustaining livelihoods, ensuring sustainable socio-economic growth, preserving healthy ecosystems and environment, ensuring resilience to water-related disasters (e.g., floods and droughts), and safeguarding human health, particularly in the ASEAN region where rapid population growth, urbanization and increased industrialization have been observed in every member country (ADB 2020b)). The ongoing COVID-19 pandemic has caused enormous disruption to sustainable development in general, and the world is seriously off track to meet Sustainable Development Goal 6 (SDG 6), in particular, to ensure water and sanitation for all by 2030 (UNEP 2021d). The COVID-19 pandemic also reinforced the urgent need for access to safe drinking water and sanitation, as well as the necessity of improved wastewater treatment and sanitation services, and good hygiene to minimize risks of infections via COVID-19 contaminated wastewater and faeces and to stop the spread of COVID-19 and other diseases to the environment (Bao, P.N. and Canh 2021). This will also facilitate AMS in achieving the overarching aims of the 2030 Agenda, as well as relevant targets under the 17 SDGs for creating a better and more sustainable world.

SDG 6 has strong interlinkages with other SDGs, and it plays a key role in achieving other important national priorities and development goals such as food and energy security, poverty reduction, sustainable production and consumption, gender equality, sustainable economic growth, etc. (UN-Water 2016). As a result, SDG 6 can provide a good framework to encourage a more comprehensive view of water and help the ASEAN region to define its own water security goals (universal and equitable access to safe and affordable drinking water and sanitation). The achievement and progress towards the eight targets of SDG 6 will have a catalytic effect on the overall 2030 Agenda (UN-Water 2021). Unfortunately, the current progress in achieving the SDG 6 targets in ASEAN has been slow or stagnant, particularly the targets related to wastewater and sanitation. Progress is also being threatened by various man-made and natural factors such as socioeconomic activities affecting water quality and quantity, climate change, and water-related disasters, which in turn contribute to increased vulnerability and risks. Many major rivers and water bodies in the region have been severely polluted by the discharge of untreated or only partially treated domestic, industrial, and agricultural wastewater, leading to substantial levels of contamination in drinking water sources as well as inland and coastal ecosystems. This pollution has also caused huge negative economic impacts (P.N. Bao 2021).

The proportion of the ASEAN population using safely managed drinking water services was below 85%, as of 2018 and reached around 90% in 2020. However, for improved sanitation facilities, the ratio of coverage is still low in some countries such as Cambodia, Indonesia and Lao PDR, particularly in rural areas (ASEAN Secretariat 2020d). Only three AMS have above 90% coverage for improved sanitation. There are still more than 100 million people without safe drinking water and over 150 million people living without improved sanitation in the region (ASEAN Secretariat 2021b). Furthermore, providing adequate access to onsite improved sanitation facilities does not ensure good water quality in receiving water bodies, if these facilities are not functioning well and their effluents are not properly collected and treated at either centralized or decentralized wastewater treatment plants before being discharged into the aquatic environment. Currently, less than 30% of generated domestic wastewater has been properly collected and treated in most AMS, except for Brunei, Malaysia, Philippines and Singapore (P.N. Bao 2021; WEPA 2022). Results from a review of current progress on achieving SDG 6 targets in AMS indicated that most ASEAN countries are making slow progress and facing either significant (Brunei, Malaysia, Philippines, Thailand, and Viet Nam) or major challenges (Cambodia, Indonesia, Lao PDR, and Myanmar) in achieving the SDG 6 targets, except for Singapore. However, lack of reliable monitoring data is one of the biggest challenges in accurately evaluating the region's progress on the SDGs. A recent report published by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) indicated that data are not available for nearly one-quarter of all SDG indicators related to the environment (UNESCAP 2021a). Therefore, it is necessary to substitute alternative indicators for which data can be realistically collected locally to more accurately track progress toward the SDGs.

Since 80% of the region is surrounded by water and the 20 largest cities with a total population of 121 million people are on the coast or on the banks of a major coastal river (World Population Review 2021), ASEAN countries and cities are also vulnerable to climate change impacts, and water related hazards and disasters such as rising sea-levels, salinity intrusion, alteration of rivers' water and nutrient flows, floods, droughts, cyclones and storm surges, regardless of mitigation progress (Indra Overland 2017). As stated in the ASEAN State of Climate Change Report (ASCCR) (ASEAN Secretariat 2021g), the region is already experiencing significant impacts from climate change, including increased intensity and magnitude of extreme weather events, especially in the water resources and agriculture sectors, and increased economic, environmental and social damage. Climate change is already having a significant impact on the economy, environment, and society. Countries such as Myanmar, the Philippines, Viet Nam, and Thailand were among the top 10 countries most affected by extreme weather events between 1999 and 2018 (Eckstein et al. 2020; ASEAN Secretariat 2021g). Moreover, future climate change impacts are projected to undermine decades of development progress, so the region needs to take appropriate action and make urgent interventions to address these challenges, particularly in managing water security.

This chapter presents the status of water security in AMS and identifies key challenges and impacts which the region is facing, particularly related to degradation of water quality, poor wastewater treatment and sanitation services, lack of access to proper wastewater treatment systems, nutrient pollution from agricultural run-off and untreated domestic wastewater discharges, low water-use efficiency for agriculture, water stress due to climate change, and water-related disasters. It also discusses various good practices and potential responses and ways forward at the city, national and regional levels, which are aimed at addressing the challenges, overcoming identified barriers, and facilitating the AMS efforts to transform their water systems towards a more sustainable, circular water economy.

The drivers-pressures-state-impacts-responses (DPSIR) framework is also applied in this chapter for improving understanding on key drivers, pressures, current state and trends, impacts and proposed responses and strategies for addressing the identified water challenges in the ASEAN region.

5.2 Drivers

Critical external drivers include rapid population growth and urbanization, increasing preference for high water footprint diets, climate change impacts on water resources, increasing need for water to produce food and energy, rapid industrial growth, insufficient capacity of wastewater treatment, and weak water governance. High population growth is one of the fundamental drivers of increasing pressure on water resources in the region, which is associated with increased water demand for households, more irrigation water to increase food production and increased need for water to produce more energy. Over the last four decades, population in the ASEAN region increased by 54% (ASEAN Secretariat 2020b), and it is projected that the regional population will reach 745 million by 2030 (UNDESA 2015). It implies that water demand will increase to meet the basic services for the growing population, as Table 5.2 projects a significant increase of domestic water withdrawals over time in two AMS. The burgeoning population will also increase challenges to develop sanitation infrastructure for all, which is the key to manage water pollution.

To meet increasing food demand for its growing population, the ASEAN region has experienced intensification of agriculture which has led to increasing water demand for food production (as shown in Table 5.1) as well as increased risk of water pollution due to excessive nutrient inputs. Agricultural pollution is already evident in the ASEAN countries although information is less documented. Many surface water bodies in the ASEAN region are more polluted in areas in proximity to highly populated areas and intensive agricultural zones (Cassou, Jaffee, and Ru 2017). ASEAN economies are experiencing rapid economic growth, with the projected annual GDP growth ranging from 3.7% to 7.0% in 2019-2023 (OECD 2019). Many of the industries driving ASEAN's rapid economic growth intensively use water and significantly contribute to water pollution by discharging organic matter along with heavy metals, nutrients, and acidic water (Lorenzo and Kinzig 2020a). Some AMS suffer from insufficient wastewater treatment facilities so the discharged pollutants degrade water quality. For example, 70% of rivers in Indonesia are classified as polluted (Lorenzo et al. 2020). In addition to anthropogenic drivers, climate change further exacerbates water challenges by altering hydrological cycles. It is projected that lower Mekong River basin will experience a 0.79¬°C temperature rise, a 13.5% increase in rainfall in the wet season, and dry season rainfall will decrease (MRC 2022).

5.3 Pressures

Human activity has induced major pressures on water resources in the ASEAN region including land use change, increasing water demand from major economic sectors, sectorial conflicts over water use, water quality degradation, desalination, hydrogen production, water transport, recreation demand and transboundary pressures. Urbanization is taking place at a particularly rapid pace in the ASEAN region. The amount of urban land increased by 22% annually between 2000 and 2010 in East and Southeast Asia (Schneider et al. 2015). Uncontrolled urbanization often leads to the expansion of built-up areas into surrounding natural and agricultural lands which can create enormous pressure on the hydrological systems that eventually cause serious social conflicts (Seto, Kaufmann, and Woodcock 2000). Massive land use change in Bangkok was mentioned as one of the major causes of the devastating flood in 2011 (Marks 2015). Increasing sectoral conflicts regarding water use is also a key pressure which can only be addressed by more sustainable water management in the ASEAN countries. It is evident that construction of a series of dams in the upstream of Mekong River basin has already altered river flow, fish production and affected communities along the Lower Mekong Basin (LMB) (Fu and He 2007; Vietnam News Agency 2011). There is huge hydropower potential in ASEAN that could significantly contribute to the region's green growth. However, uncoordinated development of hydropower plants in upstream countries may have negative impacts on food security, livelihoods, biodiversity, and ecosystems (Cronin and Hamlin 2012; T. Piman, Cochrane, and Arias 2013). Consequently millions of people who get their food and sources of livelihood from the river systems could be affected (Baran and Myschowoda 2009; ICEM 2010).

Growth of industrial sectors has also increased pressure on water resources by increasing water demand for industrial production and discharging pollutants to the environment. Intensification of the livestock industry is another source of water pollution in the AMS. Industrial piggeries are the primary source of nutrient loading in the water bodies (14-72% of nitrogen and 61-94% of phosphorus) in Thailand and Viet Nam (Reid et al. 2010). Water pollution risk from aquaculture is also increasing because small and medium size aquaculture farms are developed without considering potential environmental impacts (White 2017).

Due to the lack of legally binding procedures and inadequate management, high doses of antibiotics are used in industrial aquaculture. A number of antibacterial resistant bacteria have been reported in some AMS including Indonesia, Thailand, Philippines and Viet Nam (UNEP 2019c). For ASEAN's clean energy future, hydrogen may play a vital role in the future energy mix (Phoumin 2021). Expanding the use of green/blue hydrogen, which is made through electrolysis of water (9 kg H2O and H2) may intensify conflicts with other water users in the region. Tourism is one of the main pillars of economy in many AMS and continued increases in the number of tourists will intensify water demand for this sector. For example, Bali, Indonesia is one of the popular tourist destinations, which has been facing a tourism induced water crisis due to over exploitation of groundwater and irreversible saltwater intrusion (Ismail 2018).

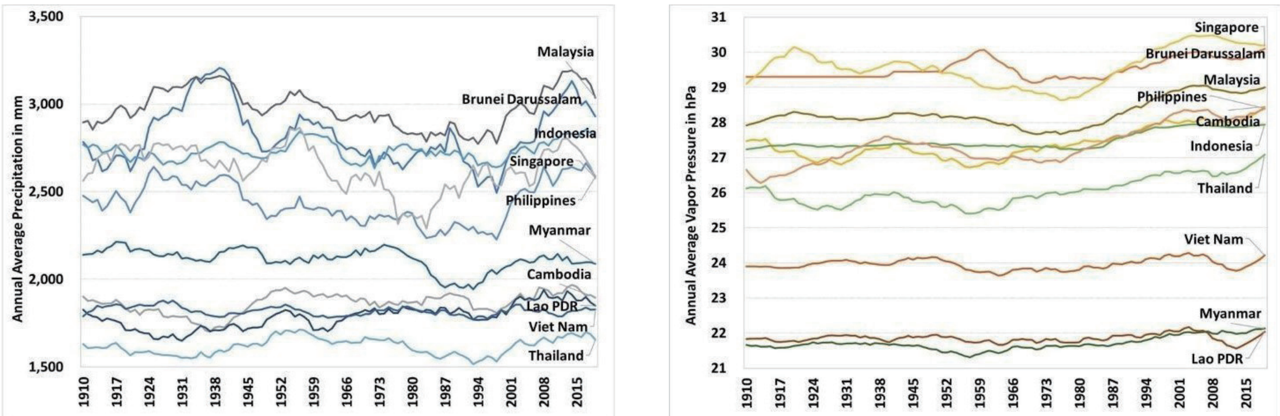
Lack of access to sanitation is still a major problem in many AMS, despite significant progress. This is a significant negative pressure on water quality as well as a major health hazard. It is also a personal everyday disaster for people without access to sanitation services.

5.4 State and trends

5.4.1 Water demand and supply

The ASEAN region is in the tropical climate zone, relatively hot and humid throughout the year with abundant water resources. Various precipitation patterns are observed in AMS. As Figure 5.1 shows, the annual average precipitation ranges between 3,200 mm and 1,500 mm. High precipitation was recorded in Malaysia and relatively low precipitation was recorded in Thailand during the past decades. Singapore and Brunei Darussalam have higher rates of vapor pressure compared to other countries, indicating the humidity of these countries is high.

Figure 5.1 10-year moving average of annual average precipitation in mm (left) and vapour pressure in hPa (right)



Source: Data from CY4.05[6] (Harris et al. 2020; University of East Anglia Climate Research Unit et al. 2021)

The water supply largely depends on the availability of freshwater resources, which is significantly affected by the amount of precipitation in addition to other factors such as geography and land use/land cover (LULC). Although the amount of rainfall fluctuates from year to year, the countries with generally high levels of precipitation (10-year moving average) are Malaysia, Brunei Darussalam, Indonesia, and Singapore, while the countries with relatively lower levels of precipitation in the region are Lao PDR, Viet Nam, and Thailand. An increase in heavy precipitation has been observed in the region, and Working Group 1 of the Intergovernmental Panel on Climate Change (IPCC) projected that summer precipitation, extreme rainfall, and winds associated with tropical cyclones are likely to increase in the region (Christensen et al. 2015).

Total internal renewable freshwater resource (IRWR) in each country indicates water availability, estimated from the average annual flow of rivers and recharge of aquifers generated from endogenous precipitation. Although water availability is not equal to the water supply because water quality, storage, and infrastructure affect the amount of supply, it does indicate the level of water shortage in each country. Table 5.1 shows IRWR, IRWR per capita, and changes in IRWR per capita from 2012 to 2017. Indonesia, Malaysia, and Philippines have higher IRWR than other countries, and Brunei Darussalam, Myanmar, and Singapore are countries with low IRWR. Although IRWR is low, Brunei Darussalam and Myanmar are countries with the highest IRWR per capita, together with Lao PDR, due to their smaller population. Singapore is endowed with high precipitation; however, as IRWR and IRWR per capita indicate, water is scarce because it is a small island with limited water storage capacity. IRWR per capita decreased from 2012 to 2017 in all AMS.

[6] Based on the climate dataset on 0.5 x 0.5 degrees grid.

Table 5.1 Total internal renewable water resources (IRWR), IRWR per capita, changes in IRWR per capita from 2012 to 2017, and % change in people affected by water related disasters

	IRWR in 2017 (km^3/year)	IRWR per capita in 2017 (m^3/capita/year)	% change in total IRWR per capita from 2012 to 2017	% change in people affected by water related disasters (from 2001-2010 to 2011-2020)
Brunei Darussalam	8,500	20,025	-6%	Not recorded
Cambodia	120,600	7,533	-8%	47%
Indonesia	2,018,700	7,628	-6%	21%
Lao PDR	190,400	27,384	-7%	161%
Malaysia	580,000	18,647	-7%	-1%
Myanmar	1,002,800	18,785	-4%	3%
Philippines	479,000	4,554	-8%	107%
Singapore	600	105	-6%	Not recorded
Thailand	224,510	3,244	-2%	16%
Viet Nam	359,420	3,799	-5%	3%

Source: Data from FAO Aquastat accessed on 4 October 2021 (https://www.fao.org/aquastat/statistics/query/index.html?lang=en) and D. Guha-Sapir, R. Below, Ph. Hoyois - EM-DAT: The CRED/OFDA International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium, accessed on 7 October 2021.

While IRWR per capita has decreased, the demand for water consumption has increased in the ASEAN region because of population growth, industrialization, and economic growth. Table 5.2 shows water withdrawals by sectors in Indonesia and Philippines. The demand for water has significantly increased in all sectors in Indonesia, and total water withdrawals have tripled from 1990 in 2016. In the Philippines, demand by the industrial sector has more than doubled from 2007 to 2017.

Table 5.2 Water withdrawal by sectors in km^3 (Indonesia and Philippines)

	Indonesia			Philippines		
	1990	2000	2016	2007	2012	2017
Agricultural withdrawals	69.2	92.8	189.7	67.2	67.9	68
Industrial withdrawals	0.4	7.4	9.1	7.3	9	15.9
Domestic withdrawals	4.7	13.1	23.8	7	7.3	8.9
Total	74.3	113.3	222.6	81.5	84.3	92.7

Source: FAO Aquastat accessed on 4 October 2021 (https://www.fao.org/aquastat/statistics/query/index.html?lang=en)

In Thailand, considering factors such as population, industrial demand, and the economy, water demand is expected to increase by 20% every year (Thailand Board of Investment 2020). In Viet Nam, water demand for irrigation, industry, domestic use, and aquaculture was 38.6 km^3, 3.5 km^3, 1.8 km^3, and 6.2 km^3 in the 2016 dry season, respectively. The demand from each sector is expected to increase by 46.4 km^3, 9.1 km^3, 3.3 km^3, and 7.4 km^3 respectively in the 2030 dry season (2030 Water Resources Group 2017). The expected increase in demand from industry is about 158%. In Cambodia, surface water use by agriculture accounts for 96% of the total, and water demand for domestic use, industry, and aquaculture is less than 1%, as the majority of the domestic water supply comes from groundwater (Sagara 2021).

Singapore has limited natural freshwater resources, and the demand for water is relatively stable. Table 5.3 shows the amount of water sold. Domestic demand for potable water has increased, but non-domestic demand for potable water and for industrial water has decreased. Despite its water scarcity, Singapore has ensured a diversified supply of water with the Four National Taps. One of it is high-grade reclaimed water known as NEWater. The demand for NEWater has been increasing, and it is used mainly for industrial and air-conditioning cooling purposes at wafer fabrication plants, industrial estates and commercial buildings (PUB Singapore's National Water Agency 2020).

Table 5.3 Water sales in million m^3 (Singapore)

Year	Potable water		NEWater	Industrial water	Total
	Domestic	Non-domestic			
2012	284.4	206.5	111.4	25.3	627.6
2015	297.1	217.6	124.8	25.0	664.5
2018	294.2	201.3	140.5	20.6	656.6
2019	297.6	202.6	145.5	17.9	663.6
2020	320.7	180.5	141.1	13.0	655.3
2021	316.5	184.9	148.9	11.4	661.7
2022	305.9	200.8	148.2	12.0	666.9

Source: 2012-2018 (Government of Singapore 2019b), 2019-2022 (Department of Statistics, Government of Singapore)

5.4.2 Water-related disasters

While the ASEAN region is endowed with water as precipitation data show, water-related natural disasters occur due to both excess and insufficient water. These include rapid onset (like floods) and slow onset (like droughts) disasters.

Table 5.4 shows the number of water-related disasters in the region, including meteorological and hydrological disasters such as tropical cyclones, flash floods, landslides, mudslides, floods, riverine floods, storms, and convective storms. The total number of events and the total number of people affected in a decade are also shown. In Indonesia, Lao PDR, and Myanmar, water-related disasters increased while they remained the same or decreased in other AMS. However, the total number of affected people significantly increased in all countries, except Malaysia. Although the number of events has decreased in the Philippines, Thailand, and Viet Nam, the number of people affected by disasters has increased. Increasing intensity of individual events and increasing numbers of people living in flood-prone urban areas due to limited land availability in cities are possible reasons for the increase in the total number of people affected in recent years.

Table 5.4 Water-related disasters in the 2001-2010 and 2011-2020 periods in AMS

AMS	2001-2010		2011-2020	
	Number of events	Total affected people	Number of events	Total affected people
BRN	Not recorded		Not recorded	
KHM	10	3,374,273	10	4,970,450
IDN	89	3,256,838	117	3,952,431
LAO	5	936,077	15	2,442,780
MYS	26	446,719	24	443,514
MMR	14	3,141,936	28	3,230,379
PHL	134	46,629,564	133	96,354,490
SGP	Not recorded		Not recorded	
THA	41	18,760,441	31	21,803,067
VNM	70	15,688,582	68	16,092,035

Source: Data from D. Guha-Sapir, R. Below, Ph. Hoyois - EM-DAT: The CRED/OFDA International Disaster Database – www.emdat.be – Université Catholique de Louvain – Brussels – Belgium, accessed on 7 October 2021.

Meanwhile, too little water is also problematic. Many AMS, especially in the Mekong Delta region and the Philippines also experience severe drought conditions, which have wide-ranging implications, from food security and agriculture to public health and livelihoods (High-level Experts and Leaders Panel on Water and Disasters (HELP) 2017; UNESCAP 2020c). Currently, around four-fifths of the economic impact of drought is felt by the agricultural sector in Southeast Asia, highlighting the urgency for AMS – especially those that rely on the agricultural sector for their economy – to build resilience (UNESCAP 2020c).

5.4.3 Access to safe and affordable drinking water and to adequate and equitable sanitation

An assessment of the Millennium Development Goals (MDGs) concluded that ASEAN successfully increased access to improved sanitation and water sources by 2015 (ASEAN Secretariat 2015a). Table 5.5 shows the levels of access to safe drinking water and to adequate and equitable sanitation in 2011 and 2020. Four categories such as "at least basic," "limited service," "basic service," and "safely managed service" are considered to have access to safe and affordable drinking water, and three categories such as "basic service," "limited service," and "safely managed service" are considered to have access to adequate and equitable sanitation in the table.

In 2020, access to safe drinking water and improved sanitation reached nearly 100% in urban areas of all AMS. Although significant progress has been made, improving access has been delayed in rural areas in Cambodia, Lao PDR, and Myanmar, particularly access to adequate and equitable improved sanitation.

Table 5.5 Proportion of population with access to safe and affordable drinking water and access to adequate and equitable sanitation in urban and rural areas

AMS	Access to safe and affordable drinking water				Access to adequate and equitable sanitation			
	2011		2020		2011		2020	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
BRN	99.7	99.1	99.7	N/A	95	65	99.9	99.9
KHM	89.9	65.4	99.3	80.6	82.2	38.0	100.0	69.3
IDN	94.4	77.4	98.2	86.8	88.8	62.8	97.2	86.5
LAO	88.6	64.7	97.1	84.1	88.4	49.1	100.0	72.0
MYS	99.5	92.0	99.4	90.7	99.5	97.8	99.9	98.7*
MMR	90.1	70.9	98.2	80.7	92.5	74.5	93.9	81.3
PHL	97.7	89.6	99.1	95.0	94.0	83.0	96.0	91.0
SGP	100.0	N/A	100.0	N/A	100.0	N/A	100.0	N/A
THA	99.4	97.3	100.0	100.0	99.7	99.1	99.9	100.0
VNM	97.7	87.1	99.2	95.5	93.0	69.9	98.7	90.0

Source: Water and sanitation coverage data (UNICEF 2021); data on access to improved sanitation for Brunei Darussalam has been provided by the Department of Drainage and Sewerage, Public Works Department, Ministry of Development, Brunei Darussalam (unpublished).

5.4.4 Water quality and freshwater ecosystem services

Good ambient water quality in the region is essential to protect ecosystems and maintain local livelihoods. Water quality degradation affects water supply, human health, aquatic life, ecosystem services, and economic activities. ASEAN countries have experienced rapid urbanization and industrialization, but infrastructure to treat wastewater has developed much more slowly. The AMS have established surface water quality and industrial effluent quality standards to protect human health and the water environment, and they have developed related governance frameworks (IGES 2018). However, the surface water resources, particularly in large cities, including Bangkok, Jakarta, Johor, Hanoi, and Manila, are still severely polluted (Koto and Negara 2018; Lee Goi 2020; IGES 2018).

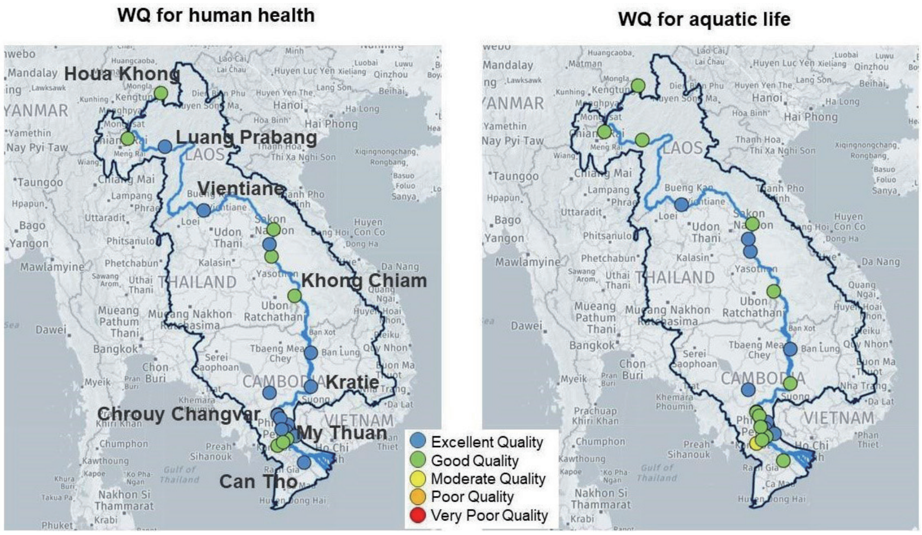
Several indicators measure the state of water quality. Dissolved oxygen (DO) is one important parameter because it is essential for aquatic life. A DO concentration below 3 mg/L is a concern, and below 1 mg/L is hypoxic so fish cannot survive. High water temperatures with low DO concentrations affect aquatic organisms, although the levels depend on the species as well as their various life stages. The minimum safe DO concentration for warm water environments is estimated to be around 5-6 mg/L (WHO 1997).

The Environmental Management Bureau of the Philippines (DENR-EMB) published the water quality data of selected water bodies by region from 2008 to 2017 (DENR-EMB, n.d.). The river systems in the Metro Manila region are all classified as class C, the second lowest classification in which the DO concentration standard is 5 mg/L; the observed DO concentrations ranged from 0 to 3.1 mg/L there. The river systems in the Central Luzon, Carabarzon, and Mimaropa regions also had low DO concentrations ranging between 0.5 and 7.0 mg/L. In these areas, the environmental standard of DO for class C was not achieved. The biochemical oxygen demand (BOD) concentration is also used to indicate the pollution level of rivers. While class C requires the BOD concentration to be below 7 mg/L and class D below 15 mg/L, the BOD concentrations of the river systems in the Metro Manila region ranged from 9.9 mg/L to 76.2 mg/L during the period. Moreover, the concentrations have gradually worsened, as they ranged between 49.4 mg/L and 76.2 mg/L in 2017. The BOD concentrations in Central Luzon and Central Visayas were also high, ranging between 2.0 mg/L to 143 mg/L during the period.

Major rivers in Thailand are classified as 3 and 4 in Thailand Environment Statistics 2020 (National Statistical Office 2020). In Thailand's classification system, surface water resources (rivers, canals, swamps, marshes, lakes, reservoirs, and other public water bodies) are divided into five classes, depending on usage, and class 4 indicates more polluted rivers. The DO and BOD standards of surface water are set at 4.0 mg/L and 2.0 mg/L for class 3 and 2.0 mg/L and 4.0 mg/L for class 4, respectively (National Statistical Office 2020). The DO concentrations of 20 major rivers in the country ranged between 1.4 mg/L and 7.5 mg/L, and the BOD concentrations ranged between 0.7 mg/L and 5.1 mg/L. Although the Lower Chaophraya and Lamtakong rivers did not meet the standards, the water quality of major rivers has been in the range of the environmental standard. On the other hand, the water quality of 13 canals in Bangkok was very poor between 2016 and 2018 as the DO concentration ranged between 0.0 mg/L and 0.7 mg/L and the BOD between 17.9 mg/L and 59.3 mg/L. Canal water flows into the Chaophraya but then it soon flows into the Bay of Bangkok because Bangkok is located in the estuary zone. The polluted water may not affect other regions but does affect the coastal ecosystems.

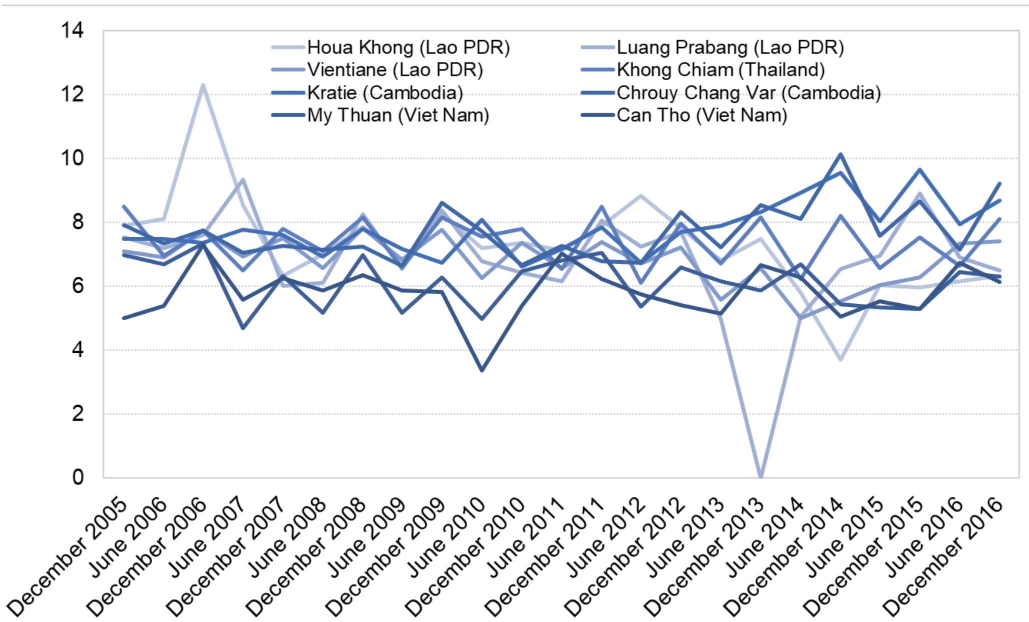
Five AMS share the Mekong River basin, and water flows from Lao PDR to the estuary in Viet Nam, with many tributaries. Water degradation upstream affects the water quality downstream; thus, the Mekong River Commission (MRC) has initiated water quality monitoring every two months

Figure 5.2 Water quality conditions for human health and aquatic life



Source: (Mekong River Commission n.d.)

Figure 5.3 Concentration of dissolved oxygen (DO) (mg/L) at 8 stations along the Mekong River



Source: authors, based on data from (MRC Data and Information Services, n.d.)

Figure 5.3 shows the DO concentration measured in June and December from 2005 to 2016, at eight sampling points. The darker lines indicate downstream sites; the darkest line, Can Tho, is the most downstream site. My Thuan and Can Tho are located near the estuary in Viet Nam. The concentrations fluctuate at all sites, but at two sites, the concentration is between 3 and 7 mg/L, constantly lower than other sites. Cambodia set the DO concentration standards between 2.0 mg/L and 7.5 mg/L and Thailand and Viet Nam between 2.0–6.0 mg/L, depending on the usage of water resources. The lowest limit, 2.0 mg/L, is assigned to water mainly used for industries and not for drinking and conserving aquatic ecosystems. In Viet Nam, the DO standard to protect aquatic fauna and flora is set at 6 mg/L, but the concentration in the lower Mekong sometimes has been lower than the standard.

Harmonized water management at the river basin scale is needed to maintain the quality of water resources for multiple water uses and to conserve aquatic ecosystems. In the ASEAN region, run-off from agriculture, mining, and urban areas, untreated municipal and industrial wastewater are the major causes of freshwater degradation, and as a result, ecosystems and aquatic species have faced great risk (ASEAN Centre for Biodiversity 2017a; IPBES 2018). Additionally, changes in LULC and construction of dams affect aquatic species. According to IPBES' regional assessment, the Mekong River basin has diversified fish species, but the diversity recently decreased, particularly in the downstream regions due to the construction of dams upstream (IPBES 2018). In the basin, river fragmentation has become one of the critical issues.

The MRC reported the state of the basin in 2019 (Mekong River Commission 2019). The average abundance of diatoms did not meet the target at four stations in Cambodia, seven stations in Lao PDR, and three stations in Thailand. The average species richness of diatoms met the target across all stations except one in Cambodia. The average abundance of benthic macroinvertebrates increased in Cambodia and Lao PDR and did not change in Thailand and Viet Nam. One station in Thailand did not meet the target. The average species richness of benthic macroinvertebrates increased in all countries. Dams have been observed to cause a great disturbance to the freshwater fish species in other rivers in Thailand (Tuantong, Chaiwut, and Apinun 2016).

5.4.5 Wastewater management

Water quality degradation due to domestic, agricultural, and industrial wastewater is widely recognized in this region, especially untreated or partially treated domestic wastewater from households. A significant amount of domestic wastewater is discharged into the environment without proper treatment. According to Table 5.6, less than 30% of the domestic wastewater generated in ASEAN members of WEPA is properly treated, except for Brunei Darussalam and Malaysia. Singapore treats 100% of its domestic wastewater. Moreover, most urban areas in the region still rely primarily on septic tanks as improved on-site sanitation for millions of their urban residents (Table 5.6). Unfortunately, many of these tanks have non-standard designs, improper construction, inaccessibility for de-sludging, and lack of regular maintenance and de-sludging. These factors are the main reasons lowering the performance of the tanks and the cause of low-quality effluent being discharged into the environment. It is believed that many of the septic tanks installed in the area are not fully achieving their original purpose of providing effective on-site sanitation (P N Bao 2021).

Thus, it will be difficult to meet the targets of SDG 6 without solving the problem of proper collection and treatment of wastewater and faecal sludge. Recent progress and SDG data showed that most AMS (except Singapore and Malaysia) are falling behind the targets (UN-Water 2022).

Table 5.6 Ratio of domestic wastewater treatment and septic tank coverage in urban areas in AMS

AMS	Proportion of domestic wastewater treatment (either by centralized or decentralized systems)[a]	Septic tank coverage in urban areas only[b]
BRN	59% (2020)[c]	34% (nationwide, mainly in sub-urban and rural areas) (2020)[c]
KHM	5.0% (2019)	49%
IDN	2% (2017)[c]	80%
LAO	Not available data	36%
MYS	95.4% (2021)[d]	20% (nationwide)
MMR	10.0% (2017)	25%
PHL	5.0% (2020)	83%
THA	27.0% (2020)	87%
VNM	12.5% (2018)	95%

Source: (WEPA 2022). (Note: The number in the parentheses is the year of sewerage system coverage data) a(WEPA 2022). b(P.N. Bao 2021). c(NIES 2021). d(UN-Habitat and WHO 2021).

Note: Singapore is not a member of WEPA.

5.4.6 Emerging pollutants and other issues in the region

Water pollution has been monitored conventionally by measuring physical, chemical, and biological characteristics of water, and the standards are generally set by considering the impacts on human health and ecosystems. In recent years, chemicals included in pharmaceutical and personal care products have been found in freshwater and are considered as emerging pollutants. These pollutants are antibiotics, analgesics and anti-inflammatory, antiepileptics, and other chemicals (Gavrilescu et al. 2015; Gomes et al. 2020). For example, the mortality rate has increased due to the widespread use of antibiotics in human medicine and agriculture, which has fostered the emergence and spread of antibiotic-resistant bacteria in the region. Detection of these emerging pollutants has been reported in Viet Nam, Malaysia, Indonesia, Philippines and Thailand (UNEP 2019c; Da Le et al. 2021; Al-Qaim et al. 2018); meanwhile the occurrence is unknown in other AMS due to a lack of research. In addition to pharmaceuticals for human use, the veterinary use has become a concern in the region because it is expected to increase in the future (H. Q. Anh et al. 2021a).

Plastic pollution is another emerging problem in the entire water system. Microplastics including fragmented pieces of large plastics and microfibers are found in the freshwater systems in the ASEAN region (Alegado et al. 2021). Microplastics is now recognized as an emerging pollutant, but assessment and regulations have not been established for surface waters, though ASEAN began to address the issue and established the ASEAN Framework of Action on Marine Debris in 2019 (Kadarudin et al. 2020).

Saltwater intrusion is a problem in the estuary region of the Mekong River and Thailand as drought conditions have significantly reduced water levels and brought saltwater into rivers (Eslami et al. 2019; Praphornkul 2021). Saltwater intrusion and surface water pollution lead to increased groundwater use, resulting in overexploitation of groundwater as well as freshwater reserves (ADB 2020b). At the same time, overexploitation causes saltwater and polluted water intrusion into aquifers (E. Lee et al. 2018; Shan, Singh, and Haritash 2020).

Sand mining in the Mekong River is also a riverine environmental problem (Hackney et al. 2020). According to Park et al. (2020), the Cambodian Government reported various negative impacts from sand-mining on its riverine systems and banned sand exports in 2009, and the Vietnamese Government also implemented regulations on riverbed sand mining in 2019 (E. Park et al. 2020).

5.5 Impacts

The ASEAN region is endowed with abundant water resources to maintain the livelihoods of its people; however, changes in climate, socio-economic structure, and LULC have negatively affected the quantity and quality of freshwater resources in the region, threatening livelihoods and ways of making a living. Increasing demands for freshwater due to the growing population, industrialization, and agricultural use have limited water availability in several AMS, and people in these countries face water scarcity (Environment Division of the ASEAN Secretariat, n.d.). Tidal amplification, salt intrusion, and high energy demand are some of the factors affecting regional freshwater resources (Eslami et al. 2019), causing people to use more groundwater, depleting an asset of future generations (E. Lee et al. 2018).

5.5.1 Impacts on water resources management

The demand for freshwater from the industrial sector has increased, as the region's economy and population has grown, along with increased urbanization. Although the region is relatively rich in freshwater resources, increasing the supply to meet the growing demand is not an easy task, because water availability is negatively affected by several factors such as surface water degradation, saltwater intrusion, and LULC change. Indeed, due to these problems, significant numbers of households in Indonesia, Lao PDR, Myanmar, and Viet Nam cannot use surface water resources and need to depend on groundwater as their source of clean water (Carrard, Foster, and Willetts 2019).

Surface water degradation is often triggered by nutrient leakages from agricultural as well as industrial activities. The chemical and mining industries are the major sources of surface water pollution since many facilities do not remove chemicals and heavy metals before discharging effluents (Ding 2019). In addition to industrial wastewater, domestic wastewater also negatively affects water quality. Although access to clean water has significantly improved in the region, domestic wastewater is not properly managed in many areas (IGES 2018). Improper management of industrial and domestic wastewaters is the major cause of water quality degradation.

Construction of dams and reservoirs on rivers also affects water resource management because it reduces river flows. One study found that the water level of the Mekong River reached a record low in 2019, dropping 70-75% lower than the same period in the previous year, at all monitoring stations on the mainstream. Additionally, the river's flood cycle has changed, affecting water resource management, fishery, and agriculture in the riparian countries (Phoumin and Thu 2020). According to the Consultative Group on International Agricultural Research (CGIAR) Research Program on Water, Land and Ecosystems, there are 212 commissioned hydropower dams and 44 hydropower dams under construction in the Mekong River Basin (WLE Greater Mekong, n.d.). These dams are being constructed to meet the growing energy demand in the region; however, they have altered the natural flow of the river and streams. Land degradation also contributes to greater variation in river flows, which is further influenced by climate change.

Dams and reservoirs contributed to reduce the sediment by as much as 67% in 2020 (Mekong River Commission 2015). Riverbed mining and deforestation also contributed to the sediment reduction (Thanapon Piman and Shrestha 2017a). The reduction of flow and sediment affects the water supply, bank erosion, and river incisions in the lower basin. Therefore, the stability of the Mekong Delta, and the soil fertility are threatened, particularly in the Tonle Sap and Mekong Delta regions (Thanapon Piman and Shrestha 2017a). Riverbed mining for sand extraction is occurring in the Mekong River Basin. Sand is being exported and imported in the region for construction and land reclamation, but this mining activity contributes to the reduction of the sediment flow (UNEP 2019e).

5.5.2 Impacts on ecosystems and ecosystem services

Reduction and alteration of river and sediment flows as well as degrading water quality all affect related ecosystems and ecosystem services. In general, dams block fish migration, flow reduction makes aquatic plants and fish habitat shrink, and degraded water such as hypoxic water is fatal to aquatic organisms. Considering freshwater ecosystem services which support human society, flow alteration has highly negative impacts on provisioning, regulation and maintenance, and cultural services (Grizzetti et al. 2016). The adverse impacts on cultural services may not be tangible because the benefits depend on individual preference; however, reduction of flows, impacts on aquatic organisms, and water degradation affect recreational uses of freshwater resources.

Furthermore, climate change, variability of rainfall, and extreme weather events are expected to threaten marine, brackish and freshwater environments in the region because saltwater brought by higher sea levels and floods may destroy wetlands and devastate aquatic ecosystems (Chan et al. 2017; Gitz et al. 2015). In the Mekong River Basin, tangible impacts on ecosystems have been reported already. Cambodia reported that the amount of fish caught in 2020 dropped by 31% compared to the previous year, and in Viet Nam, the Mekong Delta Region faced the worst drought and saltwater intrusion ever in 2020, affecting 42.5% of the cultivated area (Ha and Seth 2021).

5.5.3 Impacts on human health and well-being

Improving access to clean water and adequate sanitation reduces the risk of waterborne diseases. As Table 5.5 shows, this access has improved in all AMS. However, due to underdeveloped wastewater treatment facilities, untreated wastewater is often directly discharged into the freshwater system. Raw sewage contains harmful microorganisms, posing a serious threat to human health. In Malaysia, Giardia duodenalis and Cryptosporidium parvum (oo)cysts were found in samples taken from rivers for drinking water, lakes, wells, and drinking water (Y. A. L. Lim and Nissapatorn 2017). These pathogens were also found in samples taken from various freshwater sources in the Philippines, Thailand, and Viet Nam. Acanthamoeba and Naegleria were also found in samples from the Philippines and Thailand (Y. A. L. Lim and Nissapatorn 2017). Leptospirosis is also spread by contaminated water, and related infections were observed in Thailand, Cambodia, Laos, and Viet Nam (Davies et al. 2015).

Raw sewage or untreated wastewater, which contains harmful microorganisms, discharged into receiving water bodies poses a serious threat to human health. In many countries, water from these receiving sources is just simply treated by conventional or simple treatment technologies which are not sufficient to remove these harmful microorganisms, consequently, directly affecting human health. One example is from Tonle Sap Lake, where thousands of people still depend on polluted lake water for their daily use, including drinking and cooking water (Pham Ngoc Bao et al. 2022). The declining water quality may also affect the health and well-being of certain subsets of society, such as rural women, due to their expected role to collect water for cooking, drinking and washing in some areas, such as in Viet Nam, Thailand, and the Philippines (ASEAN and UN Women 2021). Water scarcity increases women's burden and time allocation in collecting water, which may cause negative health consequences (such as back pain) and reduce leisure time for rural women (Nagel 2015). Moreover, in addition to direct human exposure to pathogens in the water, disease can be further spread through human-to-human transmission (Korea Environment Institute (KEI) 2018).

Antibiotics and endocrine-disrupting chemicals are emerging pollutants found in freshwater resources worldwide. These are also found in the ASEAN region, and they are discharged from industrial, agricultural, and residential sources. Water containing antibiotics can cause bacteria to become antibiotic-resistant, and the antibiotic-resistant bacteria are a threat to human health. The possible adverse impacts of endocrine-disrupting chemicals are developmental malformations, interference with reproduction, increased cancer risk, and disturbances in the immune and nervous system functions (US EPA 2021). Anh et al. (2021) reviewed the literature on the presence of antibiotics in surface water in Viet Nam, Thailand, Philippines, Singapore, and Malaysia, finding that possible sources were effluents from hospitals, pharmaceutical companies, aquaculture, livestock production sites, and wastewater treatment plants as well as untreated wastewater and landfill leachates (H. Q. Anh et al. 2021b).

5.5.4 Impacts on the economy

Although the ASEAN region has abundant water to support the economy, changes in water availability could undermine this and threaten human well-being.

The service and industrial sectors are rapidly growing in AMS. The share of service sector employment in the total increased about 104-203% from 2000 to 2018 in all AMS (World Bank 2021b). However, agriculture and fishery are still important sources of livelihoods for many people. Over 30% of the population is employed in the agricultural sector in Myanmar, Lao PDR, Thailand, and Viet Nam (ASEAN Secretariat 2020b). Considering the high share of employment in agriculture, water availability is a critical issue to maintaining local economies.

Furthermore, some prominent industries in the region, such as food/beverages processing, electronics/semiconductor assembly, and pharmaceuticals, require high-quality water in production, and other industries such as agriculture, chemical, electric/gas, metallurgy, mining, paper processing, petrochemical, rice milling, rubber, textiles, and steel, also need a significant amount of water in their production processes (Lorenzo and Kinzig 2020b). Reduced availability and quality of water could adversely affect important AMS industrial sectors and thus their overall economies. Moreover, organic pollutants, heavy metals, oil, grease, and chemical substances found in the effluents from these industries will be released into freshwater ecosystems if the wastewater is not properly managed (Lorenzo and Kinzig 2020b). Agriculture and aquaculture also degrade water resources if pesticides, pathogen, chemical, and organic pollutants are not properly managed (P. T. Anh et al. 2010; Thuy et al. 2012). Important economic activities both affect and are affected by the state of freshwater resources. Thus, more concerted efforts are needed not just for water treatment but also for reuse.

According to an assessment of economic water security by ADB, Malaysia and Singapore are considered to be potentially able to meet all water demand for economic activities, while there are some concerns regarding the situation in Cambodia, Lao PDR, Myanmar, and Viet Nam (ADB 2020b). A number of studies conducted by the World Bank in AMS clearly showed the negative impacts of poor sanitation on the countries' economies. For example, Cambodia, Indonesia, the Philippines and Viet Nam lose an estimated US$ 9 billion a year because of poor sanitation(World Bank 2008), which was approximately 2% of their combined GDP. The annual economic impact is approximately US$ 6.3 billion in Indonesia, US$ 1.4 billion in the Philippines, US$ 780 million in Viet Nam and US$ 450 million in Cambodia.

5.6 Responses

5.6.1 National and city/provincial level responses

There needs to be access to safe and clean water and sanitation services. Many countries have also adopted holistic strategies and approaches for ensuring sustainable water and sanitation development and management such as integrated water resource management (IWRM), which has been implemented at both sub-regional and national levels (ASEAN Secretariat 2017c). This section presents specific examples of responses, good practices and lessons learned, which have been observed in selected ASEAN countries to address the long-lasting challenges regarding water supply and sanitation.

Non-revenue water management in the City of Phnom Penh, Cambodia

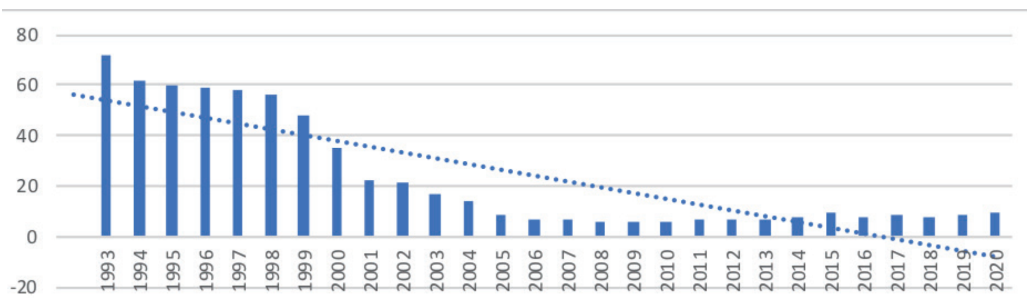
Issues and challenges

One of the major challenges facing most water utilities in the region is the high ratio of water loss (and non-revenue water) along their distribution networks. This negatively affects their ability to meet consumer demands and maintain service quality, as well as their revenue. Unfortunately, this situation is commonly observed in many big cities and countries in ASEAN. For example, similar to other cities, the rate of water loss in Phnom Penh city of Cambodia was reported to be 72% in 1993 (PPWSA 2021). "Non-Revenue Water" (NRW) is often defined as the difference between the amount of water put into the distribution system and the amount of water billed to consumers. The average percentage of NRW is around 30% in Asia, and it can be higher in some ASEAN cities and countries. Meanwhile, the World Bank recommends an NRW loss of less than 25%, which can be considered acceptable (R.B. Singh 2020). Similar to other cities, the rate of water loss in Phnom Penh city of Cambodia was reported 72% in 1993 (PPWSA 2021).

Good practices and lessons learned

Within a short timeframe (1993–2003), with strong political will, dynamic leadership, a new mindset, team spirit and strong support from various development partners, including grants and loans (e.g., ADB, World Bank and Government of Japan), the Phnom Penh Water Supply Authority (PPWSA) has been continuously expanding its network, improving management and operational efficiency, becoming financially self-reliant, and gradually increasing its annual net income. PPWSA implemented six key measures in its water loss reduction programme, including: (i) customer management improvements; (ii) management of water meters; (iii) replacement of old pipes with new ones; (iv) timely repair of leaks in the pipelines; (v) management of water loss in the service areas; and (vi) preventing and deterring offenses. Consequently, the NRW rate decreased to below 10% in 2020, as shown in Figure 5.4 (PPWSA 2021).

Figure 5.4 Non-Revenue Water (%) in Phnom Penh City (1993-2020)



Source: (PPWSA 2021)

In addition, the percentage of bills currently collected both in terms of the number of bills and the value of the bills exceeds 99.5% (PPWSA 2021). The experience of PPWSA can be considered a good example, which provides a valuable lesson for other ASEAN cities in improving their water security through the reduction of NRW.

Community-based sanitation systems in Indonesia

Issues and challenges

Like other ASEAN countries, Indonesia has problems related to poor sanitation and domestic wastewater management. One of the critical issues is the lack of proper sewerage and drainage systems and domestic wastewater treatment facilities. For most households, on-site sanitation systems such as septic tanks are the only major means of wastewater treatment, and the wastewater flows into open road drains and is discharged directly into rivers without further treatment, or it infiltrates into nearby soil.

Conventional centralized wastewater management has failed to meet the needs of low-income people living in urban, peri-urban and rural areas of Indonesia. In Indonesia, the rate of access to piped sewerage is among the lowest in the region. It has been reported that only about 1% of urban wastewater in Indonesia, or about 115 million litres per day, is treated, and 14% of the population excretes outdoors (World Bank 2013). On the other hand, on-site sanitation, mainly in the form of septic tanks, is often inappropriate for solving the problem; thus, intermediate and complementary solutions are needed.

Since 2002, with a strong commitment by the Government of Indonesia and extensive efforts by the international community through multi-stakeholder partnerships between the Government of Indonesia and the Australian Government, nongovernmental organizations (NGOs), and international aid agencies such as the World Bank, the Islamic Development Bank (IsDB), Japan International Cooperation Agency (JICA), and ADB, a large number of decentralized wastewater treatment plants have been constructed under the community-based sanitation programmes called SANIMAS, especially in poor and densely populated urban areas, helping to bridge the gap between on-site and centralized systems. By the end of 2019, nearly US$ 1 billion was invested through six key SANIMAS programmes. Through these programmes, 21,832 SANIMAS decentralized small-scale sanitation systems have been implemented across the country, serving an estimated 6 million people, and the Ministry of Public Works and Housing of Indonesia was responsible for implementing 97% of them (Bappenas 2021).

Despite these significant achievements, there are still many issues that need to be properly addressed to enhance the sustainability of the SANIMAS system, especially regarding operation and maintenance. Remaining issues include: (i) limited budget allocation for ongoing or long-term operation and maintenance (O&M) support by local governments; (ii) lack of monitoring and evaluation activities; (iii) inadequate or limited O&M; (iv) technical design issues; (v) lack of regular desludging; (vii) low connectivity rates and poor network management; (viii) weaknesses in technical capacity and skills for proper operation and maintenance (Bappenas 2021).

Good practices and lessons learned

A recent “Independent Evaluation of the SANIMAS model as an approach for providing decentralized sanitation” led by the Ministry of National Development Planning (Bappenas) and IsDB, in collaboration with other partners assessed the success and limitation factors of the SANIMAS approach. The evaluation also identified lessons learned as well as the feasibility of introducing an updated SANIMAS as a sustainable decentralized sanitation approach for enhancing future sanitation access investments, not only in Indonesia, but also its possible replication in other ASEAN countries. A number of good lessons aimed at facilitating a more sustainable service delivery, while significantly up-scaling implementation and promoting safely managed and sustainable sanitation access for all (Bappenas 2021). Three major aspects have been highlighted in the lessons learned, including (a) institutional (e.g. asset ownership; strengthening a sanitation management unit in all cities/regencies; setting-up a national SANIMAS database and conducting an inventory of existing SANIMAS; improving the capacity of local governments on planning, operation and monitoring; and establish co-management arrangements for operation and maintenance, etc.); (b) technical (e.g. piloting new or innovative technologies and methods; rehabilitating poorly operating and dysfunctional SANIMAS systems and increasing house connections, etc.), and (c) funding (e.g. establishing a model for capital expenditure (CAPEX) and operational expenses (OPEX) financing; setting-up program financing with measurable outcomes and outputs (Bappenas 2021). In addition, the results from this evaluation also indicated the need to define and formalise roles and responsibilities of relevant local government agencies to ensure sustainable urban sanitation infrastructure operation and maintenance and define each agency's performance indicators. Moreover, it is important that a five-year city O&M programme should be introduced and coordinated by provincial governments. The provincial government should be charged to manage and update data of installed infrastructure.

Application of economic tools and measures to complement conventional standard-based approaches for water pollution control in Viet Nam

Issues and challenges

Viet Nam experienced rapid economic growth and urbanization between 2016 and 2020. The total population of Viet Nam in 2020 reached nearly 100 million, of which the urban population accounted for about 37%. Because of rapid urbanization and industrialization, the surface water environment in many large cities is heavily polluted by untreated or partially treated wastewater from a variety of sources, including domestic, industrial, agricultural, and aquaculture. However, domestic and industrial wastewater still account for the largest share. According to the Ministry of Natural Resources and Environment (MONRE), domestic wastewater accounts for more than 30% of the total wastewater discharged directly into rivers, lakes and canals leading to rivers, and is characterized by high levels of organic compounds, nutrients, suspended solids, and large numbers of coliforms (MONRE 2019). The proportion of domestic wastewater collected and properly treated in Class IV urban areas (and above) is estimated to be about 12.5%, an increase of 5% from 2011 to 2015, and there are 45 centralized wastewater treatment plants across the country with a total capacity of about 926,000 m^3/day. In large cities such as Hanoi, only 20.62% of the domestic wastewater generated in the city is treated. Currently, about 80 additional centralized wastewater treatment systems, including the sewers, are planned to be built in ongoing projects, with a total design capacity of about 2.4 million m^3/day (MONRE 2019). Existing septic tanks are also expected to be connected.

In addition to domestic wastewater, other sources of wastewater such as industries, services, and craft villages also affect the urban water environment. In some urban centres such as Hanoi, there are still small production units and craft villages (e.g., food processing and cattle slaughtering) consisting mainly of households, which have not invested in waste and wastewater treatment systems. In Viet Nam, industrial wastewater, especially that generated from industrial and export processing zones, is carefully managed and treated. Environmental pollution prevention and reduction activities in industrial and export processing zones have undergone many positive changes in recent years. The number of industrial zones that invested in the installation of wastewater treatment systems and automatic wastewater monitoring systems increased at an average rate of 1.26%/year between 2016 and 2020 (MONRE 2021). In 2020, the total wastewater treatment capacity of these industrial zones was more than 1.1 million m^3/day (up 4.6% from 2015). Costs for installing automatic monitoring systems should be paid by factories/industrial estates/industrial zones which discharge treated wastewater to the environment, according to the country's new Law on Environmental Protection 2020.

Based on the Government's report on environmental protection in 2020, 90.69% of the operating industrial zones have centralized wastewater treatment facilities, of which 90.9% have installed automatic wastewater monitoring systems. According to Circular No. 31/2016/TT-BTNMT, all factories, production, business, and service facilities located outside of industrial zones/parks and discharging large amounts of wastewater (more than 1,000 m^3/day) must install an automatic continuous wastewater monitoring system and transmit all real-time data directly to MONRE.

Good practices and lessons learned

In recent years, to complement conventional effluent-based approaches for water pollution control, the Government of Viet Nam has focused more on the use of economic tools, including taxes, environmental fees or other forms of sanctions or compensation as measures to complement other conventional standard-based approaches.

The current tax policy aims to limit activities that adversely affect the environment in general and the water environment, as well as activities having a direct or indirect impact on environmental protection. The 2009 Law on Natural Resources Tax stipulates that "natural water, including surface water and underground water, except natural water used for agriculture, forestry, fisheries, and salt production" is subject to a natural resources tax. It is expected that implementing a natural resources tax on natural water will contribute to encouraging sustainable exploitation and rational use of natural resources.

In addition, the environmental protection fee for wastewater has been regulated and implemented since 2003, and regulations on such fees have undergone two revisions to date. According to Decree No. 53/2020/ND-CP, the environmental protection fee for wastewater continues to apply to domestic and industrial wastewater. Collection of the fees has been assigned to local authorities, with the Department of Natural Resources and Environment collecting the fees for industrial wastewater, and clean water service providers (i.e., People's Committees of communes, wards, and towns) collecting the fees for domestic wastewater.

Moreover, sanctions for administrative violations in the field of environmental protection and water resources have also been introduced. Administrative violations related to water environment are specified in two documents: Decree No. 155/2016/ND-CP, related to environmental protection, and Decree No. 33/2017/ND-CP, related to water resources and minerals.

National Strategic Master Plan provides a framework to enhance water security in Thailand

Issues and challenges

Water security has become one of the most important challenges and issues for Thailand due to competing and increasing water demands from major water-consuming sectors such as agriculture, industry, and services. In addition, degradation of water quality due to severe pollution; increasing damage from floods and droughts due to climate change; and fragmented institutional frameworks for water resource management are also key issues affecting the country's water security. Additionally, the decentralized wastewater management approach is relatively new and is not yet part of Thailand's city sanitation plan on a large scale despite its cost effectiveness, coverage, end-product reuse etc. Despite universal sanitation coverage and billions of Baht investment in 105 centralized wastewater treatment plants and over 1,500 faecal sludge treatment plants, the safe treatment of wastewater and faecal sludge accounts for only 27% and 13% of total generated volume, respectively. No single institution is responsible for sanitation in Thailand. Instead, responsibility is distributed among multiple ministries at the national level and multiple departments at the local level. Over 19 ministries are involved in wastewater management. While the Ministry of Public Health (MoPH) and associated departments at the local level are responsible for FSM and developing guidelines, the Ministry of Interior (MoI) and the Ministry of Natural Resource and Environment (MoNRE) and associated local bodies are responsible for wastewater management. The Thailand Industrial Standard Institute (TISI) is responsible for publishing standardized materials and methods for testing performance of prefabricated residential wastewater treatment products. This has resulted in overlaps and gaps in roles and responsibilities. Furthermore, local bodies lack the capacity to construct and operate treatment plants and heavily rely on central government funds. They also cannot afford to use the local budget for the operation and maintenance costs even for centrally funded wastewater treatment plants.

Good practices and lessons learned

Thailand's National Strategy (2018-2037) provides a framework for security, prosperity, and sustainability for all, and it mainstreams water security as part of its eco-friendly development and growth strategy. Specifically, Thailand is working to achieve eco-friendly water, energy, and agriculture and food security by (i) developing the entire river basin management system; (ii) improving water system productivity through efficiency and value addition; (iii) developing a national energy strategy; (iv) improving energy efficiency; and (v) strengthening agriculture and food security at the national and community levels (NESDB 2019).

Furthermore, the Plan focuses on water quality management of surface water and coastal water using appropriate methods suitable for different uses. Methods include reducing and controlling pollution released from various pollution sources, for example, the application of a permitting system and the Polluter Pays Principle (PPP). Moreover, the Plan indicates short, medium, and long-term strategies and goals for water quality management and water resource conservation to be implemented by the coordinating and operating agencies. The Plan is generally focused on management at point sources – installing and upgrading community treatment facilities. The Plan aims to develop 741 new wastewater treatment plants, upgrade existing ones and improve onsite household sanitation systems, and 60 million Baht (US$ 2 million) is already being invested for SDG implementation.

Additionally, for the next two decades, the Wastewater Management Authority (WMA) plans to develop 464 wastewater treatment facilities, both decentralized and centralized. Among the proposed facilities, about two facilities will be funded by central government, and about 10 facilities will be managed as public-private partnerships, while the remaining facilities would be developed by WMA. The WMA secured funds for 2021 to construct about six centralized wastewater treatment facilities. Also, the WMA has installed monitoring systems at the wastewater treatment plants and has been providing services to 41 units as of the time this report was prepared.

5.6.2 Regional level responses

Recognizing the importance of regional cooperation towards sustaining the quality of freshwater resources and ensuring equitable access of acceptable quality, AMS adopted the ASEAN Working Group on Water Resources Management (AWGWRM) Action Plan. The main objectives of the AWGWRM Action Plan are: (i) to promote IWRM for sustainability of water resources, equitable accessibility, and sufficient water quantity of acceptable quality to meet the needs of the people, economy and environment; (ii) to manage water resources efficiently and effectively in order to provide adequate and affordable water services; (iii) to reduce the number of people without sustainable access to safe drinking water and improved sanitation; and (iv) to reduce risks and impacts of water-related disasters (such as flood, drought, storm, etc.) and strengthen resilience of social and ecosystem (ASEAN Secretariat 2016c).

In 2009, the ASEAN Working Group on Water Resources Management developed and adopted the IWRM Performance Indicators to monitor and evaluate the progress and achievements of IWRM in ASEAN member countries on six water management issues, including water supply management, irrigation management, storm-water management, flood management, water pollution management, and sanitation management. The IWRM Performance Indicator Framework was revised in 2015, which includes four types of indicators: (1) outcome indicators, (2) enabling environment indicators, (3) institutional setting indicators, and (4) management tool indicators (ASEAN Secretariat 2005).

Later, a web-based ASEAN Water Data Management and Reporting System was also established as a platform for sharing Annual Reports on IWRM's performance indicators. It also provides an expandable framework for an ASEAN regional river monitoring system. This system would allow ASEAN to commence assessing the status and broad trends relating to the overall condition and water quality of rivers across the region by (i) designing a limited, agreed and affordable programme that requires national water management agencies to measure, assess and report on a regular basis; (ii) making full use of existing monitoring programmes (to maximize cost effectiveness); (iii) maximizing national consistency in monitoring related to water quality and river management; and (iv) building the initial programme in a way that enables future expansion (ASEAN Working Group on Water Resources Management (AWGWRM) 2022).

In addition to ASEAN 2025: Forging Ahead Together and ASPEN, the ASCC Blueprint 2025 also contains several commitments related to water and sanitation, including: “(i) adopt good management practices and strengthen policies to address the impact of development projects on coastal and international waters and transboundary environmental issues, including pollution, illegal movement and disposal of hazardous substances and waste, and in doing so, utilize existing regional and international institutions and agreements; (ii) enhance policy and capacity development and best practices to conserve, develop and sustainably manage marine, wetlands, peatlands, biodiversity, and land and water resources; and (iii) promote coordination among relevant sectors to provide access to clean land, green public space, clean air, clean and safe water, and sanitation”. Recognizing the interlinkages between water and other sectors, the ASCC Blueprint 2025 emphasized that cross-sectoral and cross-pillar coordination to ensure clean water and sanitation should be considered as one of the strategic measures for strengthening and optimizing financing systems, food, water and energy supply, and other social safety nets during crises, by making resources more available, accessible, affordable and sustainable (ASEAN Secretariat 2016b).

As briefly mentioned earlier, many AMS have experienced an increase in the frequency, severity, and magnitude of drought events over the past two decades, which not only affects the consumption of water for agriculture and domestic and industrial use, but also has long-term impacts on local people and the environment. In 2020, ASEAN Leaders adopted the first ASEAN Declaration on Enhancing Drought Adaptation, which aims to further strengthen coordination at the regional and national levels to achieve sustainable management of drought. Less than a year later, ASEAN member countries adopted the ASEAN Regional Plan of Action for Drought Adaptation (ARPA-AD) 2021-2025. This plan will facilitate the development of effective drought policies to manage drought risks, strengthen adaptive capacity, and minimize the vulnerability of affected groups and sectors to drought. The Plan of Action outlines nine key actions, complemented by 26 sub-actions, covering the areas of risk assessment, early warning systems, adaptive actions, response and recovery, ASEAN sectoral coordination, cooperation with external partners, capacity building, data sharing, and monitoring and evaluation. The following principles are set as the guidance of implementing ARPA-AD: (1) institutionalization, localization and communication; (2) finance and resource mobilization; (3) gender and social inclusion; (4) multi-hazards approach; (5) innovation; (6) partnership; and (7) synergy (ASEAN Secretariat 2021f).

In addition to the regional cooperation efforts discussed above, AMS have established a number of regional platforms (working groups, learning forums, workshops, conferences, etc.) to facilitate the sharing of information, knowledge, good practices, practical experiences, and to build capacity among member countries to implement the IWRM approach. The AWGWRM is a well-known established regional platform, aiming to work on five programme areas: (i) IWRM country strategy guideline and indicator framework implementation; (ii) public awareness and cross-sectoral coordination; (iii) water conservation; and (iv) improvement of water quality and sanitation; and (v) water-related disasters (ASEAN Secretariat 2017c).

The ASEAN Secretariat and AMS have also been collaborating with various development partners and international organizations on specific projects and activities. For example, the ASEAN Secretariat has collaborated with United Nations Development Programme (UNDP) to improve IWRM, reduce pollution loads from nutrients and other land-based activities, sustain freshwater environmental flows and reduce climate vulnerability through demonstrations and replications in selected AMS (ASEAN Secretariat 2017c).

A recent project funded by JAIF entitled: "Policy Dialogue and Network Building of Multi-stakeholders on Integrated Decentralized Domestic Wastewater Management in ASEAN Countries" was implemented by the National Institute for Environmental Studies (NIES) and IGES, who have worked closely with all AMS. This project has successfully served as a policy and institutional development platform and technical showcase for multi-stakeholders on integrated management of decentralized domestic wastewater treatment in AMS. Outcomes from the project have also contributed the ongoing efforts of ASEAN countries in achieving relevant targets under SDG 6 (NIES 2021). As a continuation of this success, Phase 2 of the project, Strengthening Capacity Development for Local Governments in ASEAN to Tackle Microplastics and Water Pollution through Decentralised Domestic Wastewater Management Approach, is being implemented to support ASEAN countries in achieving inclusive, sustainable, resilient and dynamic development from 2022 – 2024.

ASEAN has also been closely collaborating with the MRC under the Cooperation Framework between ASEAN and MRC. The Cooperation Framework provides a framework for developing and maintaining cooperation between ASEAN and MRC in the field of their common interests in integrated water resources management to ensure close coordination and better utilization of water and water-related resources, such as sustainable management of rivers and basin development including the Mekong River Basin, and integrated management of land-sea ecosystems. The Cooperation Framework between ASEAN and MRC focuses on areas such as (i) basin development planning; (ii) strategic cooperation on water resources management; (iii) climate change adaptation; (iv) environment management; (v) flood and drought management; and (vi) any other areas, including but not limited to sustainable fisheries and aquaculture development, based on mutual interest and agreement of ASEAN and MRC. The ASEAN-MRC Water Security Dialogue is one of the initiatives implemented under this Framework which aims to share innovative solutions and best practices in addressing emerging water security issues across the ASEAN region.

In May 2021, with support from the World Bank, ASEAN also successfully launched the ASEAN Regional Action Plan for Combating Marine Debris in the AMS, which is expected to play an important role in helping to reduce unnecessary use of plastics, increase plastics recycling, and minimize plastics leakages on land and in water bodies, as well as protect vital marine environments.

5.6.3 Responses to COVID-19

Many governments recognized that to protect public health during the COVID-19 pandemic, the provision of clean drinking water and improved water treatment and sanitation services is critical, especially in low-income countries. Consequently, investments for sanitation sector, including water treatment facilities, increased in some countries, as one of the countermeasures for mitigating COVID-19 impacts.

The COVID-19 pandemic also affected sanitation policies in many AMS. For example, Viet Nam and Lao PDR introduced new policies/regulations on sanitation considering the potential impacts of the COVID-19 pandemic and provided investment funds for improving sanitation infrastructure, especially related to healthcare waste and wastewater treatment, to minimize the risks to public health.

5.7 Way forward

5.7.1 Summary of major points

Over the past several decades, the ASEAN region has made remarkable progress in improving water resource management, providing clean water supplies and improved sanitation. However, despite the geographical abundance of water resources, overexploitation of water resources, combined with the adverse effects of climate change, has led to increased salinization of coastal waters and agricultural systems in many ASEAN countries. In addition, urban and industrial water pollution, changes in land use, mismanagement, and lack of proper wastewater treatment facilities, particularly for domestic wastewater, and poor sanitation have a significant impact on water quality, which in turn threatens water security in the region. River fragmentation is also another critical issue, especially in the countries of the Mekong River Delta, which has a negative impact on fish migration and biodiversity. Moreover, changes in precipitation patterns have intensified water-related disasters and drought in some areas. Although some regional efforts have been made, recent rapid economic growth, urbanization, unpredictable effects of climate change, and the ongoing COVID-19 pandemic have led to a need for further regional efforts to ensure regional water security, and to assist the member countries to achieve relevant targets under the SDG 6 on water and sanitation by 2030.

5.7.2 Policy recommendations to address major national and regional water security issues

The AMS economies depend on freshwater and are closely linked with the regional and global economies. Water scarcity, water degradation, and loss of ecosystem services are still observed in some areas in the region; thus, collaborative efforts are needed to solve man-made problems and mitigate impacts from natural disasters. Since the region occasionally faces emerging issues, more frequent evaluation of existing efforts and updating regional and national policies would help to respond more effectively to these emerging problems. Setting numerical goals and targets both regionally and nationally, as well as utilizing multilevel and multiscale governance approaches and effective regular monitoring systems are also recommended.

The new SDG6 Global Acceleration Framework, coordinated by UN Water and based on requests from member countries, has further mobilized the support of the international community to facilitate achievement of the SDG 6 targets. As part of the Decade of Action, the framework is expected to help drive rapid results at scale through four pillars of action to achieve SDG 6 by 2030: (i) engagement - rapid response to country requests through leveraged expertise and mobilization; (ii) alignment - coordinated approaches across sectors and actors through unified strategies and initiatives; (iii) acceleration - eliminating bottlenecks through five accelerators; and (iv) accountability - strengthening accountability through joint review and learning to strengthen accountability. In addition, five key accelerators have been identified to accelerate progress towards SDG 6, including financing, data and information, capacity development, innovation, and governance (UN-Water 2020). The AMS could consider how to make use of the SDG6 Global Acceleration Framework.

The integrated approach of the SDGs also suggests that if people have access and benefit from water and sanitation services, it might help to generate support for a taxation or tariff system that supports the operation of these systems and their expansion and renovation over time. This could be promoted through better communications strategies, especially for local governments and communities.

Promising progress on SDG 6 has been observed in some AMS, especially on improved access to safe and clean water, improved sanitation and ending open defecation. However, most of the targets are still not on track and will not be reached by 2030 without stronger national efforts, as well as regional and global support (UN-Water 2021).

Specific issues that need to be addressed and possible solutions:

- Practical technical guidelines on the ground are lacking, especially related to the proper design, operation and maintenance of onsite and off-site sanitation, wastewater, and faecal sludge treatment systems, for either centralized or decentralized treatment systems. Detailed technical guidelines are needed for effective enforcement and implementation of relevant national laws and regulations at the city/provincial or local levels.

- The capacity of institutions for monitoring and data management needs to be strengthened. As discussed earlier, data availability and quality data with a high level of reliability remain among the greatest challenges for most ASEAN countries, particularly data on treatment and disposal of excreta from on-site sanitation facilities such as septic tanks and latrines, and off-site wastewater treatment facilities (either through centralized or decentralized systems). Monitoring and data on all wastewater streams are insufficient. These data gaps result from weak technical capacity and limited financial resources. Examples include lack of monitoring infrastructure or facilities, lack of data management systems, and low staff expertise (UN-Water 2021). Therefore, efforts to further increase national-level capacity on data management for SDG 6 monitoring by improving technical and institutional capacity, as well as monitoring facilities or infrastructure are urgently needed. Greater involvement of industry and the public in monitoring is also desirable. In addition to the SDG 6 monitoring, an "Integrated Municipal Information System" can be also established at city and regional level, which will enable planning and implementation of the SDG 6 related projects or programmes. This initiative has been successfully implemented in South Asia (e.g., cities in Bangladesh) (SNV Netherlands 2022).

- There is a lack of effective inter-sectoral coordination mechanisms and coordinated investments between water-related sectors, as well as effective institutional collaboration and stakeholder participation at different levels, including the national, subnational and basin level (UN-Water 2021). Therefore, it is necessary to improve cross-sector coordination and integration on freshwater security, on both vertical and horizontal dimensions, to facilitate the achievement of SDG 6 targets.

- Various good practices observed in AMSs as discussed in the section 5.6.1 and 5.6.2 indicated that: (i) there is no silver bullet or no single solution to solve the problem. It is clear that an integrated approach should be employed for effectively addressing the challenge of water security in the region; (ii) a strong political motivation, dynamic leadership, new mindset, team spirit and strong support from external partners are critical to create progress as in the case of Phnom Penh, Cambodia; and (iii) willingness to learn and to involve communities in developing functioning systems for sanitation and wastewater treatment, rather than just building infrastructure.

- There is a strong need for further strengthening both national and transboundary water resources conservation and management. Collaboration on transboundary water resources could bring riparian countries up to the same level of capacity, especially in terms of data-sharing, joint planning and monitoring, notification of planned developments. In addition, countries with less IWRM capacity will have opportunities to strengthen their capacity through participation in joint activities with more advanced riparian partners, such as joint monitoring or joint assessments, resulting in creating win-win solutions for all.

- Climate change may continue further adversely affect water security in the region, increasing production costs and inequitable access to clean water, and reducing the effectiveness of existing water and sanitation services. Therefore, innovative water and sanitation technologies or systems that are climate-smart or climate-adaptive should be adopted as alternative solutions compared to traditional methods.

- Lastly, strong political prioritization and support and further commitments from both central and local governments, especially in terms of sufficient budget allocation for the improvement of the water and sanitation sector's performance, is urgently needed.

Chapter 6
Coastal and Marine Environment

Main Messages

- Except for land-linked Lao PDR, the remaining ASEAN Member States (AMS) are bordered by seas. Those seas, however, are under increasing direct and indirect pressure from human interference, including the preference for many forms of development in the region's coastal zones and islands.
- Aquaculture is rapidly replacing overexploited capture fisheries as an important source of exports from the ASEAN region.
- Coastal and marine waters in the region are increasingly affected by shipping, offshore oil and gas, pipelines and cables, sand mining, wastewater disposal, tourism resort development, and potentially seabed mining, with accumulating impacts on marine biodiversity and water quality.
- The Coral Triangle is referred to as the "global epicentre of marine biodiversity" and is home to 76% of the world's 798 coral species and 37% of the world's 6,000 coral reef fish species but is subject to illegal fishing, and coral mining for construction, increased coral bleaching due to climate change, among other damaging practices.
- The estimated economic value of coastal and marine ecosystem services at risk from poor management in ASEAN ranges from US$ 62,400/km^2/yr. for coastal protection and fisheries to US$ 23,100 - US$ 270,000/km^2/yr. for fisheries, coastal protection, tourism, and recreation.
- Climate change will have major impacts on ASEAN's extensive shorelines and coastal waters, as the projected sea level rise of 1 m by 2100 would affect 410 million people, with 59% in tropical Asia. The effects of sea level rise will be exacerbated by land subsidence, which can exceed 25 mm/yr. in coastal cities like Jakarta.
- Current responses include an inadequate coverage of marine protected areas, coastal zone adaptation plans, a Strategic Plan of Action for ASEAN Cooperation on Fisheries (2021-2025), and sustainable port development.
- High priority should be given to integrated coastal zone planning and management, incorporating climate change adaptation.
- National Adaptation Plans (NAPs) should include major efforts to protect coastal and marine assets and livelihoods, and marine protected areas should be expanded, possibly through the designation of more Marine Heritage Parks in the region.
- The ASEAN region should develop a common strategy for handling decommissioning of offshore oil and gas facilities, as well as improved environmental management of undersea pipelines and cables.
- The recently updated Strategic Plan of Action for ASEAN Cooperation on Fisheries (2021-2025) highlights the need to complete the outstanding activities from the previous plan (2015-2020).
- Other ASEAN initiatives that should be further strengthened include the ASEAN Leaders' Declaration on Blue Economy, ASEAN Comprehensive Recovery Framework (ACRF), and the ASEAN Mangrove Restoration Initiative.
- Implementation of SDGs 14 and 15 on land and ocean ecosystems, as well as SDG 12 on sustainable consumption and production, would especially contribute to the improvement of coastal and marine ecosystems.

6.1 Introduction

Except for land-linked Lao PDR, the remaining AMS are bordered by seas. Those seas, however, are under increasing direct and indirect pressure from human interference. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) "human activities have had a large and widespread impact on the world's oceans. These include direct exploitation, in particular overexploitation, of fish, shellfish and other organisms, land- and sea-based pollution, including from river networks, and land-/sea-use change, including coastal development for infrastructure and aquaculture" (IPBES 2019). At the global level, only 3% of the ocean is regarded as free from human pressure (IUCN 2021). In a geographic region (i.e., southeast, east, and south Asia) hosting half of the world's population it is almost inevitable, therefore, that ASEAN regional coastal and marine ecosystems and associated biodiversity are under increasing pressure from direct and indirect uses (see Chapter 4).

The South China Sea, bordered by AMS and China, separates ASEAN from the vast Pacific Ocean, while the Andaman Sea links Thailand and Myanmar to the Indian Ocean. As there are multiple disputes about overlapping territorial water claims in the South China Sea, the areas currently claimed as the Exclusive Economic Zone (EEZ) of AMSs may change in future, so they are not listed here. Collectively, however the ASEAN EEZs cover at least 11 million km^2 or about 3% of the global area covered by sea.

6.2 Drivers affecting coastal and marine utilization

6.2.1 Fishing and mariculture

Global fish production in 2014 was 167.3 million tonnes, of which ASEAN supplied 18.3% (i.e., 30.6 million tonnes). Modelling by the International Food Policy Research Institute shows that fish production in the ASEAN region will supply about one quarter of the world's fish demand from 2030 to 2050 (Chan et al. 2017). About half of that will come from aquaculture (Pangasius spp., carp, tilapia, and shrimp) although capture fisheries will retain an important complementary role. Aquaculture production in the ASEAN region has increased by four times from 2000 to 2014 and has transitioned from small-scale capture fisheries to larger aquaculture farms for export markets (Chan et al. 2017). In addition to fish, the ASEAN region is an important source of seaweed, with Indonesia responsible for one third of the world's total output. Per capita consumption of seafood in AMS also ranks number one globally at 35.2 kg/capita/annum. Other related products are fish oil and fish meal (Chan et al. 2017).

Table 6.1 Projected growth of fish production in ASEAN 2015-2050

Indicator	2015	2020	2030	2040	2050
			Thousand tonnes		
Total fish production	33,298.7	41,662.7	50,313.9	52,032.9	53,301.6
Aquaculture production	13,292.6	18,387.7	24,793.1	26,658.3	27,400.2
Capture fisheries	20,481.1	23,956.7	26,757.5	26,791.9	26,767.8
Net trade	6,348.2	10,173.3	10, 982.6	5,793.6	3,648.9
			Kg/capita/annum		
Per capita consumption	38.4	43.1	51.5	58.9	61.5

Source: (Chan et al. 2017)

As of 2019, Indonesia has the largest reported number of fishing folk according to the Southeast Asian Fisheries Development Centre (SEAFDEC) with about 5.6 million people engaged in the sector—48.4% in aquaculture, 41.2% in marine capture fisheries, 9.2% in inland capture fisheries, and the balance unspecified (SEAFDEC 2019b). The second largest is Malaysia with almost 150,000 people, of which 84.8% are in marine capture fisheries (SEAFDEC 2019b).

6.2.2 International and intra-regional shipping

In 2019, ASEAN's merchandise trade had grown to US$ 2,815.2 billion, trade in services was US$ 844.6 billion, and foreign direct investment was US$ 160.6 billion. Much of this trade is moved by international and intra-regional shipping. Intra-ASEAN trade is about 23% of the total merchandise trade. The largest external markets are China (14.2%), USA (12.9%), EU-28 (10.8%) and Japan (7.7%) (ADB 2020a).

More than 80% of the world's merchandise trade is transported by sea. The global volume of merchandise trade in 2019 was 11.08 billion tonnes, with a world fleet of 98,140 ships greater than 100 gross tonnes, or 2.06 billion deadweight tonnage (dwt) (Han, E.S., Goleman, D., Boyatzis, R., Mckee 2020). Some 811.2 million twenty-foot equivalent units (TEUs) of containers were handled in ports worldwide. Since 1970, the global volume of shipping has grown more than four times, with the greatest growth in bulk items (i.e., iron ore, grain, coal, bauxite/alumina, and phosphate) (Han, E.S., Goleman, D., Boyatzis, R., Mckee 2020).

In the ASEAN region, Indonesia is the world's largest exporter of coal, with a 35% market share, followed by Australia at 29.7% (Han, E.S., Goleman, D., Boyatzis, R., Mckee 2020). Partly as a result of trade sanctions on China, manufacturing is moving to some ASEAN countries and export container trade has increased from Malaysia, Thailand, Viet Nam, and Indonesia. Singapore and Malaysia have some of the heaviest container port traffic in the world, after China (e.g., Shanghai, Ningbo-Zhoushan, Shenzen, Guangzhou, Qingdao).

In relation to future port development, Cambodia and Indonesia need to increase capacity to handle larger vessels and increased traffic while Viet Nam needs to invest in deep water berths, with the infrastructure gap estimated as US$ 12 billion (Han, E.S., Goleman, D., Boyatzis, R., Mckee 2020). Land reclamation for port development or expansion is also responsible for adverse environmental impacts.

6.2.3 Oil and gas development

According to the ASEAN Energy Outlook 2017-2040, continuation of historical trends will see ASEAN's energy demand double by 2040, mostly met by fossil fuels, including major increases in offshore oil and gas (ASEAN Centre for Energy 2020a). Modelling of the total final energy demand indicates that oil and gas would make up 44% of the 624 million tonnes of oil equivalent (Mtoe) required in 2040.

In general, offshore production of oil and gas in ASEAN waters has been in decline in recent years as the fields mature, making the region increasingly dependent on imports. Oil and gas producers in ASEAN, however, see good prospects for gas development, with recent large finds off Sarawak, for example (Jacobs 2021). Natural gas is seen as a bridging fuel in the region, as coal is being phased out to achieve a net-zero carbon future by 2050. Indonesia offshore output declined from 1.5 million barrels per day (bpd) to less than 700,000 bpd in 2020. The Indonesian government, however, hopes to boost production to 1 million bpd to meet half of the projected domestic demand (Jacobs 2021). To meet this production target, Indonesia may need to drill 1,000 additional wells annually by 2030.

Another driving force likely to have major environmental implications is the proposed trans-ASEAN gas pipeline, which is intended to interconnect the gas pipeline networks of AMS (ASCOPE, n.d.). The ASEAN Council on Petroleum (ASCOPE) projects that ASEAN gas production will grow by 30% over the next two decades. The original masterplan for the gas pipeline (issued in 2000) proposed 4,500 km of pipelines, mostly undersea, with an initial price tag of about US$ 7 billion. Most of the connections to date are bilateral, but already covered more than 3,673 km in 2017 (ASCOPE, n.d.; Shi, Variam, and Shen 2019). Integrated gas markets triggered by the trans-ASEAN gas pipeline would also encourage further development of domestic gas production (Shi, Variam, and Shen 2019).

6.2.4 Construction material

Sand is not often regarded as a driver of environmental degradation, but its role in development of AMS is increasingly being recognized. For example, if all the proposed hydropower dams on the Mekong River were developed, then about 96% of the sediment flow would be trapped behind dam walls, with drastic implications for the delta region and the region's fisheries (Thanapon Piman and Shrestha 2017b). Offshore sand and rock extraction are also having major impacts on coastal and marine ecosystems.

Two examples from Malaysia are the Forest City Project (Clark 2020a) and Penang South Reclamation (J. W. S. Zeng 2020). The Forest City is part of the Iskandar Malaysia Special Economic

Zone, providing a mix of residential, commercial, and industrial uses, for an ultimate population of 700,000 residents. The land reclamation has created four artificial islands covering 30 km^2, close to Singapore and is being promoted as a "smart and green futuristic city" (Clark 2020a). Planned for completion by 2035, the estimated costs are of the order of US$ 100 billion. For the Penang South Reclamation, covering three islands (18.2 km^2) mining and dredging of 189 million m^3 is underway, with sand coming from Port Klang and 20 km off the coast of Perak (Hasnan 2019; J. W. S. Zeng 2020).

The United Nations Comtrade website shows that Cambodia has been the major exporter of sand from 2008-2017 (80,095.2 tonnes) followed by Viet Nam (73,714.2 tonnes), Malaysia (48,216.7 tonnes), Myanmar (27,587.1 tonnes) and Philippines (9,137.7 tonnes), with negligible amounts reported by Thailand and Indonesia (United Nations n.d.).

The global demand for sand is 40-50 million tonnes annually and illegal trade in sand has affected more than 70 countries (Bendixen et al. 2019). In 2007, Indonesia banned the export of sand as the islands it was extracted from started to erode. Malaysia has also recently banned the export of sand from the sea in 2019, although river sand can still be exported.

6.2.5 Climate change

While the details on climate change are included in Chapter 3, climate change should be recognized as a driver of possibly irreversible change in the planet's oceans and seas. While climate change is often characterised as increased surface air temperature over land, the oceans act as a major sink for the increased heat generated by the greenhouse effect, absorbing around 90% of the excess heat attributable to GHG emissions. The oceans have warmed, on average, by 0.18°C per decade since 1981. Possibly the most immediate impact of this increasing heat is the inability of coral reefs to withstand warming waters, which initially affected the upper oceanic waters but increasingly affect the entire water body down to the ocean floor. Warming water is also leading to reduced sea ice at both poles and contributing to polar glacial melt which has the potential to raise sea levels well beyond the ability of coastal populations to adapt. Marine mammals and fish species are also affected as they seek cooler waters, which in turn may impact on the contribution of the fisheries sector to the national economy. Marine species which are unable to move to cooler waters will either disappear or adapt to the higher temperatures.

6.3 Increasing pressures on the coastal and marine environment

6.3.1 Urbanization and recreational resorts

There are at least 100 coastal cities in AMS, including mega-cities such as Hanoi, Ho Chi Minh City, Bangkok, Jakarta, Singapore, Kuala Lumpur, and Manila (World Bank 2010). Many of these cities are also prime destinations for tourism (Table 6.2). International and intra-ASEAN tourism has been growing at a phenomenal rate, essentially doubling over the past decade.

Table 6.2 Tourism arrivals in ASEAN

AMS	2011 (‘000)	2015 (‘000)	2019 (‘000)
BRN	242	218	333
KHM	2,882	4,775	6,610
IDN	7,650	10,407	16,110
LAO	2,724	4,684	4,790
MYS	24,714	25,721	26,100
MMR	816	4,681	4,360
PHL	3,917	5,361	8,260
SGP	13,171	15,231	19,110
THA	19,098	29,881	39,800
VNM	6,014	7,944	18,010
Total	81,229	108,904	143,480

Source: (Statista 2021e; ASEAN Secretariat 2017c)

Viet Nam’s coastal population is expected to grow from 43.1 million in 2000 to 80.4 million in 2060, while the Philippines could see an increase from 13 million to 34.9 million over the same duration, exposing them to sea level rise, flooding, and typhoons (Li-Lian 2020; ADB 2017a). Out of 50 cities with a population of more than 1 million, 18 are located on the coast (Simarmata 2020).

Examining tourism development in Thailand, the authors concluded that “rapid urbanization from tourism development is the main driver of environmental changes and makes the areas vulnerable to climate change-related risks” (Nitivattananon and Srinonil 2019)

6.3.2 Land-based pollution and marine litter

Since the 1950s, global plastic production has amounted to almost 8 billion tonnes, of which less than 20% has been recycled or incinerated (Salhofer et al. 2021). The remainder has been deposited into landfills or watercourses, where it finds its way to the sea. Marine plastic litter, globally, has increased by 10 times since 1980, affecting at least 267 species of turtles, seabirds, and mammals (IPBES 2019). ASEAN countries are among the main sources of marine plastic litter. Land-based pollution is also an important source of coastal, marine, and estuarine water quality degradation throughout the ASEAN region (ASEAN Secretariat 2008).

With China's ban on imported plastic waste coming into force in 2018, waste exporters have been looking for other destinations, legally and illegally, including AMS. From 2015-2018, scrap plastic imports to Indonesia increased 485%, Malaysia 193%, and Viet Nam 111% (Salhofer et al. 2021). The plastic industry has grown very rapidly in Viet Nam (11.6% per annum from 2012-2017) and is now one of the top 20 plastic product exporters, sending products to more than 55 countries. In Viet Nam, so-called "craft villages" are involved in plastic waste informal recycling using very basic technologies to partially feed this increase in plastic production. Households may focus on sorting, shredding, cleaning, or processing plastic granules, with some villages processing up to 600 tonnes/day (Salhofer et al. 2021). During collection, or from uncontrolled storage on roadsides, plastic waste is easily blown away or washed into drains or streams during rainstorms. Very small particles of plastic, or microplastics and nano-plastics, are becoming increasingly difficult pollutants in all aquatic environments and may be transferred by wind and water.

6.3.3 Ballast water discharges

Ballast water is taken into a ship or discharged from the ship to balance the vessel while loading or unloading (H. C. Yang et al. 2018). As ballast water is carried around the globe it contains the marine species and pollutants taken up with that water, posing significant problems when discharged. The International Convention for the Control and Management of Ship's Ballast Water and Sediments entered into force in September 2017. Currently 82 countries have ratified/acceded to the Convention, covering more than 80% of the global tonnage. Among ASEAN countries these include Indonesia, Malaysia, Philippines, and Singapore (as of March 2019) (Lloyd's Register 2019). Unlike other regions, there is currently no regional requirements aligned to the Convention. Parties to the Convention are generally required to install waste treatment systems in their flagged vessels if there is no authorized safe discharge zone more than 200 nautical miles from land and in waters at least 200 m deep (coastal organisms are not expected to survive in remote ocean areas). Ballast water should only be discharged after removing potentially harmful organisms.

6.3.4 Undersea pipe and cable laying

The extent of submarine cables globally would surprise many and ASEAN has its fair share of these cables, such as (i) Asia Direct Cable (Singapore. Thailand, Philippines, Viet Nam, China, Japan – 9,400 km) (ii) Asia-Africa-Europe (25,000 km); (iii) Asia Pacific Gateway (10,400 km); (iv) Asia Submarine-cable Express/Cahaya Malaysia (8,148 km); (v) Asia-America Gateway Cable System

(20,000 km); (vi) Australia-Singapore Cable (4,600 km); (vii) SEA-US (14,500 km); and (viii) Bifrost (15,000 km), among others. Singapore alone has 11 submarine cables connecting it to the rest of the world (TeleGeography 2022). Globally there are 464 submarine cables with 1,245 landing points and at least 36 new cables are planned.

While most cables are laid on the seabed or buried, some are in the water column (e.g., servicing offshore oil platforms or connecting to offshore wind turbines) (Taormina et al. 2018). Seabed burial is achieved with a cutting wheel for rocky areas or high-pressure water jets, with the extracted material returned to fill in the trench. Damage to the offshore environment includes habitat loss, chemicals, electromagnetic emissions, entanglement with fishing gear, although much more research is needed on these impacts (Taormina et al. 2018).

6.3.5 Deep sea mining

There is increasing interest in mining the sea floor for polymetallic nodules, which contain many of the minerals needed for solar panels and wind turbines as well as other modern technologies. These nodules contain manganese, iron, nickel, copper, cobalt, and rare earths. The seabed minerals may be available in larger volumes and at higher grades than deposits on land (Schlossberg 2021). The International Seabed Authority, which was set up to regulate such mining in international waters, has granted 22 exploration contracts (International Seabed Authority, n.d.). The Singapore company, Ocean Mineral Singapore, for example, has a 15-year contract to explore 58,000 km^2 of the Pacific Ocean seabed.

Understandably there is some concern about the largely unknown environmental consequences of deep-sea mining and the disruption to previously unstudied ecosystems (Filho et al. 2021). To date, AMS have had minimal input to controlling this potentially harmful form of mining (Nugroho and Putranti 2018).

6.3.6 Damage due to extreme weather events

Climate change will also cause extreme weather event impacts not only on coastal zones but also on shipping, fishing, and oil and gas production at sea. There is increasing ability to attribute extreme weather events to climate change (Masson-Delmotte et al. 2021; IPCC 2021a). The Intergovernmental Panel on Climate Change (IPCC) has concluded “It is very likely that human influence is the main contributor to the observed increase in the intensity and frequency of hot extremes and the observed decrease in the intensity and frequency of cold extremes on continental scales. Some specific recent hot extreme events would have been extremely unlikely to occur without human influence on the climate system” (IPCC 2021a).

More than 90% of the increase in the Earth’s total energy has been stored in the oceans, thus providing the “fuel” for increased intensity of extreme weather events, such as cyclones. Marine heatwaves have become more frequent and intense, especially since the 1980s, and are projected to become 4-8 times more frequent by the end of the century (IPCC 2021a).

6.4 State and trends of the coastal and marine environment

6.4.1 Coastal and marine water quality

Recent coastal and marine water quality data are not readily available, but the Water Environment Partnership in Asia (WEPA) does provide some earlier data.

For example, in 2003, Thailand set up 240 monitoring stations along its 2,600 km coastline and found that 68% of the locations had "very good" to "good" quality, 30% were "fair" and 3% were "poor" (WEPA n.d.). An update in 2018, found 1% "excellent", 58% "good", 35% "fair", 5% "poor", and 1% "very poor" (Ministry of Natural Resources and Environment Pollution Control Department of Thailand 2019). The areas of poor water quality are the estuaries of the Chao Phraya, Tha Chin, and Mae Klong Rivers. The 2018 results were reported to be a significant improvement over the period 2009-2013, although 22 red tide events were recorded in 2018 for the Andaman Coast and Gulf of Thailand, suggesting excessive inputs of nutrients.

WEPA's data for Viet Nam (latest data 2001) shows: (i) Red River Delta coastal waters – phosphate, nitrate, and oil exceeded national standards; (ii) South Central coastal region – phosphate, nitrate, and oil exceeded national standards; and (iii) Mekong delta coastal waters – nitrate, oil, and coliforms exceeded national standards (WEPA, n.d.). A more recent (2017-2018) monitoring of the Red River Delta estuarine waters found that most physicochemical results were within Viet Nam's coastal water quality standards, except for ammonium, total suspended solids, and total coliforms (Quang Tri et al. 2019). Coastal water quality was also impaired close to wastewater sewerage discharges.

Coastal water quality is not only important for marine biota but is a critical consideration for coastal recreation. A good example is the popular tourist resort Boracay Island in the Philippines. Due to overdevelopment and poor wastewater management, the coastal waters offshore from Boracay have become progressively degraded (Limates, Cuevas, and Benigno 2016). The sources of pollution were illegal reclamation of mangrove swamps, partially or untreated sewage discharge, and pumping flood water out to sea. Coastal waters surrounding developed areas without sewerage and with depleted mangrove cover were more degraded than areas with intact mangroves and commercial areas with centralized wastewater treatment (Limates, Cuevas, and Benigno 2016). In 2018, the water quality was described as a "cesspool" and the area was shut down for 6 months to allow additional water quality management measures to be implemented. Establishments within the 30-metre coastal zone were demolished and 400 hotels and restaurants were closed down. The area is now reopened, and the water quality appears to have improved (McKirdy 2018).

The accumulated impacts of ASEAN's megacities on nearshore coastal water pollution are also obvious. For example, studies in Jakarta Bay have found that the coral reefs of the Thousand Islands north of Jakarta have been degraded by nitrite, phosphate, and chlorophyll-a pollution, with pollutant sources from surfactants, diesel fuel compounds, sewage, and bilge water (Kunzmann, Arifin, and Baum 2018; Baum et al. 2016).

6.4.2 The Coral Triangle

The Coral Triangle is often referred to as the "global epicentre of marine biodiversity (Nature Conservancy 2008). Covering six countries, Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor Leste, the Coral Triangle Initiative for Coral Reefs, Fisheries, and Food Security (CTI-CFF) was launched in 2009. The Coral Triangle is home to 76% of the world's 798 coral species and 37% of the world's 6,000 coral reef fish species. There are 15 regionally endemic coral species and 235 endemic (or locally restricted) coral reef fish (Table 6.3). Ecoregions with the highest level of endemism are Papua, Lesser Sunda Islands, Palawan-North Borneo, and the Solomon Seas (Nature Conservancy 2008). Many of these rare species are valuable for the live reef fish trade for aquaria throughout the world.

Table 6.3 Coral reef fish and endemic species in the Coral Triangle

Area	Number of species	% of total # of species in the world	# of endemic species	% endemism (% of total #)
World	6,000	100		
Indo-Pacific	4,050	67.5		
West Pacific	2,989	49.8	938	31.4
Indian Ocean	2,086	34.8	532	25.5
Central Pacific	1,403	23.4	130	9.3
Coral Triangle	2,228	37.1	235	7.8%
Eastern Philippines	1,763	29.4	7	0.4
Palawan – North Borneo	1,684	28.1	14	0.8
Banda Sea	1,728	28.8	2	0.1
Papua and Halmahera	1,660	27.7	22	1.3
Northeast Sulawesi	1,658	27.7	6	0.4
Lesser Sunda Islands	1,715	28.6	19	1.1
Bismarck Sea	1,493	24.9	5	0.3
Solomons Archipelago	1,403	23.4	3	0.2
Solomon Sea	1,603	26.7	13	0.8
Sulawesi Sea / Makassar Strait	1,717	28.6	0	0

Source: (Nature Conservancy 2008)

6.4.3 Coastal and marine habitats

Globally, seagrass, mangroves, and coral reef ecosystems have suffered the most from human interference (IPBES 2019). "Almost a third of reef-forming corals, sharks and shark relatives and over a third of marine mammals are currently threatened". ASEAN contains about one third of global coastal and marine habitats: coral reefs, mangroves, estuaries, sandy beaches, rocky shores, seagrasses, seaweed beds, mudflats, and other seabed communities (ASEAN Centre for Biodiversity 2017a). The ASEAN region contains about 35% of the world's mangrove forests and 30% of the coral reefs (ASEAN Secretariat 2008). As well as the Coral Triangle referred to above, the South China Sea also has over 571 species of coral and some of the highest biodiversity globally (Ives 2016).

These habitats are essential for a wide range of ecosystem services including (i) breeding and feeding resources for marine plants and animals; (ii) supporting coastal community livelihoods; (iii) carbon sequestration; (iv) shoreline protection; and (v) tourism, recreation, and cultural services, among others. (Also see Chapter 4 on marine ecosystems.)

6.4.4 Fish catch and consumption

In 2014, AMS accounted for 18.3% (30.6 million tonnes) of world fish production (167.3 million tonnes), and 14.7% of aquaculture production (10.9 million tonnes) (Chan et al. 2017). By 2019, Southeast Asia's fish production reached 21.9% (46.8 million tonnes) of global production (213.7 million tonnes). Significantly, however, from 2015-2019 the fish production volume increased at only 1.5% per annum, but the value increased by 9.5% (US$ 55 million) (SEAFDEC 2019a). Seafood consumption ranges from 25 kg/cap/yr. in Lao PDR to 57 kg/cap/yr. in Malaysia (SEAFDEC 2019a). In general, as incomes have risen in AMS, the consumption of seafood has also increased. In addition, seafood consumption trends need to be monitored in the ASEAN region as they are a good indicator of the fisheries resources under increasing pressure.

Due to the emergence of new technologies in aquaculture feeds, aquaculture is often more resource-efficient than wild-caught fisheries and may reduce pressures on wild fish species (World Bank 2018; Naylor et al. 2021). Although the practice is not entirely free of ecological impacts, the growth of aquaculture production in the region may pave the way for more sustainable seafood production.

6.4.5 Coastal and marine disasters

The United Nations Office for Disaster Risk Reduction (UNDRR) states that Southeast Asia is one of the most disaster-prone regions in the world, suffering more than US$ 4.4 billion in disaster damages each year (Amach 2021). The major threats include cyclones, floods, inundation, tsunamis, storm surges, coastal erosion, pollution, and anoxic zones (UNESCAP 2021c). Recent coastal disasters include Typhoon Rai (Philippines, 2021), Central Viet Nam Flood (2020), Cyclone Seroja (Indonesia, 2021), harmful algal bloom (Malaysia, 2015), and Typhoon Damrey (Thailand, 2017). In addition to the loss of life, these disasters cause enormous physical damage and loss of economic assets and livelihoods.

6.5 Impacts

6.5.1 Biodiversity loss

The estimated economic value of coastal and marine ecosystem services at risk from poor management varies widely, such as (i) US$ 62,400/km^2/yr. for coastal protection and fisheries; (ii) US$ 23,100 - US$ 270,000/km^2/yr. for fisheries, coastal protection, tourism, and recreation; and (iii) millions of people living close to and depending on these ecosystem services for their livelihoods (ASEAN Centre for Biodiversity 2017a). These potential losses are now being exacerbated by climate change.

The ASEAN Biodiversity Outlook 2 lists the following impacts to the region's coastal and marine ecosystems (ASEAN Centre for Biodiversity 2017a):

- Habitat change: mangrove conversion increases storm surge vulnerability, and seagrass destruction removes food and protection for marine fauna.
- Overexploitation: reduces marine biota populations, changes population structures, reduces fish catch per unit effort, and disrupts interactions between species and habitats.
- Pollution: increases vulnerability of coastal habitats and reduces resilience to disasters. Oil and chemical spills damage ecosystem health.
- Ineffective governance: allows irresponsible and illegal natural resource use, misallocates resources for conservation or restoration, and fails to educate the public on the value of coastal and marine habitats.
- Climate change: increased temperatures cause coral bleaching. Climate change and sea level rise also modify coastal habitats and erode coastal areas reducing mangrove habitats and sandy beaches.

The IPBES Regional Assessment for Asia and the Pacific (IPBES 2018) lists a similar set of main drivers, except that invasive alien species replace ineffective governance in that list. (See relevant subsections in section 4.3 for more details on pressures on marine biodiversity.)

6.5.2 Coastal erosion, subsidence, storm surges and inundation

Globally, the coastal area subject to storm surges and inundation (i.e., less than 2 m above mean sea level) is 649,000 km^2, of which 62% is in the tropics (Hooijer and Vernimmen 2021). Sea level rise of 1 m by 2100 would affect 410 million people, with 59% in tropical Asia. Sea level rise will be exacerbated by land subsidence, which can exceed 25 mm/year in coastal cities like Jakarta (60-250 mm/yr.), Semarang (100 mm/yr.) and Bangkok (up to 100 mm/yr. in the 1980s) (Phien-wej, Giao, and Nutalaya 2005; Bott et al. 2021; Marfai 2014; Erkens et al. 2015). Relative sea level rise due to land subsidence in northern Jakarta is about 12 cm/yr., compared to the global average of about 3.2-4.2 mm/yr. (Bott et al. 2021; Masson-Delmotte et al. 2021). At the current rate, Jakarta would be almost completely under water by 2050. The situation has become so serious that the Government of Indonesia has announced plans to move the capital from Jakarta to East Kalimantan (Arsac 2020). Current plans, however, only provide for about 1.5 million of Jakarta's existing population of at least 10 million to move to the new location. It is hoped that a giant 32 km long seawall called the

Great Garuda will protect the remaining population at a cost of US$ 40 billion (van der Wulp et al. 2016; Garschagen, Surtiari, and Harb 2018; M. M. Lin and Hidayat 2018).

While not only due to climate change, urban flooding in the past decade has had major social and economic impacts. The 2011 floods in Bangkok almost paralyzed the national economy; the 2013 Jakarta flood inundated 75% of the city, forcing 83,000 people to evacuate; and the 2020 Jakarta flood forced 32,000 people to evacuate and led to an estimated US$ 665 million economic loss (Simarmata 2020).

Many of the ASEAN region's coastal cities are also under threat from the future impacts of climate change (World Bank 2010). In Bangkok, it is predicted that the area affected by a 1-in-30-year flood will increase by 30%. Manila's 1-in-100-year flood will increase the area affected by 42%, while Ho Chi Minh City will see the area flooded increase by 68-71% under a high emissions scenario. Millions of city residents and important national infrastructure will be affected unless climate change is brought under control. For Bangkok, the cost of the 1-in-30-year flood was estimated at US$ 4.6 billion by 2050, and for a similar event in Manila the cost would be US$ 1.5 billion. For Ho Chi Minh City the annual costs of flooding would be similar to Bangkok and Manila (World Bank 2010).

ASEAN has a total coastline of 173,000 km (ASEAN Secretariat 2008). Coastal erosion has been a problem associated with over-development of coastal resources for many years and is now being exacerbated by sea level rise due to climate change. In the "COBSEA YEOSU: Addressing the Challenge of Sea-Level Rise and Coastal Erosion in the East Asian Seas Project" 35% of Indonesia's coast was found to be subject to moderate to very high erosion; 29% of Malaysia's coast; 50% of areas mapped in the Philippines; 11% of the Gulf of Thailand coast; and along the entire coastline of Viet Nam (Wong 2016). In Viet Nam, sand mining, tourism development, sandbag walls, and concrete seawalls are contributing to the coastline retreating by up to a kilometre in some areas over the past 20-30 years (T. Y. Lin, Onselen, and Vo 2021). The initial national coastal erosion study (1984-1986) in Malaysia found that 25% of the coastline had facilities or infrastructure in immediate danger or threatened within 5-10 years unless remedial action was taken (Ghazali 2007). In recognition of this danger, the National Coastal Erosion Control Sector Project was implemented from 1991, at a total cost of US$ 64.8 million (ADB 2002). As sea level rise and storm surges continue to eat away at the coast, the expected economic and social costs, including the eventual relocation of populations and retreat away from the coast, are expected to be a significant burden on public and private sector finances.

6.5.3 Extreme weather event damage

Heatwaves will have increasingly adverse impacts on marine ecosystems, such as coral reefs. Marine heatwaves may cause mass deaths of benthic communities, phytoplankton blooms, changes in fish distribution, toxic red tide algal blooms, oxygen depletion and dead zones. Extreme sea levels, and hence coastal flooding, will be experienced 20-30 times more frequently by 2050 and 160-530 times more frequently by 2100 (IPCC 2021a).

The impacts of extreme weather events include damage to port infrastructure and jetties, ecosystem damage and disruption, coastal erosion, storm surges and coastal flooding. Currently, there is no reliable economic or social assessment of the annual average climate-related damages in the ASEAN region, as most assessments relate to single extreme events.

6.5.4 Food insecurity

Food insecurity means that people do not have continuous access to enough safe, nutritious food to meet their dietary intake for active, healthy lives. According to one report, nearly 60 million people in ASEAN are chronically undernourished (Chan et al. 2017). Seafood provides an extremely important source of animal protein in the ASEAN region, as the population consumes less animal protein daily than the world average but has consumption of fish 1.8 times the 2013 world average (19.2 kg/capita/annum). In addition to protein, seafood is an important source of lipids, nutrients, and minerals to overcome malnutrition in low-income communities.

The International Food Policy Research Institute (IFPRI) model under a "business-as-usual" scenario predicts that fish consumption in ASEAN will grow from 24.5 million tonnes in 2015, to 36.9 million tonnes in 2030, and 47.1 million tonnes in 2050, with consequent increases in annual per capita consumption from 38.4 kg in 2015 to 61.5 kg in 2050 (Chan et al. 2017). Accordingly, maintenance of a healthy coastal and marine environment is essential for ensuring the future of this important industry for the ASEAN region. As noted in the conclusions of the IFPRI modelling "there is a critical role for improved capture fisheries management and governance to sustain fish supply" (Chan et al. 2017)

6.6 Responses

6.6.1 Spatial planning

An integrated coastal zone planning guideline titled "Spatial Planning in the Coastal Zone of the East Asian Seas Region: Integrating Emerging Issues and Modern Management Approaches" was prepared by the Coordinating Body on the Seas of East Asia (COBSEA) with an objective to integrate "new concepts such as climate change, ecosystem-based management, disaster risk reduction and integrated land-sea planning" into existing spatial planning systems (COBSEA 2011).

In the Philippines, Executive Order No. 533 (2006) proposed adoption of integrated coastal zone management. In Thailand, relevant legislation includes the Marine and Coastal Resources Management Promotion Act (2015), the Royal Ordinance on Fisheries (2015) as well as a National Maritime Security Plan (2015-2021). Viet Nam's Government Decree No. 25/2009/ND-CP provides a guiding framework for integrated coastal zone management planning by coastal provinces (Nagabhatla et al. 2019).

Over the past two decades, AMS have made considerable advances in coastal and marine spatial planning. For example, since 1992, Indonesia has had a Spatial Planning Act (24/1992) and incorporated marine spatial planning in 2001. In 2007, the process was strengthened as the Zoning Plan for Marine, Coast and Small Islands and, by 2012, 65 regencies/municipalities had prepared such zoning plans (Yudiarso 2012). Acts No. 27/2007 and No. 1/2014 require the involvement of the affected communities in the planning process (Nagabhatla et al. 2019).

6.6.2 Regional and national strategy plans

The AMS have collectively agreed on multiple regional strategies and action plans, several of which involve coastal and marine environmental management. The ASCC Blueprint 2025 adopted in 2015 is the overarching regional framework for environmental and social management. The governance structure includes the ASEAN Ministerial Meeting on Environment, ASEAN Senior Officials on Environment (ASOEN), thematic working groups, ASEAN Centre for Biodiversity (ACB), among othercross-sectoral bodies. In 2017, ASEAN and China agreed on a decade of coastal and marine environmental protection in the South China Sea (2017-2027). Several AMS (Cambodia, Indonesia, Philippines, Malaysia, Thailand, Singapore and Viet Nam) are members of the Coordinating Body on the Seas of East Asia (COBSEA) which oversees implementation of the East Asian Seas Action Plan, which aims to protecting the region's marine and coastal environment. Similarly, six AMS are members of the Partnerships for the Environmental Management of the Seas of East Asia (PEMSEA), which oversees the Sustainable Development Strategy for Seas of East Asia, bringing together 14 countries. In 2021, the ASEAN Leaders Declaration on the Blue Economy agreed to cooperate on the blue economy and suggested developing a regional action plan.

The ASEAN Working Group on Coastal and Marine Environment (AWGCME) is focused on the conservation and sustainable management of coastal and marine ecosystems and the communities dependent on these resources for their livelihood, and it implements the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021-2025). The Coastal and Marine Ecosystems Management Program (CMEMP) (2017-2028) deals with the drivers and threats of coastal and marine ecosystems degradation by using a ridge-to-reef management approach.

6.6.3 Marine protected areas

Globally, marine protected areas (MPAs) only cover about 7% of coastal and marine waters, often without encompassing the most threatened species or ecosystems (IPBES 2019). ASEAN has 50 ASEAN Heritage Parks (AHPs) but relatively few coastal and marine parks such as (i) Lampi Marine National Park; (ii) Mu Ko Ang Thong Marine National Park; (iii) Ao Phang-Nga – Mu Ko Surin – Mu Ko Similan National Park; (iv) Hat Chao – Mu Koh Libong; (v) Tarutao National Park; (vi) Kepulauan Seribu National Park; (vii) Tubbataha Reefs Natural Park; (viii) Wakatobi National Park; and (ix) Bai Tu Long National Park.

Based on the World Database on Protected Areas, in ASEAN, Malaysia has the largest proportion of its marine area protected (5.6%), followed by Thailand (4.4%), the Philippines (1.7%), Indonesia (3.1%), Viet Nam (0.6%), Brunei Darussalam (0.2%) and Myanmar (0.5%) (UNEP-WCMC 2021f; 2021h; 2021c; 2021d; 2021g; 2021a; 2021j; 2021i; 2021e; 2021b). Out of the 82 marine key biodiversity areas identified, 78% are unprotected, 10% partially protected, and 12% under protection but with often ineffective management. For seagrasses, there is only 8.33% protection, while 14% of coral reefs and 15% of mangroves are protected but under continual threats.

6.6.4 Coastal zone adaptation and mitigation

ASEAN has been very proactive in relation to climate change adaptation (CCA). The ASEAN Working Group on Climate Change provides a platform for sharing best practices on adaptation. In November 2020, the ASEAN Declaration on the Strengthening of Adaptation to Drought was released. In June 2021, the ASEAN Disaster Management and Emergency Response Work Programme (2021-2025) was launched. It has five priority programmes (i) risk assessment and monitoring; (ii) prevention and mitigation; (iii) preparedness and response; (iv) resilient recovery; and (v) global leadership.

Each AMS has also prepared strategies and action plans for climate change adaptation such as National Adaptation Programmes of Action (NAPAs) and National Adaptation Plans (NAPs) and/or provisions for adaptation in their Nationally Determined Contributions (NDCs) to the United Nations Framework Convention on Climate Change (UNFCCC).

For example, Thailand's NAP (2020-2037) has six priority objectives (i) water management; (ii) agriculture and food security; (iii) public health; (iv) natural resources management; (v) tourism; and (vi) human settlements and security (GIZ 2020).

The United Nations Development Programme (UNDP) is implementing a US$ 3 million Green Climate Fund (GCF) project "Increasing resilience to climate change impacts in marine and coastal areas along the Gulf of Thailand" to undertake adaptation planning in the Gulf of Thailand.

Practical experience in some AMS suggests that affected communities start autonomous adaptation by responding to rising sea levels with rather weak, informal seawalls and drainage pumps, followed by better organized and constructed seawalls plus reclamation of land behind the seawalls, then ultimately elevation of districts or building super levees. Relocation is a last resort, especially in urban areas where land values are high (Esteban et al. 2020). Where effective government intervention is absent, however, affected landowners feel like they are “throwing money into a bottomless pit” (Saputra, Spit, and Zoomers 2019).

The oceans and coastal ecosystems also play a major role in climate change mitigation through carbon sequestration. Response options include blue carbon credit or investments, blue bonds, or carbon trading under Article 6 of the Paris Agreement.

6.6.5 Fisheries management

The Strategic Plan of Action for ASEAN Cooperation on Fisheries (2016-2020) built on the ASEAN Multi-sectoral Framework on Climate Change, ASEAN Integrated Food Security Framework and Strategic Plan of Action (2015-2020), and the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region towards 2020 (ASEAN Secretariat 2015e). One of the “strategic thrusts” is to “enhance the quantity and quality of production with sustainable, green technologies, resource management systems, and minimize pre- and post-harvest losses and waste”. This requires AMS to report on best practices and management systems and to promote implementation of the “ASEAN Guidelines for Standard Operating Procedures for Responsible Movement of Live Aquatic Animals”. The Plan of Action also requires AMS to strengthen their fish quality and safety management systems to remain competitive in global markets and adopt an ecosystem approach to fisheries management. The Plan of Action was recently updated with the Strategic Plan of Action for ASEAN Cooperation on Fisheries (2021-2025), which includes 61 activities and sub-activities (ASEAN Sectoral Working Group on Fisheries 2021).

As an example of national fisheries management challenges, fisheries in Viet Nam provide around 4.7 million formal jobs and 5% of GDP, so maintaining a sustainable fisheries sector is crucial to the economy (World Bank 2021a). The sector is constantly challenged, however, by food safety concerns and illegal, unreported, and unregulated (IUU) fishing. In 2017, the major market of the European Union issued a "yellow card" warning to Viet Nam for not doing enough to combat IUU fishing. Cambodia was also issued with such a yellow card in 2012 and then a "red card" in 2013, resulting in significant sanctions. Such warnings also have implications for other export markets such as the US and Japan (World Bank 2021a). Since the issuance of the yellow card, Viet Nam has attempted to implement the nine recommendations of the European Union, with particular attention paid to illegal fishing outside the national EEZ and the need for traceability of fish and fish products. The 2019 inspection team confirmed progress made in implementing the 2017 Fisheries Law, monitoring systems, management of fishing density, data on fishing vessels, and planning for sustainable fishing vessels (World Bank 2021a). Viet Nam is also a signatory to the UN Fish Stocks Agreement and the Food and Agriculture Organization (FAO) Port States Measures Agreement and is "cooperating, non-contracting party" of the Western and Central Pacific Fisheries Commission. The Port State Measures Agreement, currently ratified by 71 countries, including Viet Nam, requires flag states to submit to port inspections and if there is any evidence of IUU fishing the responsible flag state must investigate and penalize any illegal activity.

In addition, seafood consumption trends need to be monitored in the ASEAN region as they are a good indicator of the fisheries resources under increasing pressure.

6.6.6 Marine water quality management

The ASEAN Marine Water Quality: Management Guidelines (2008) are designed to protect marine and estuarine ecosystems, biota, and water quality (Table 6.4). A companion Monitoring Manual sets out 19 parameters to be monitored in ASEAN waters as well as guidance on proper design of monitoring programmes. The Guidelines also noted the need to consider adding additional parameters such as persistent organic pesticides (POPs), acidification (pH), hydrocarbons, and endocrine disruptors (ASEAN Secretariat 2008).

Table 6.4 Marine water quality criteria

For Aquatic Life Protection			
Parameter	**Criteria Values**	**Parameter**	**Criteria Values**
Ammonia	70 µg/L	**Mercury**	0.16 µg/L
Cadmium	10 µg/L	**Nitrate**	60 µg/L
Chromium (VI)	50 µg/L	**Nitrite**	55 µg/L
Copper	8 µg/L	**Oil and grease**	0.14 mg/L
Temperature	<2oC above maximum ambient temperature	**Total phenol**	0.12 mg/L
Cyanide	7 µg/L	**Phosphate**	15 µg/L (coastal) 45 µg/L (estuarine)
Dissolved Oxygen	4 mg/L	**Tributyltin**	10 ng/L
Lead	8.5 µg/L	**Total suspended solids**	Permissible 10% maximum increase over seasonal average concentration
For human health protection			
Parameter	**Criteria Values**	**Note**	
Bacteria	100 faecal coliform per 100 mL	Coastal water quality for recreational activities	
Bacteria	35 enterococci per 100 mL		

Source: (ASEAN Secretariat 2008)

6.6.7 Sustainable infrastructure

Another key response in the ASEAN region is to focus on climate-proofed and sustainable infrastructure. The Asian Development Bank (ADB) estimates that developing Asia will need to invest US$ 26 trillion on climate-adjusted infrastructure from 2016-2030, including US$ 3,147 billion for Southeast Asia (ADB 2017c). For example, increased reliance on manufacturing in AMS will require greater investment in ports and airports, along with the associated road, energy, and water investments. Most of the climate-adjustment expenditure needs to go the transportation sector (US$ 37 billion annually for developing Asia) (Wu et al. 2020).

The ASEAN Infrastructure Fund was set up in 2011 with a paid in equity of US$ 485.3 million and offers loans to AMS for infrastructure investment in energy, water, transport, and urban sectors, along with co-financing from the ADB (ADB 2019). In addition, the ASEAN Catalytic Green Finance Facility was established in 2019, under the ASEAN Infrastructure Fund, for investment in energy, transport, water, urban, and multisector projects that support environmental sustainability and climate change goals (ADB 2020a).

To facilitate increased ASEAN integration and intra-ASEAN shipping services, a Roadmap towards an Integrated and Competitive Maritime Transport in ASEAN plus an Outline Plan for the Implementation of ASEAN Single Shipping Market have been prepared (T. T. Nguyen 2016). As there is insufficient port capacity to cater for the increase in intra-ASEAN trade, there is considerable opportunity to design and implement sustainable, climate-adjusted port facilities throughout ASEAN seaports, sometimes referred to as "eco-ports". For example, in Viet Nam, there were 37 seaports with 166 terminals (as at 2016) handling 328.7 million tonnes (in 2013), but there are few deep-water terminals or container ports, with much of the container traffic transhipped in Singapore, Malaysia or Hong Kong (T. T. Nguyen 2016). Container shipment demand is expected to triple from about 100 million TEUs to 350 million TEUs by 2040.

The Sustainable Port Development in the ASEAN Region project is supporting the Port Safety, Health and Environmental Management Code developed by Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), which has been adopted in Cambodia, Malaysia, Philippines, and Thailand (PEMSEA 2018b). Also, the APEC Port Services Network created a Green Port Award System, with certified ports in Singapore (1), Malaysia (2), Thailand (1) and Philippines (1). The Maritime Singapore Green Initiative comprises a Green Ship Programme, Green Port Programme, Green Energy and Technology Programme, and a Green Awareness Programme. The Green Ship programme, for example, encouraged state-flagged ships to reduce carbon dioxide (CO_2) and sulphur dioxide (SO_2) emissions, so they can apply for reduced registration fees and tax breaks (PEMSEA 2018b).

6.7 Way forward

The coastal and marine environment throughout ASEAN is under multiple threats and climate change is going to exacerbate those threats. Clearly, the global efforts to mitigate climate change and keep the temperature rise below 1.5°C over pre-industrial are critical to minimize those impacts. Nevertheless, even with existing temperature increases already approaching 1.2°C, coastal zone adaptation will become increasingly urgent. Each AMS must prepare a NAP that includes a major effort to protect coastal and marine assets and livelihoods at risk from climate change.

While climate change will also impact fisheries and other marine organisms, effective adaptation measures are less obvious, so emphasis must be on the Strategic Plan of Action for ASEAN Cooperation on Fisheries (2021-2025) that contains important environmental management activities such as (i) developing a regional plan of action on anti-microbial resistance in aquaculture; (ii) developing a regional guideline on indicators for aquaculture and capture fisheries to facilitate ecosystem-based adaptation; (iii) establishing the ASEAN Network for Combating IUU Fishing; and (iv) developing the Roadmap on Combating IUU Fishing in the ASEAN Region (2021–2025). Other ASEAN initiatives that should be further strengthened include the ASEAN Leaders' Declaration on Blue Economy, ACRF, and the ASEAN Mangrove Restoration Initiative.

The coastal and marine environment is addressed in SDGs 14 and 15 (life in the ocean and life on land, respectively) which propose a variety of related responses. In addition to strategies and plans (14.2, 15.2, 15.4), protected areas (14.5), and fisheries management (14.4) mentioned above, the importance other measures is also highlighted including the need to reduce pollution of all kinds, in particular from land based activities (14.1), eliminate certain kinds of subsidies which contribute to overcapacity and overfishing (14.6), increase related scientific research and capacity (14.a), integrate ecosystem and biodiversity values into national and local planning, development processes, and poverty reduction strategies (15.9), and mobilize significantly more financial resources (15.b).

As indicated in Chapter 4, the ASEAN Centre for Biodiversity should aim to revise the selection criteria to encourage more designation of marine heritage parks. The Coral Triangle Initiative, which involves Indonesia, Malaysia, and the Philippines should continue to prioritize activities that address biodiversity loss and poverty reduction.

Pressures on the coastal zone continue through development of tourism, industry, shipping and other sectors with a preference for coastal locations. Greater attention needs to be paid to spatial planning, pollution control, combatting marine litter and debris, land reclamation, removal of coastal vegetation like mangroves, and waste management.

The future of offshore oil and gas development is uncertain as AMS pursue low-carbon development paths towards net-zero GHG emissions by or around mid-century. The ASEAN region should develop a common strategy for handling decommissioning of offshore facilities, as well as deciding on responsibilities for implementation, as well as improved environmental management of undersea pipelines and cables, such as the proposed trans-ASEAN gas pipeline and transboundary electricity trading.

Chapter 7
Chemicals and Waste

Main Messages

- As ASEAN increasingly transitions away from its agrarian traditions and becomes a core part of the global supply chain, improved environmental management of chemicals and waste is imperative.
- Manufacturing is now a major contributor to AMS' gross domestic product (GDP) and exports but too many outdated factories in some developing ASEAN countries nations produce or use hazardous chemicals that harm local communities. The chemical industry needs a new paradigm to contribute to environmentally sustainable development.
- Outdated, unsustainable smokestack industries and end-of-pipe pollution controls need to be replaced with cleaner, more efficient production technology.
- Agricultural chemicals, such as pesticides and herbicides, are also dangerous to the environment, farm workers and consumers of the region's fruits and vegetables.
- The ASEAN region spends too little on research and development (R&D) and therefore is not prepared to manage the risks of the wide range of new chemicals that are being released to the environment.
- Plastic waste generation keeps increasing with industrialization and the increasing adoption of high material consumption lifestyles. There are growing concerns in AMS on marine plastic litter and microplastic related pollution and their impacts. However, evidence-based responses require standardized monitoring procedures and capacity building.
- The ASEAN Joint Declaration on Hazardous Chemicals and Waste Management (2017) needs to be supported by increased funding, R&D, and international support.
- Gradually, the key tools of environmental management of chemicals and waste are being implemented in AMS, but much greater efforts are needed regarding source and ambient monitoring, public awareness, compliance, and enforcement.
- Chemicals and waste management is a cross-cutting issue relevant to circular economy, extended producer responsibility (EPR), cities, climate change, biodiversity, water, and environmental education, so it needs to be considered in a holistic and integrated manner.
- Stronger capacities (financial, institutional, technical resources) are needed for political prioritization and awareness building, setting policies, regulations, strategies, and action plans to achieve sustainable waste and chemicals management as well as control of transboundary pollution.
- Much greater efforts are needed to implement existing policies and regulations, on chemicals and waste, including compliance and enforcement as well as source and ambient monitoring, and promoting public awareness
- Regional cooperation should be expanded, and regional action plans should be developed on chemicals and waste, including plastic, using a lifecycle approach.
- Measures to strengthen environmentally sound management of chemicals and waste can be important sources of green jobs in government and the private sector.
- Implementation of SDG 12 on sustainable consumption and production would especially improve the management of chemicals and waste.

7.1 Introduction

Modern society is awash in chemicals and waste, imposing unprecedented hazards to the environment, health, and biodiversity. These hazards are generating increased economic costs and social burdens. Improved environmental management of chemicals and waste is imperative as ASEAN increasingly transitions away from its agrarian traditions to an economy based on manufacturing and services, its growing population migrates to urban centres, and societies become more middle-class and consumption based.

This chapter focuses on industrial chemicals and waste. Other waste-related issues, such as municipal solid waste, other emerging waste streams (food waste, plastic waste, e-waste, healthcare waste), and the need to develop a circular economy, are discussed separately in Chapter 10. While acknowledging sustainable chemicals and waste management is a crucial and cross-cutting theme highly relevant to other themes in this report, this chapter aims to follow UNEP's recommendation to strengthen the knowledge base necessary to empower decision-makers and stakeholders to act and support policy making aimed at sound management of waste to minimize risks to public health and the environment associated with chemicals and hazardous waste (UNEP 2021b).

7.2 Drivers

The fundamental drivers of industrial chemicals and waste in ASEAN include ASEAN's growing position in the global industrial supply chain and the increasing demand for industrial products as the population continues to grow and becomes more urbanized and less dependent on products taken directly from nature (see Chapter 2). AMS also need to secure employment in the ever-increasing industrial and services sectors as agriculture becomes more mechanized and less dependent on family labour. The growing middle class in AMS has not only led to high consumption growth rates, but also changed the consumption patterns and lifestyles. AMS are dependent on other countries to produce the goods demanded by modern societies, so they also want to promote economic security by investing in domestic industrial development.

As globalization continues, AMS are fully engaged in international trade, which includes exports and imports of industrial goods and services, often promoted by free trade agreements with key trading partners. In addition, recent global trends, such as Sustainable Development Goals (SDGs), climate change, including methane and short-lived climate forces, plastic pollution, marine litter, and COVID-19 have converged to reshape what we call waste management and its daily practices. In addition, they create urgent questions that require nuanced scientific answers, pushing practitioners, researchers, academics, and public officials towards the developmet of a more cohesive and systematic framework for chemicals and waste management policy and practice in ASEAN.

7.2.1 Industrialization

In 1975, manufactured products accounted for less than 18% of ASEAN's exports but made up more than 63% by 1991. In 2019, the export share of manufacturing was 77.5% (US$ 1.1 trillion), and the import share was 76.7% (US$ 1.07 trillion) (ASEAN Secretariat 2020c). The contribution of the manufacturing sector to GDP in 2019 ranged from 24.7% (Singapore) to 63.1% (Brunei Darussalam), and to employment from 4.2% (Brunei Darussalam) to 21.0% (Malaysia). The AMS most dependent on manufacturing exports are Cambodia, Viet Nam, Philippines, and Thailand. The number of factories in ASEAN exceeds 1.25 million, with Viet Nam hosting 923,724 manufacturing establishments alone, with over 8.9 million employees. The manufacture of chemicals and chemical products across the 10 AMS involves more than 15,000 factories.

7.2.2 International trade in chemicals

Organic chemicals have been consistently among the top 10 imports and exports in ASEAN, valued at US$ 26.6 billion and US$ 31.9 billion, respectively, in 2018-2019. Organic chemicals also feature in the top 10 intra-ASEAN exports (US$ 5.8 billion in 2019) and imports (US$ 5.6 billion in 2019), with other chemical products in the top ten intra-ASEAN imports in 2019 (US$ 4.1 billion). China is the main export destination for organic chemicals (US$ 7.1 billion in 2019), with US$ 5.8 billion in imports of organic chemicals from China. The second largest destination is the European Union (US$ 4.2 billion in 2019) (ASEAN Secretariat 2020c).

The speciality chemical market in ASEAN (i.e., adhesives, agrichemicals, cleaning materials, cosmetic additives, construction chemicals, elastomers, flavours, food additives, fragrances, industrial gases, lubricants, polymers, surfactants, and textile auxiliaries) was valued at US$ 46.6 billion in 2016 (Statista 2021c).

7.2.3 The growing middle class and consumption

Although each AMS has different economic and cultural backgrounds, ASEAN's domestic consumption, accounting for roughly 60% of GDP, is expected to double to US$ 4 trillion by 2030. Similar to other countries around the world, AMS face uncertainty as the COVID-19 pandemic continues to disrupt economic activities and cause drastic changes in consumer behaviour. Moreover, estimates project that ASEAN will have about 140 million new consumers, accounting for 16% of the world's consumers over the next decade (World Economic Forum 2020). According to UOB's Quarterly Global Outlook 1Q2021, 65% of the region's population is expected to be middle class by 2030, with 60% of them under 35 years of age (UOB Global Economics & Markets Research 2020). This rapidly growing demand will put pressure on ASEAN's resources, infrastructure, and public utilities, including municipal waste management. The demographic transition towards an ageing society in ASEAN has deep social, economic, and political implications. As a result, the ASEAN region must find innovative ways to sustain economic prosperity and provide better support for its growing elderly population (ASEAN 2020; ADB 2017d).

7.3 Pressures

7.3.1 Fourth Industrial Revolution

the Fourth Industrial Revolution (4IR) promises a significant move away from the old smokestack industries, purporting to converge the physical and digital worlds (ASEAN Secretariat 2021i). The Strategic Framework for a Digital ASEAN Community builds on the launch of the ASEAN Declaration on Industrial Transformation to Industry 4.0 under the ASEAN Economic Community and the ASCC's promotion of inclusive and sustainable work in the 4IR era. The Digital ASEAN Community will build on technical governance and cybersecurity, economic opportunities of a digital economy, and digital transformation of society. The internet economy in Indonesia, Malaysia, Philippines, Singapore, Thailand, and Viet Nam is predicted to reach US$ 309 billion by 2025 (ASEAN Secretariat 2021i). The extent to which digitalization will influence the chemical manufacturing industry is unclear, however, with the greatest impact likely to be through improved trade facilitation, banking, and blockchain tracking of goods and services. Blockchain is seen as a key technology to advance a circular economy through more reliable lifecycle assessment, improved recyclability, improved use of resources, and reduced costs (Gomollón-Bel 2021). Blockchain is expected to generate more than US$ 3 trillion in multiple business sectors by 2030, and the chemical industry will have a large share. As indicated in the ASEAN Strategic Framework "new technologies are also changing the way goods and services are being produced and supplied, blurring distinctions between goods and services, and introducing new combinations of goods and services and new modes of delivery" (ASEAN Secretariat 2021i).

7.3.2 Inadequate research and development

One way of reducing the societal impacts of chemicals and waste is through increased research and development of more environment-friendly products and production processes. The ASEAN Declaration on Industrial Transformation envisages adoption and diffusion of Industry 4.0 innovation and technologies such as the "Internet of Things, big data and cloud-based technology, artificial intelligence, augmented reality, and additive manufacturing (3D printing)" though joint research, investment, and development.

Historically, however, AMS have spent relatively little of their national budgets on research and development, generally relying on international transfer of technologies (Table 7.1). In contrast, in 2018, the Republic of Korea and Japan spent 4.53% and 3.28% of GDP, respectively, on research and development. The ASEAN Joint Declaration on Hazardous Chemicals and Wastes Management (2017) refers to the need for capacity building, transfer of technology, and exchange of information but makes no reference to the role of R&D (ASEAN Secretariat 2017a). The inadequate expenditure on R&D means that AMS are too heavily reliant on research breakthroughs in other countries, which limits the modernizing of the chemical industry in ASEAN.

Table 7.1 Research and development expenditures in ASEAN

AMS	R&D as % of GDP	US$ million*	Year of latest data
BRN	0.28	38.00	2018
KHM	0.12	21.66	2015
IDN	0.23	2396.60	2018
LAO	0.04	0.70	2002
MYS	1.04	3730.47	2018
MMR	0.03	20.61	2018
PHL	0.16	490.24	2015
SGP	1.92	6591.36	2017
THA	1.00	4564.00	2017
VNM	0.53	1186.14	2017

Source: (UNESCO 2021a)

Note: The amount in US$ was calculated based on respective AMS' GDP in corresponding years (World Bank 2022a).

7.3.3 Trade agreements

Generally, environmental safeguards are not a strong feature of the trade agreements that ASEAN has acceded to. For example, the Regional Comprehensive Economic Partnership (RCEP) that came into force in January 2022 has a section on Phytosanitary and Sanitary measures, but nothing on other environmental areas (RCEP Secretariat 2020a).

A potential free trade agreement between ASEAN and the European Union probably would contain such safeguards and put pressure on AMS to control chemical pollution related to traded goods. However, negotiations on a free trade agreement (FTA) with ASEAN, which started in 2007, were abandoned in favour of bilateral FTAs, which to date have been concluded only with Singapore (2019) and Viet Nam (2020). This latter agreement contains the usual chapter on sanitary and phytosanitary measures but also a chapter on "non-tariff barriers to trade and investment in renewable energy generation" and article 13.6 on climate change, article 13.7 on biological diversity, and various articles on natural resource protection (European Commission 2018). In the Preamble it notes that the FTA is intended to promote trade and investment "in a manner mindful of high levels of environmental and labour protection and relevant internationally recognized standards and agreements". There is no requirement of labelling or certification of products unless it is necessary in view of environmental or security risks. Nevertheless, the parties may specify technical product requirements and specifications, "including safety and environmental performance". Chapter 13 of the Agreement deals with trade and sustainable development and states that the "objective of sustainable development shall be integrated in their bilateral trade relationship" and any attempt to weaken environmental protection to encourage trade and investment would be inappropriate. Each party is required to ensure that its policies and laws provide for high levels of environmental protection and should be continuously improved. There is, however, no specific reference to the environmental impacts associated with chemical products or potential contamination of traded goods.

7.4 State and trends

7.4.1 Municipal Solid Waste (MSW)

ASEAN is one of the highest MSW generating regions in the world. AMS produced about 143 million tonnes of waste in 2016, at an average rate of 0.61 kilograms per person per day (Table 7.2). It is estimated that ASEAN will generate about 188 million tonnes of waste per year by 2030, a 31% increase. Indonesia generates the largest amount of waste, followed by Thailand, the Philippines, Malaysia, and Viet Nam. On average, the per capita waste generation in ASEAN was 0.61 kg/ person/ day in 2016, which is estimated be 0.71 in 2030. Brunei Darussalam had the highest per capita waste generation rate (1.4 kg/per/day) in 2016, while Lao PDR had the lowest per capita waste generation rate (0.15 kg/per/day) in the region.

Table 7.2 MSW generation in AMS

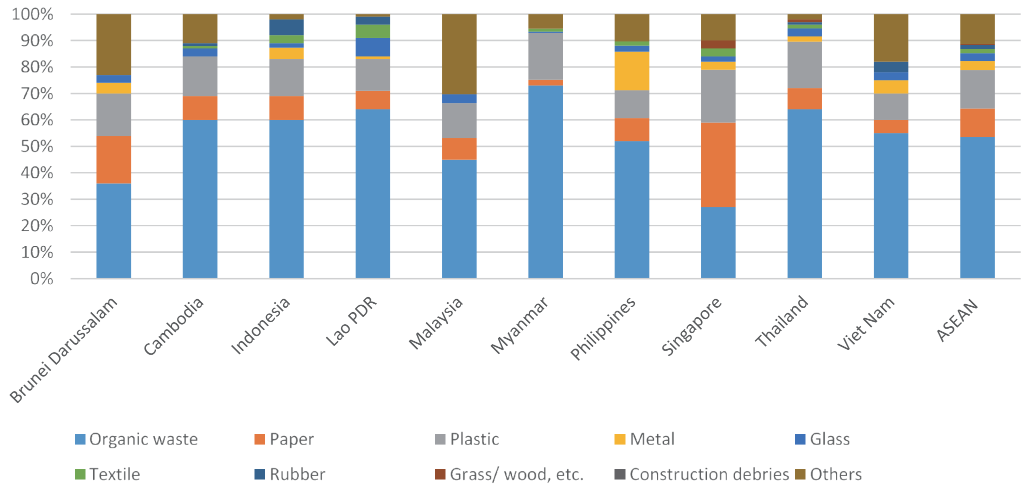
AMS	2016 adjusted			2030 projected		
	MSW generation (tons/ year)	Population ('000s)	Per capita (kg/ person/ day)	MSW generation (tons/ year)	Population ('000s)	Per capita (kg/ person/ day)
BRN	170,059	417	1.12	262,788	490	1.47
KHM	1,159,859	15,762	0.20	1,702,523	18,798	0.25
IDN	65,200,000	261,115	0.68	87,958,248	295,595	0.82
LAO	364,463	6,758	0.15	522,053	8,049	0.18
MYS	13,723,342	31,187	1.21	18,235,817	36,815	1.36
MMR	7,451,835	52,885	0.39	9,315,917	58,916	0.43
PHL	14,631,923	103,320	0.39	20,039,044	125,372	0.44
SGP	2,092,000	5,607	1.02	2,366,232*	6,342	1.02
THA	27,268,302	68,864	1.08	32,484,794	69,626	1.28
VNM	11,562,740	94,569	0.33	15,922,186	106,284	0.41
ASEAN	143,670,717	640,490	0.61	188,809,602	726,287	0.71

Sources: Adapted from (Kaza et al. 2018). Singapore's statistics are based on the domestic waste generation figures from Singapore's National Environment Agency (NEA) website (National Environment Agency Singapore 2022b). Brunei's figures are based on unpublished data.

* The 2030 per capita value is that of the 2016 value.

As shown in Figure 7.1, the MSW generated in the AMS is composed mainly of organic waste, plastic, paper, glass, and metal. Organic waste accounts for more than half of total waste generated in the majority of AMS, except for Brunei Darussalam, Malaysia, and Singapore. Organic waste is 27% of the MSW generated in Singapore, 32% in Brunei Darussalam, 45% in Malaysia, and about 73% in Myanmar.

Figure 7.1 Composition of MSW in AMS



Source: (Jain 2017)

* Singapore's statistics are based on (National Environment Agency Singapore 2022b).

However, there are no unified definitions for MSW and MSW composition among AMS (Table 7.3). MSW may include waste from households, commerce and trade, small businesses, office buildings, and institutions (schools, hospitals, government buildings). It also includes bulky waste (e.g., white goods, old furniture, mattresses) and waste from selected municipal services, e.g., from park and garden maintenance, and street cleaning services (street sweepings, the content of litter containers, and market cleansing waste) (UN Statistics Division 2018). Indonesia, Myanmar, Philippines, and Viet Nam include industrial waste and demolition and construction debris, toxic and hazardous waste in their definitions (Jain 2017). Thus, comparison of MSW data among AMS is methodologically difficult and unrealistic. Also, incompatible definitions of MSW pose serious consequences for treatment. Composting quality, for example, is compromised.

Table 7.3 Definitions of MSW in AMS

AMS	Definitions of MSW
BRN	MSW includes waste from residential, commercial, institutional, green, bulky and abattoir waste.
KHM	MSW includes household waste that does not contain toxins or hazardous substances, and is discarded from dwellings, public buildings, factories, markets, hotels, business buildings, restaurants, transport facilities, recreation sites, etc.
IDN	MSW is broadly categorized as domestic waste consisting of household waste and household-like waste and wastewater. Household waste is generated by daily activities performed within households, but does not include faeces and specific wastes while household-like waste is generated from commercial zones, industrial estates, special zones, social facilities, public facilities and any other facilities.
LAO	MSW includes any scrap material or other unwanted surplus substance or rejected products arising from the public solid waste, imported solid waste, household solid waste, institutional solid waste, and special solid waste such as waste from commercial, construction, industrial and controlled activities.
MYS	MSW is domestic and industrial solid waste from materials produced during the process of consumption, production, and services, including unwanted waste.
MMR	MSW comes from human and animal activities and is normally solid, discarded as useless and unwanted. It is all-inclusive, encompassing the heterogeneous mass disposed from urban community as well as the more homogeneous accumulation of agricultural, industrial, and mineral wastes.
PHL	MSW refers to waste produced from activities within local government units which includes a combination of domestic, commercial, institutional, and industrial waste and street litter.
SGP	MSW includes waste collected from households and trade premises such as schools, hawker centres, markets, community centres and places of worship.
THA	MSW means solid waste created by municipal activities e.g., residence, shops, business, service provider, marketplace, and institutes, i.e., organic and food waste, leaves and grass, etc., recyclable waste e.g., glass, paper, metal, plastic, aluminium, rubber, etc. and general waste e.g., fabric, wood, and material debris, excluding municipal hazardous waste.
VNM	MSW includes waste discharged from production, services, daily life, and other activities. This can include domestic and industrial waste as well as hazardous and non-hazardous waste.

Sources: Compiled by authors from definitions provided by the countries (BRN and SGP) and various sources (Premakumara and Maeda 2014; Borongan and Okumura 2010; UNCRD 2018a; Jain 2017)

7.4.2 Food waste

Reduction of food loss and waste can offer multiple benefits for people and planet. On average, one-third of the edible parts of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tonnes per year (UNEP 2021e). Food loss in AMS largely takes place in the food supply chain rather than at the consumer level. For example, food loss per capita in Southeast Asia is 120-170 kg/year, accounting for 26-36% of the total per capita production of edible parts of food for human consumption–460 kg/year (FAO 2011). However, the per capita food waste by consumers is about 76-91 kg/year, with an average of 82.4 kg/year (Table 7.4). Indonesia generates the largest amount of food waste in the region, 20.9 million tonnes/year. However, Malaysia has the highest level of per capita household food waste, 91 kg/ person/year.

Table 7.4 Household food waste estimates for AMS

AMS	Household food waste estimate (kg/ capita/ year)	Household food waste estimate (tons/ year)
BRN	80	34,742
KHM	86	1,423,397
IDN	77	20,938,252
LAO	86	618,994
MYS	91	2,921,577
MMR	86	4,666,125
PHL	86	9,334,477
SGP[11]	77	442,000
THA	79	5,478,532
VNM	76	7,346,717
ASEAN average	82.4	5,276,281

Sources: (UNEP 2021e). Singapore's statistics are based on (National Environment Agency Singapore 2021).

While a large amount (45 to 50%) of food waste ends up in landfills, AMS are still struggling to overcome hunger and malnutrition. According to the recent Global Hunger Index (GHI) in 2021, even the top performer of the region–Thailand–only ranked 53rd out of the 116 countries surveyed. The results also show that the state of hunger in Viet Nam, Philippines, Cambodia, Myanmar, Indonesia, and Lao PDR is "serious" and/ or "alarming", with children suffering the most. On average, 26.1% of children under five in ASEAN are stunted, while 7.9% and 6.6% of children under five are wasting and overweight, respectively. The average under-five mortality rate in ASEAN countries is about 2.6% (Table 7.5).

Table 7.5 Global Hunger Index Scores for AMS

AMS	GHI ranking 2019	Proportion of undernourished in the population (%) 2018-2020	Prevalence of wasting in children under five years (%) 2016-2020	Prevalence of stunting in children under five years (%) 2016-2020	Under-five mortality rate (%) 2019
KHM	69	6.2	8.8	28.9	2.7
KDN	73	6.5	10.2	30.8	2.4
LAO	78	5.3	9.0	33.1	4.6
MYS	58	3.2	9.7	21.8	0.9
MMR	71	7.6	6.7	26.7	4.5
PHL	68	9.4	5.6	30.3	2.7
THA	53	8.2	7.7	13.4	0.9
VNM	61	6.7	5.8	23.8	2.0
ASEAN average	66	6.6	7.9	26.1	2.6

Source: (von Grebmer et al. 2021)

7.4.3 Plastic waste

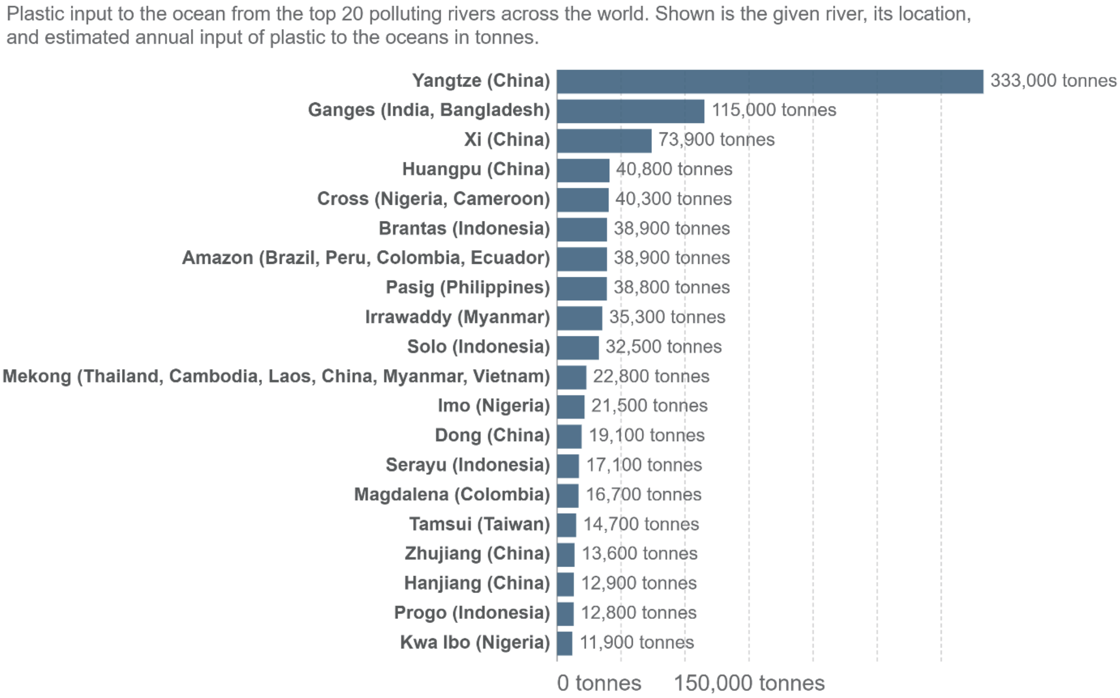
Total global plastic production in 2020 was about 367 million metric tonnes, which was about 0.3% less than the previous year due to COVID-19's impact on the industry (Statista 2022). Plastic waste pollution has reached serious proportions with about 100 million tonnes of plastic now found in the oceans, 80-90% of which came from land-based sources. Although ASEAN's per capita plastic waste generation rate is lower than countries like Kuwait, Germany, Netherlands, Ireland and US (Jambeck et al. 2015), AMS are among the world's largest sources of plastic pollution. More than half of the plastic waste in the ocean comes from just five Asian countries, including four from ASEAN: Indonesia, the Philippines, Viet Nam, and Thailand (Table 7.6).

Table 7.6 Plastic waste generation in AMS, 2010

AMS	Plastic waste generation (tons/ year), 2010	Per capita plastic waste (kg/ person/ day), 2010	Share of inadequately managed plastic waste (%)
BRN	3,688	0.03	1
KHM	344,698	0.07	87
IDN	5.05 million	0.06	81
LAO	NA	NA	NA
MYS	2.03 million	0.20	55
MMR	1.37 million	0.07	87
PHL	2.57 million	0.07	81
SGP	359,483	0.19	0
THA	3.53 million	0.14	73
VNM	3.27 million	0.10	86

Source: (Jambeck et al. 2015)

Figure 7.2 Plastic pollution from top 20 rivers, 2015



Source: (Lebreton et al. 2017)

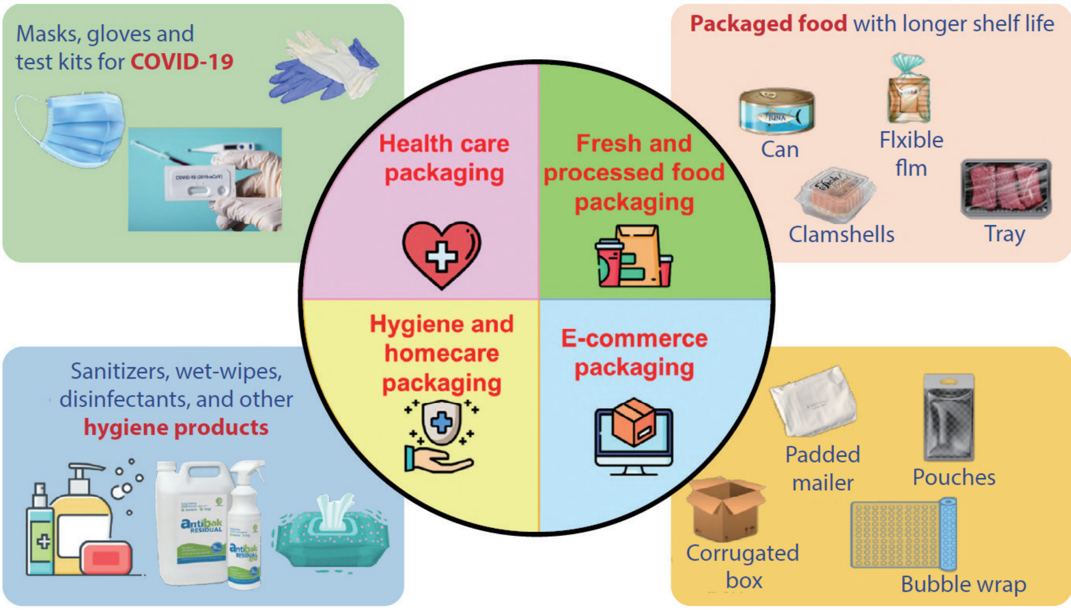
Much mismanaged plastic waste flows to the ocean from rivers. About 67% of ocean plastic originated from only 20 rivers, seven of which are in ASEAN. While AMS contribute the highest proportion of mismanaged plastic waste and contamination of the worlds' oceans, they also import more plastic waste than any other region in the world. According to a report by Greenpeace, "between 2016 and 2018, the ASEAN region saw plastic waste imports grow by a staggering 171%, from 836,529 tonnes to 2,265,962 tonnes. Much of it was labelled as 'recyclable' even though the shipments carried thousands of tonnes of contaminated plastic and other mixed wastes from developed countries … into the region" (Greenpeace Southeast Asia 2019).

COVID-19 and plastic waste

The COVID-19 pandemic has set back actions to tackle plastic waste including the initiatives and commitments by the plastics industry and national-level marine plastic prevention programmes in the ASEAN region. The main areas of impacts are the plastic value chain, E-commerce, food services sector, health care service sector, and municipal waste sector (AIT and UNEP 2021). The pandemic has made it more difficult for recycling value chains to collect, clean, and process the plastics for recycling (GA Circular 2020). Interruptions and in some cases the complete shutdown of plastic recycling value chains have led to more plastics entering landfills, open burning, and likely more plastics entering the open environment and waterways, as there have been fewer formal and informal collectors engaged in waste management and plastic collection. Apart from the quantity of the plastics collected, the lockdowns and other COVID-19-related restrictions have reduced the quality of the recycled plastics. The closure of hotels, restaurants, and other commercial venues, which tend to be better at separating waste for recycling, has meant recyclers have had to rely more on poorly segregated recyclables from households for feedstock (Hicks 2020). Further, COVID-19 has affected the AMS plastic recycling trade as demand for recycled plastic declined due to fossil fuel price reductions. Due to the fossil fuel price reductions, the prices of virgin plastic pellets fell by 30% which forced recycled plastic pellet prices to be reduced by 21% on average in four AMS (Indonesia, Philippines, Thailand, and Viet Nam) (GA Circular 2020). This situation led to the bankruptcy of approximately 40% of the recycling businesses in the region (Hicks 2020).

Figure 7.3 illustrates the areas within the packaging industry that have experienced a surge in demand (adapted from (AIT and UNEP 2021)). Facemasks, plastic gloves, and food containers were the major products found in the waste, illustrating the direct influence of COVID-19 in Thailand (Srikanth et al. 2022). The global e-commerce market is expected to double by 2025 (Research and Markets 2020). Hence, plastic packaging for e-commerce is also projected to grow in the ASEAN region.

Figure 7.3 Areas within packaging that are experiencing a surge in demand due to COVID-19



Source: authors, adapted from (AIT and UNEP 2021).

Increased healthcare waste (HCW) generation due to COVID-19 has been reported in the region and is discussed further in section 7.4.6 (Table 7.12). The plastics and plastic-containing products that are not easily recyclable include masks, gloves, and test kits. Public consumption of these items has increased due to the pandemic situation (Srikanth et al. 2022). The takeaway culture associated with plastics such as single-use flexible food packaging has grown due to lockdowns and social distancing. Wood Mackenzie forecasted the EU and US flexible packaging demand to increase by 5-10% in 2020 (Gilfillan 2020). Specific information on the ASEAN region is lacking for these sectors; however, the global trends indicate that plastic waste is generally increasing in all the mentioned sectors.

Microplastics

Secondary microplastics from plastic waste and primary microplastics generated during the user phase of plastic-related products are being released to the environment due to the overall increase of plastic waste in the AMS. Air, land, freshwater, and marine water pollution caused by microplastics (for example tire-wear particles, broken road-markings, synthetic textile microfibres from textile washing, microbeads from personal care products, discharged domestic wastewater from households, coastal landfills etc.) is being recognized in AMS (Pham et al. 2021). Table 7.7 summarizes the microplastic sources from Asian countries excluding China, India, and Japan, with a major share coming from AMS.

Table 7.7 Microplastic sources from Asian countries excluding China, India, and Japan

Type of microplastic	Metric tons/year	% of the global total
Microbeads in the environment from the use of cosmetics and personal care products	1,700	17
Loss of rubber from tire abrasion	197,400	14
Loss through weathering of marine coatings	3,000	6
Loss via washing textiles/clothing	52,000	20
Road markings	35,400	6
City dust	136,500	21
Loss of plastic during upstream plastic production (Virgin plastic pellets)	2,700	9

Source: (UNEP 2018b)

Table 7.8 summarizes the reported microplastic concentration ranges in AMS. The reported ranges are influenced by sampling and analytical methods (Abeynayaka et al. 2022; Kumar et al. 2021). Nevertheless, the presence of microplastics in AMS environments is obvious. Standardization of methods and data reporting is crucial for gathering useful information on microplastics in the ASEAN region for decision-making. Proper data sharing plays key role in maximizing the effectiveness of funding and research on microplastics. Proper sharing meets four criteria – that is, the system must be findable, accessible, interoperable, and reusable (FAIR) (Jenkins et al. 2022).

Table 7.8 Reported ranges of microplastic concentrations in AMS

Environmental compartment	Reported concentration range	Review study reference
Fresh water	0.0 – 41.8 pieces/L	(Chen et al. 2021)
Fresh water-sediment	14.5 – 20,316 pieces/kg	(Chen et al. 2021)
Sea water	0.0 – 120,000 pieces/L	(Curren et al. 2021)
Sea-sediment	3.9 – 49,000 pieces/kg	(Curren et al. 2021)
Beach-sediment	0.0 – 599.0 pieces/kg	(Curren et al. 2021)

Source: (UNEP, 2018b)

7.4.4 Industrial and hazardous waste

Table 7.9 shows the estimated hazardous waste generation in selected AMS based on each country's reporting to the Secretariat of the Basel Convention. Among the five ASEAN countries with updated hazardous waste inventories for 2012-2019, Malaysia and Philippines generated the largest amounts of hazardous waste in ASEAN, followed by Viet Nam, Singapore, and Myanmar. Brunei Darussalam, Cambodia, Indonesia, Thailand, and Lao PDR did not report on hazardous waste during that period.

Table 7.9 Annual production of hazardous waste (unit: thousand tonnes)

AMS	2012	2013	2014	2015	2016	2017	2018	2019
MYS	1,707	1,343	1,665	2,314	1,769	1,240	2,355	4,013
MMR						280		
PHL			1,712	4,332	1,381	2,097	833	4,823
SGP	290	332	411	446	478	471	538	450
VNM								800

Source: (Secretariat of the Basel Convention, n.d.)[7]

7.4.5 E-waste management

According to the United Nations University's (UNU) Global E-waste Monitor 2020, Indonesia generated the highest amount of E-waste in ASEAN, 1,618 kilotonnes (kt) per year, followed by Thailand (621 kt), Philippines (425 kt), Malaysia (364 kt), and Viet Nam (257 kt). Even though Brunei Darussalam is generated the lowest quantity of electronic waste, its per capita E-waste generation rate (19.7 kg/ person) was the second largest after Singapore (19.9 kg/ person) (Table 7.10). There is generally limited data on e-waste collection in AMS. Moreover, as some AMS do not have national e-waste policies, improper management of e-waste remains a risk. E-waste disposal and informal recycling could lead to environmental contamination by e-waste constituents (Purchase et al. 2020) (see section 7.5.1).

[7] The data include (a) hazardous wastes generated for which official data are available, (b) hazardous wastes generated under Art. 1 (1)a, and (c) hazardous wastes generated under Art. 1 (1)b. It does not include other wastes generated (Annex II) under the Report Dashboard: BC Report Dashboard (basel.int) (http://ers.basel.int/eRSodataReports2/ReportBC_DashBoard.html), accessible at: https://www.basel.int/Countries/NationalReporting/NationalReports/BC2020Reports/tabid/8989/Default.aspx.

Table 7.10 Amount of E-Waste generated in AMS in 2019

AMS	E-waste generation (kg/person)	Amount of E-waste generated annually (kilotons)	E-waste documented to be collected and recycled	National e-waste legislation/policy/ regulation in place
BRN	19.7	8.70	NA	No
KHM	1.1	19.00	NA	Yes
IDN	6.1	1618.00	NA	No
LAO	2.5	17.00	NA	No
MYS	11.1	364.00	NA	Yes
MMR	1.6	82.00	NA	No
PHL	3.9	425.00	NA	No
SGP	19.9	113.00	NA	Yes*
THA	9.2	621.00	NA	Yes
VNM	2.7	257.00	NA	No

Source: (Forti et al. 2020)

*Note: Singapore's EPR scheme for E-waste commenced on 1 July 2021. See https://www.nea.gov.sg/e-waste-epr.

7.4.6 Healthcare waste management

HCW includes a significant quantity of hazardous substances, so inadequate healthcare waste management causes serious environmental and human health risks in ASEAN. However, it is difficult to find accurate data on HCW generation in AMS (Ghosh 2020) (Table 7.11).

Table 7.11 Amount of HCW generated in AMS in 2017

AMS	Total quantity of HCW generation (tonnes/ day)	Average HCW generation (kg/ patient/ bed)
KHM	342.54 kg/ day	
IDN	225	0.75
LAO		0.51
MYS	110,200 kg per day	1.9
MMR	Nay Pyi Taw (4 tonnes/ week); Yangon (5 tonnes/day), Mandalay (2 tonnes/ day)	
THA	53,868	2.05
VNM		1.57

Sources: Compiled by authors from (WHO 2017; Minoglou, Gerassimidou, and Komilis 2017; ECD and MONREC 2018).

Global attention on risks associated with healthcare waste and its management has increased with the COVID-19 pandemic. There has been a rapid increased in HCW generation in many cities in AMS, with a five-fold increase from prior to the pandemic (Table 7.12).

Table 7.12 Increase of HCW generation due to the COVID-19 pandemic

City	The volume of HCW generation before COVID-19 pandemic (tonnes/day)	The volume of HCW generation during the COVID-19 pandemic (tonnes/day)
Manila (Philippines)	47	280
Jakarta (Indonesia)	35	212
Bangkok (Thailand)	35	210
Ha Noi (Viet Nam)	27	160
Kuala Lumpur (Malaysia)	26	154
Wuhan (China)	40-50	247

Sources: Compiled by authors based on (ADB 2020c; Tsukiji et al. 2020; L. Yang et al. 2021).

7.4.7 Hazardous chemicals in the ASEAN environment

Pesticides and herbicides

Based on information from pesticide registration authorities in 13 Asian countries (including Malaysia, Myanmar, Philippines, and Singapore) there are about 3,557 pesticide products registered, of which 214 highly hazardous pesticides (containing 61 different active ingredients) are used in Asia (Dhoj GC et al. 2021). Of the 4 million tonnes of global pesticide consumption, herbicides (50%), insecticides (30%), and fungicides (18%) are the main uses.

Pesticide consumption in Asia is dominated by China (1,807,000 tonnes) but Malaysia (49,199 tonnes), Thailand (21,800 tonnes), and Viet Nam (19,154 tonnes) also rank high (Sharma et al. 2019). Large annual increases of pesticide imports have been reported for Cambodia (61%), Lao PDR (55%) and Viet Nam (10%).

Chemical accidents

There is no central registry of chemical accidents in ASEAN, but they are frequently mentioned in the local media. For example, in July 2021, a fire at a large plastic foam and pellet factory in Thailand caused a huge explosion of a chemical storage tank. The factory stored two hazardous chemicals: styrene monomer (1,600 tonnes) and pentane (60-100 tonnes), and it is adjacent to several housing estates. The chemicals were released into the atmosphere, and people within 5 km of the fire were ordered to evacuate. The long-term health impacts of exposure to the released gases are unknown (Enviliance Asia n.d.).

7.5 Impacts

7.5.1 Health impacts

According to 2016 data, the WHO estimated the global burden of disease attributable to chemicals was 1.6 million lives and 45 million disability adjusted life years lost (WHO 2021b). Unintentional poisoning kills about 78,000 people per year, while occupational exposure to carcinogens kills more than 300,000.

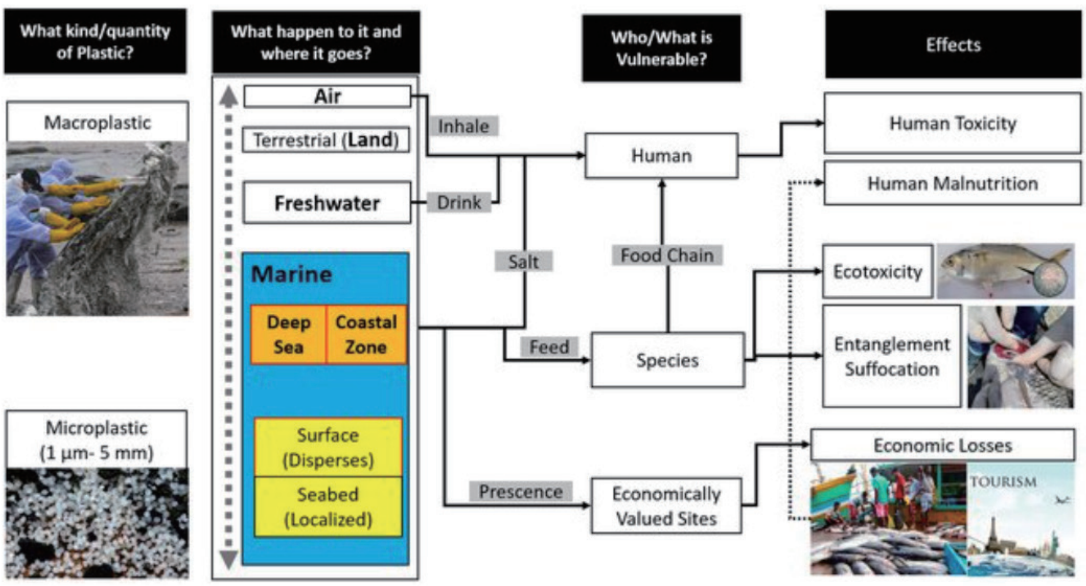
In AMS, most pesticide related health impacts are due to uninformed handling of pesticides by inadequately trained farm workers, many of whom are migrant workers from neighbouring countries working without protective clothing or equipment.

Pesticide contamination of water, fruits, and vegetables may have long-term impacts on human health including reduced immunity, hormone imbalance, reduced intelligence, reproduction problems, asthma, and cancer (Sharma et al. 2019).

Typical e-waste streams are composed of a heterogeneous mix of metals, metalloids, rare earth elements, number of halogenated compounds, glass, and plastics and plastic related chemicals such as flame retardants and other additives. Due to ongoing technological improvements, the composition of e-waste changes with time, different from other waste streams (Ladou and Lovegrove 2013; Purchase et al. 2020). Some of these e-waste elements are known to be toxic to humans, and there are reports of human exposure to such compounds via e-waste recycling processes in AMS (Tue et al. 2013).

Plastic waste and microplastics related pollution include direct potential human health effects due to the related chemical toxicity (UNEP 2021a). The indirect health impacts include food insecurity due to fish stock depletion. Figure 7.4 (Abeynayaka and Itsubo 2019; Abeynayaka 2021; Woods et al. 2021) illustrates a broad view of plastic related impacts. Microplastics have been identified in human blood recently and the consequences may be serious.

Figure 7.4 Impact pathways of plastic litter



Sources: (Abeynayaka and Itsubo 2019; Abeynayaka 2021; Woods et al. 2021)

7.5.2 Biodiversity impacts

Macro-plastic related impacts include the entanglement related damage to species such as marine mammals and the microplastic impacts include the toxicity on biota (Figure 7.4). These ecological impacts have been reviewed and documented in AMS countries as well (Phuong et al. 2022; Chen et al. 2021; Curren et al. 2021). Apart from that, most of the plastic is floating and long-lasting material, so the transportation of foreign invasive species is another potential threat to ecosystem quality and biodiversity (García-Gómez, Garrigós, and Garrigós 2021).

E-waste, if its constituents leach into the environment, may also have implications for biodiversity. While more research is needed, empirical evidence has demonstrated that e-waste constituents at several e-waste recycling sites may adversely impact microbial richness and diversity (Zhang et al. 2016). Apart from recycling sites, e-waste disposal sites and environmental leakage contaminate environments with a concoction of toxicants, which may impact ecological stability.

7.5.3 Social impacts

In AMS, factories producing or storing dangerous chemicals are often located close to housing estates and these housing estates are almost never those of wealthy residents, raising environmental justice concerns. Often factory workers live close to their workplaces to minimize travel times and commuting costs. Plastic related pollution also impacts the tourism and fisheries sectors, potentially threatening livelihoods of fishing and coastal communities.

7.5.4 Climate change impacts

The waste sector is linked to releases of both hazardous chemicals and greenhouse gases (GHGs). It is estimated that 1.6 billion tCO_2eq of GHG emissions were generated from solid waste treatment and disposal in 2016, driven primarily by open dumping and disposal in landfills without landfill gas capture systems, representing about 5% of global emissions (Basel Convention Secretariat et al. 2021). More than 90% of this contribution came from methane, which needs to be reduced by 40-45% by 2030 to achieve the Paris Agreement’s 1.5°C target (UNEP and CCAC 2021). However, these calculations have not considered the potential emission mitigation contribution from waste prevention, recovery, and recycling. With these mitigation actions, the waste sector could contribute 15-20% or even more to national GHG reduction strategies. In addition, reducing black carbon emissions from the open burning of waste would make an additional short-term contribution to climate mitigation. In selected cities in ASEAN, black carbon emissions from open burning of waste could contribute between 2-48% of GHG emissions from the waste sector (Table 7.13). However, MSW Generation in all AMS has been increasing annually, so GHG emissions could increase further.

Table 7.13 Summary of GHG and SLCP (black carbon; BC) emissions from current waste management systems (BAU) in selected cities in ASEAN

Description	Nay Pyi Taw (Myanmar)		Nonthaburi (Thailand)		Jambi (Indonesia)		Kampong Chhnang (Cambodia)	
	GHG	BC	GHG	BC	GHG	BC	GHG	BC
Collection (kg of CO_2-eq/ tonne)	1,412	439	3,622	1,127	2,369	737	195	16
Composting (kg of CO_2-eq/ tonne)	2	1	840	3	145	1	0	0
Recycling (kg of CO_2-eq/ tonne)	(29)	(2)	(2,640)	(40)	(738)	(7)	0	0
Final disposal (kg of CO_2-eq/ tonne)	22,156	53	87,438	105	92,234	96	102	1
Burning at final disposal site (kg of CO_2-eq/ tonne)	660	1,134	0	0	0	0	16	45
Uncollated (scattered and open burning) (kg of CO_2-eq/ tonne)	67	40	0	0	1,062	492	462	743
Total climate impact from GHGs (tonnes of CO_2-eq)	34,710 (82%)		86,356 (98%)		125,800 (98%)		1,679 (52%)	
Total climate impact from BC (tonnes of CO_2-eq)	7,366 (18%)		968 (2%)		793 (2%)		1,542 (48%)	
Total climate impact from both GHG and BC (tonnes of CO_2-eq)	42,076		87,324		126,593		3,221	

Sources: (Premakumara, Hengesbaugh, and Singh 2019; UNEP 2019a)

7.6 Responses

7.6.1 Public sector responses

Hazardous and chemical management

All AMS realize the importance of controlling the chemicals produced and used domestically, given the public health implications. Misuse of chemicals in agriculture, occupational health and safety issues in factories, chemicals in food, drugs, and cosmetics have all been a cause of concern in one or more AMS. Gradually, however, controls have been tightened, as exemplified by Thailand's Chemical Management Master Plan (2019-

2027). The revised plan has a vision of "chemical management which leads to safe population, clean environment, and quality products, which are compatible with international standards" (Enviliance Asia, n.d.). The main strategies are (i) increased efficiency of chemical management and inspection; (ii) development and management of a large database; (iii) risk assessment and designation of standards; (iv) building awareness and changing production and consumption habits; (v) complete reduction of risk from chemical hazards; and (vi) research and development on innovative chemical use replacement. The Cabinet appointed a National Chemical Management Policy Committee in 2019 and a 4-year action plan (2019-2022) was developed under the Master Plan. Ministerial regulations have been updated and a new Development of Chemicals Act has been drafted (Figure 7.5).

Figure 7.5 Chemical management master plan evolution in Thailand

Source: (Enviliance Asia, n.d.)

Municipal waste management

Although sustainable chemical and waste management based on the waste hierarchy includes waste reduction, reuse, recycling, and energy recovery before disposal, open dumping and open burning of MSW are still commonly practiced in many AMS (Table 7.14). Waste prevention, composting and recycling rates are relatively low in ASEAN except in Singapore. Although there are large differences across countries, generally, there are huge gaps in recycling infrastructure, as well as gaps in using technology to reduce the volume of MSW.

Though there is no "one size fits all" solution, AMS should plan and invest in waste management technologies that are appropriate to the amount of their waste, physical and biological characteristics of the waste, regulatory framework, and institutional and financial capacities. For organic waste that is the largest component of the MSW with moisture content, biological treatment such as anaerobic digestion or aerobic composting is an alternative option. The material resulting from these processes can be used as fertilizer, but past experience shows that success requires receiving cleaner materials with effective waste separation programmes at source, and a well-functioning market for the fertilizer or ways to use the fertilizer for organic agriculture (Liu, Onogawa, and Premakumara 2018). AMS have also limited experience with incineration, except Singapore (Jain 2017). Incineration of MSW is getting attention among other AMS, particularly Thailand, Indonesia, Viet Nam and the Philippines, which are considering its potential to reduce the waste volume to be landfilled, as an alternative to landfills, and the co-benefits in generating energy from waste. Some countries have already introduced new legislation and established an enabling environment to allow waste-to-energy projects to get off the ground. For example, the Philippines has filed Senate Bill No. 363[8], also known as the Waste-to-Energy (WTE) Act. Viet Nam has also moved in a similar direction implementing a number of new policies to help firms involved in WTE projects. Another alternative is mechanical treatment of the waste to sort out high calorific waste fractions to be used as a fuel, typically in cement kilns, called Refuse Derived Fuel (RDF). However, it is worth noting that WTE alone cannot solve all problems related to MSWM. It should be embedded in an integrated solid waste management system based on "reduce, reuse, recycle" (3Rs) and tailored to specific local conditions, such as waste composition, collection and recycling, financing, and other aspects (Liu et al. 2020). The success of these projects is largely based on scale of the plants and a guarantee for long term agreements for the tipping fees, offtake of electricity and ensuring the quality of RDF to be produced. It may be advantageous for the region to consider the experiences of Japan, China, and Singapore.

Table 7.14 Waste management systems in AMS (%)

AMS	Open dumping	Landfill (unspecified)	Controlled landfill	Sanitary landfill	Recycling	Composting	Anaerobic digestion	Incineration	Un accounted
BRN				70.0		2.0			28.0
KHM									100.0
IDN	10.0	69.0			7.0				14.0
LAO	60.0		30.0		10.0				
MYS		71.5		10.0	17.5	1.0			
MMR									100.0
PHL					28.0				72.0
SGP				3.0	61.0			36.0	
THA	53.5	27.0			19.1			0.4	
VNM					23.0	15.0			62.0

Sources: (Kaza et al. 2018). Singapore's statistics are based on the 2018 figures in Key Environmental Statistics 2021 (Ministry of Sustainability and the Environment Singapore 2021).

Most ASEAN countries have already established national strategies to address challenges related to waste management broadly (Jain 2017) and 3Rs through specific acts or laws on environmental protection or public health with the technical and financial support from the development partners. For example, the National Solid Waste Management Master Plan (2016-2021) and Action

Plan for Zero Waste (2016-2017) in Thailand promote sustainable waste management. The Philippines has enacted the Ecological Solid Waste Management Act of 2000 (RA 9003) to promote more decentralized waste management systems at the barangay level. The National Strategy on Integrated Solid Waste Management to 2025 with vision to 2050, the National Waste Management Strategy and Master Plan for Myanmar, 2018-2030, Solid Waste and Public Cleansing Management Act, 2007 in Malaysia, National Waste Management Strategy and Action Plan for Cambodia (draft) and Law No. 18/2008 on Municipal Solid Waste Management in Indonesia also regulate sustainable waste and resource management in the respective countries.

AMS have also taken some initiatives to establish national policies, strategies, and action plans to address emerging waste streams, such as plastic and marine litter. ASEAN has already developed its Regional Action Plan to Combat Marine Debris (2021-2025). Based on that most AMS have taken steps in developing their national action plans with the technical support of development partners. For example, Thailand, Indonesia, Malaysia, and Viet Nam have already enacted their national plastic waste management and marine litter reduction strategies and action plans. Currently, Myanmar and Cambodia are working with Institute for Global Environmental Strategies (IGES) and the Japan-ASEAN Integration Fund (JAIF) in developing their national plastic waste and marine litter reduction plans. In addition, Thailand developed a Road Map on Waste and Hazardous Waste Management in 2014 to regulate hazardous waste management Cambodia, Malaysia, Thailand, and Singapore have also enacted national policies to manage e-waste based on the 3Rs. Singapore implemented an Extended Producer Responsibility (EPR) Scheme for e-waste on 1 July 2021 to ensure the collection and proper treatment of e-waste. However, most AMS found it difficult to implement these national policies due to insufficient capacity (technical, financial, human resources), political willingness, and awareness of stakeholders across the waste management chain (Jain 2017; Premakumara and Maeda 2014).

7.6.2 Legal avenues

The World Health Organization (WHO) reported that 65,000 people died from chemical incidents during 2009-2018. These incidents include (i) explosions at factories that store or use chemicals; (ii) contamination of food or water with chemicals; (iii) oil spills; (iv) leakage from storage units during transportation; (v) deliberate release of chemicals in conflict or terrorism; or (vi) outbreaks of disease associated with chemical exposure. Viet Nam has taken the unusual measure of creating a cadre of environmental police to act as the environmental enforcement arm of the Government. Other countries have created an environmental bench in the court system and are training new judges to adjudicate environmental crimes (ADB 2012). In the future, civil society is increasingly likely to turn to the courts for redress following accidental or deliberate chemical spills or explosions.

7.6.3 Private sector responses

Chemical production

The private sector is encouraged to follow the 12 principles of green chemistry "(i) prevention of waste; (ii) atom economy; (iii) less hazardous chemical syntheses; (iv) designing safer chemicals; (v) safer solvents and auxiliaries; (vi) design for energy efficiency; (vii) use of renewable feedstocks; (viii) reduce derivatives; (ix) catalysis instead of stoichiometric; (x) design for degradation; (xi) real time analysis for pollution prevention; and (xii) inherently safer chemistry for accident prevention" (ACS n.d.).

Similarly, the principles for green engineering were developed in 2003 as follows: "(i) engineer processes and products holistically, use systems analysis, and integrate environmental impact assessment tools; (ii) conserve and improve natural ecosystems while protecting human health and wellbeing; (iii) use lifecycle thinking in all engineering activities; (iv) ensure that all material and energy inputs and outputs are as inherently safe and benign as possible; (v) minimize depletion of natural resources; (vi) strive to prevent waste; (vii) develop and apply engineering solutions, while being cognizant of local geography, aspirations, and cultures; (viii) create engineering solutions beyond current or dominant technologies; improve, innovate, and invent (technologies) to achieve sustainability; and (ix) actively engage communities and stakeholders in development of engineering solutions" (Abraham and Nguyen 2003).

Hazardous chemicals transport

In Thailand and Malaysia, companies undertaking the transport of hazardous chemicals are required to (i) maintain a manifest document or document which help identify information regarding the hazardous substance being transported; (ii) document how to respond in case of accidental spill, on properties of the hazardous substances, and on equipment required to handle such material; (iii) carry a certificate for the vehicle used to transport the hazardous material; (iv) provide a training certificate on transportation of hazardous substances for the drivers; (v) have a special driving license issued by government; and (vi) the manifest documents should have at least: UN Number, Name of Hazardous Substance, Globally Harmonized System (GHS) Label, package, tunnel code, the number of vessels, the amount of hazardous substance, name of sender and name of receiver (Enviliance Asia, n.d.).

Municipal waste management

In general, MSW management is the responsibility of local governments except in Malaysia where it is under the Federal Government. There is a growing trend in ASEAN, however, driven by failing municipal systems or by pressure from national policies and international agencies, to outsource MSW management, particularly the provision of waste collection services and management of treatment or final disposal facilities to the private sector. However, private sector involvement in the provision of MSW management services should not be seen as a silver bullet. Building appropriate partnerships with the private sector requires a careful framework including carefully designing the terms of service, clear division of responsibility between local governments and the private sector, appropriate selection of private providers, ensuring fair competition, and an effective monitoring system (JICA 2017). A community-based, decentralized primary collection system has proved effective in achieving increased collection rates in ASEAN countries. The kampongs (villages) of Indonesian cities have formal responsibility for primary collection and bring the waste to a transfer station or temporary storage point for collection by the city service. The Philippines also uses a similar system at the Barangay level (the lowest level political and administrative body) and has achieved reasonably good results. However, a lack of efficient transfer facilities is a weak link in the primary MSW collection and transportation system. The transfer stations often serve as material recovery facilities (MRF) where recyclables are separated.

7.6.4 International support

Multilateral Environment Agreements (MEAs)

Most AMS have ratified a range of multilateral agreements dealing with chemicals and waste such as the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, the Stockholm Convention on Persistent Organic Pollutants and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal; Minamata Convention to maintain emissions and releases inventories of mercury, the Strategic Approach to International Chemicals Management; International Labour Organization Conventions; and the International Health Regulations of 2005, all of which place requirements on countries to develop capacities for improved chemical management (WHO 2021b) (see Table 7.15).

Table 7.15 The ratification status of MEAs relevant to chemicals and waste in ASEAN

AMS	Basel Convention	Rotterdam Convention	Stockholm Convention	Minamata Convention	Availability of SAICM national focal points
BRN	O	X	O	X	X
KHM	O	O	O	O	O
IDN	O	O	O	O	O
LAO	O	O	O	O (Accession)	O
MYS	O	O	O	O (Signature)	O
MMR	O	X	O	X	O
PHL	O	O	O	O	O
SGP	O	O	O	O	X
THA	O	O	O	O (Accession)	O
VNM	O	O	O	O (Approval)	O

Sources: (InforMEA 2015; Minamata Convention on Mercury Secretariat 2021; SAICM 2022)

The World Health Organization/International Programme on Chemical Safety (WHO/IPCS) project on the Harmonization of Approaches to the Assessment of Risk from Exposure to Chemicals has recently released an updated version of the "WHO human health risk assessment toolkit: chemical hazards" which provides a roadmap to calculate human health risks and provides links to useful international resources (WHO 2021b). The Inter-Organization Programme for the Sound Management of Chemicals (IOMC) was established in 1995 to promote international cooperation on sound management of chemicals to protect human health and the environment.

The Organisation for Economic Cooperation and Development (OECD) has been researching chemical accidents triggered by natural hazards (such as the 2011 tsunami in Japan) and has published an addendum to the OECD Guiding Principles on Chemical Accident Prevention, Preparedness, and Response, which addresses such chemical accidents (OECD 2020b). Climate change has been identified as a looming cause of such chemical accidents, although most countries are not yet well prepared.

Chemical safety

The ASEAN-Japan Chemical Safety Database (AJCSD) was developed by under the AEM-METI Economic and Industrial Cooperation Committee Working Group on Chemical Industry and includes chemical regulatory information, globalized harmonization system (GHS) classification results, risk and hazard information, etc. The AJCSD was created to reduce compliance risk on chemical safety. GHS is an international system of classifying and communicating chemical hazards, used on chemical labels and safety data sheets (National Institute of Technology and Evaluation 2018).

Agent Orange clean-up

Due to the use of dioxin-contaminated Agent Orange during the Viet Nam War (1955-1975) the soil in certain areas is still contaminated with herbicides and dioxin and many birth defects have been linked to its use. USAID is funding remediation at the Bien Hoa Air Base (estimated to cost US$ 300 million over 10 years), following a similar earlier clean-up at the former Danang Air Base, which cost US$ 110 million (Byatnal and Amruta 2020).

Waste management

In recent years, ASEAN has been working with international partners to improve waste management in the region. Aiming to promote a systematic and integrated response to guide regional actions in addressing marine plastic pollution in ASEAN over the next five years (2021-2025), the ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States was developed with the World Bank in 2021 based on the ASEAN Framework of Action on Marine Debris in 2019. ASEAN also published a report, “Circular Economy and Plastics: A Gap-Analysis in ASEAN Member States”, in 2019 with the support of the Enhanced Regional EU-ASEAN Dialogue Instrument (E-READI), a European Union cooperation programme to understand the status and challenges faced by AMS to overcome unsustainable plastic consumption, waste management and marine debris pollution. In addition, ASEAN and UNEP International Environmental Technology Centre (UNEP-IETC) conducted several regional studies, including Waste Management in ASEAN Countries, 2017 and a Regional Study on Mercury Waste Management in the ASEAN Countries, 2017 aiming to strengthen the science-based policy decision making in the region. In addition, UNEP-IETC in partnership with the IGES Centre Collaborating with UNEP on Environmental Technologies (CCET) provides technical support to national and local governments in developing and implementing environmentally sound waste management systems in AMS. With support from the Government of Japan and others, the Economic Research Institute for ASEAN and East Asia (ERIA) established the Regional Knowledge Centre for Marine Plastic Debris in 2019 to share knowledge and capacity development on marine plastic debris in ASEAN+3 countries.

7.7 Way forward

The increasing amounts of chemicals and waste and their management pose a serious and complex challenge for most AMS. The growth of chemical-intensive industry sectors (e.g., construction, agriculture, and electronics) means that hazardous chemicals and pollutants (e.g., plastic waste and pharmaceutical products) continue to be produced in large quantities creating public health, environmental and climate risks in the region. This is not exceptional in waste management. Most AMS are facing a tremendous challenge in environmentally-sound management of waste.

The countries need to move away from a linear economic approach to more sustainable materials management, cleaner production, and circular economic models.

At the same time, most AMS have ratified international conventions and some basic relevant policies, strategies, action plans and regulations have been developed at national level, though their implementation is weak and uneven. Thus, addressing legislation and capacity gaps for stronger enforcement of global and national legislations is a priority in the region. Development of national and regional chemicals and waste management action plans using a lifecycle approach based on the globally agreed targets and priorities is important. For example, Thailand's Chemical Management Master Plan (2019-2027) is a good example at national level adapting to the national legislative and regulatory context. At regional level, an ASEAN regional chemical and waste outlook and regional chemical and waste management road map are required to integrate chemicals and waste considerations, strengthen the data and knowledge base of chemicals and waste as well as enhance the capacity of selected countries to track progress.

Also, investments and resources are not adequate for effective implementation and enforcement of legislation in most AMS, thus new and innovative financing models, including cost recovery, polluter pay principles, green bonds, fiscal incentives, venture capital and public/private partnerships need to be encouraged. The business community should be encouraged to take voluntary or regulatory actions to introduce sustainable supply chain management, full material disclosure and risk reduction throughout the production value chain, integrate chemicals and waste management into the corporate sustainability policies, promote appropriate chemical-intensive industry sector and the waste recycling sector including eco-industrial parks. The respective governments also need to take actions to integrate chemicals and waste management into national and sectoral budgets and strengthen collaboration among all actors in the value chain in designing and using safer chemicals and sustainable products.

Widespread implementation of effective public education and awareness programmes are needed. Consumer demands, sustainable lifestyles and sustainable green and chemistry education can be important drivers of behaviour change. AMS can also work on reforming formal education and curricula in tertiary, secondary, primary, and professional education to integrate green and sustainable chemistry in education, research, and learning. Also, creating awareness and knowledge sharing programmes about hazardous chemicals in the supply chain to factory workers, consumers, citizens and communities is important to protect them and the environment. Engaging citizens to collect data applying citizen science methods and involving them, particularly women, indigenous communities and informal sector workers in regulatory and other decision-making processes can promote meaningful citizen participation and actions to promote chemical safety.

ASEAN also needs to strengthen the knowledge base of chemicals and waste as well as enhance the capacity of selected countries to track progress based on science-based criteria. To strengthen the evidence base for policymaking and stakeholder action in the region, ASEAN can follow the methodology for measuring and reporting on the SDG indicators related to chemicals and waste, including (i) SDG 11.6.1 - municipal solid waste collected and managed in controlled facilities, out of total municipal solid waste generated, by the city; (ii) SDG 12.3.1 (a) food loss index and (b) food waste index; (iii) SDG 12.4.2 - hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment; and (iv) SDG 12.5.1 national recycling rate, tonnes of material recycled. ASEAN can work with multilateral and bilateral development agencies and other interested partners in providing both technical and financial assistance to its member countries to improve waste and chemical management in the region. ASEAN also need to strengthen the science-policy interface through enhanced collaboration of scientists and decision-makers.

Chapter 8
Sustainable Cities

Main Messages

- By 2050, more than half the population of most ASEAN Member States (AMS) will live in cities, and by 2035 the ASEAN region will have at least five mega-cities.
- Cities are a laboratory of local and global challenges and solutions, and ASEAN cities are frequently frontrunners in developing sustainable (model) cities, with multiple good practices shared through ASEAN programmes on sustainable cities.
- Cities need to improve solid waste and wastewater management systems, control air pollution, and alleviate traffic congestion as well as plan for increasing population, providing sustainable forms of transport and housing, while confronting increasing threats from climate change and other environmental damage. This wide range of interrelated problems calls for integrated responses that go beyond traditional siloed policymaking approaches.
- Actions on climate change adaptation and mitigation, localizing and delivering the Sustainable Development Goals (SDGs), reducing poverty and inequalities, and advancing a circular economy, will help the ASEAN region meet its sustainable development objectives.
- The ASEAN Sustainable Urbanisation Strategy recognizes the challenge that climate change poses, particularly to coastal cities, necessitating efforts to improve resilience to city flooding.
- COVID-19 has increased solid waste (including medical waste and single-use plastics) among other negative impacts on the environment and severely disrupted life and economic progress in ASEAN cities. There is, however, an opportunity for a “green” recovery and building back better.
- The ASEAN Smart Cities Network is responding to the fourth industrial revolution and digitalization of the ASEAN economies through smart city technologies.
- Long-term planning of ASEAN cities is an urgent priority, and some cities are already moving towards relieving some of the stresses on existing mega-cities by developing new or satellite cities that build in sustainability from the outset.
- SDG 11 on cities includes several environment-related targets; implementing them would significantly contribute to reducing the environmental impact of cities. Cities would also greatly benefit from implementing other city-related SDG targets.

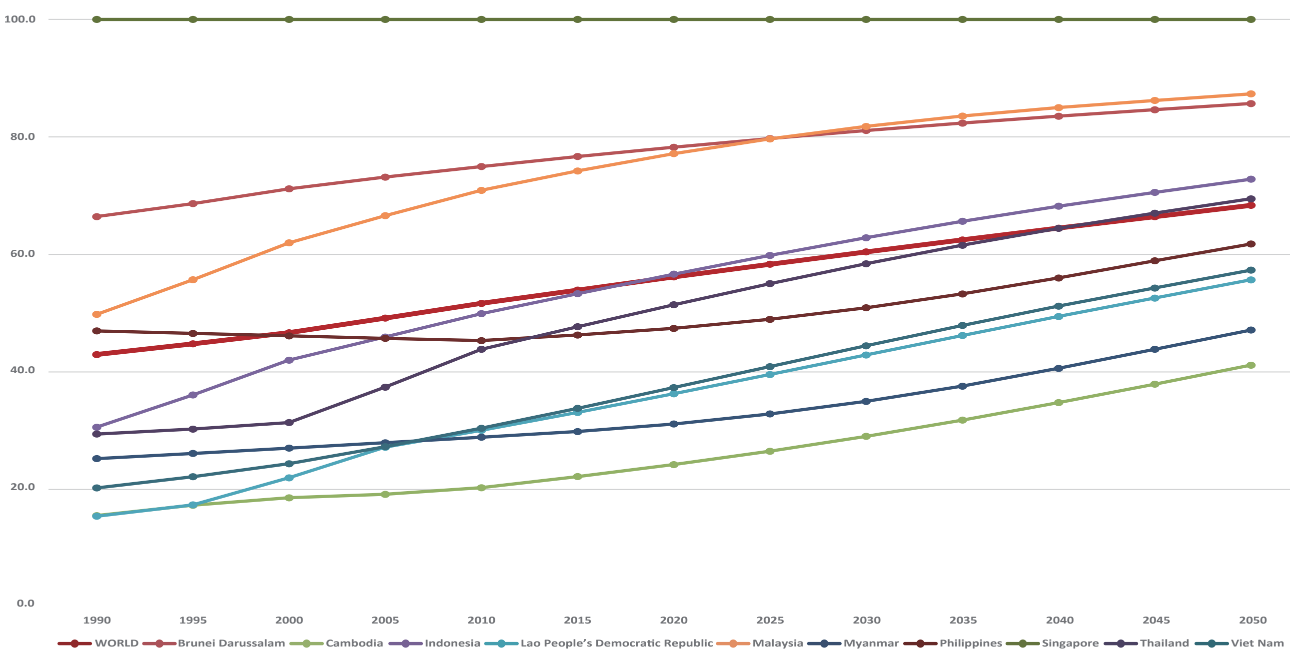
8.1 Introduction

The rapid and unprecedented expansion of urban populations that started in the twentieth century is expected to continue throughout the twenty-first century (UNDESA 2018a). This is significant for the ASEAN region, where cities are expected to rapidly grow in population size and industrialize. The United Nations Population Division has forecasted that by 2050, more than half of the people in Brunei Darussalam, Indonesia, Lao PDR, Malaysia, Philippines, Singapore, Thailand, and Viet Nam will live in cities. For reference, in 1990, only Brunei Darussalam and Singapore had more than 50% of their populations living in cities (Figure 8.1). Moreover, by 2035 the region will have five megacities, or urban agglomerations with more than 10 million inhabitants—namely Bangkok (12.680 million); Ho Chi Minh (12.236 million); Jakarta (13.688 million); Kuala Lumpur (10.467 million); and Manila (18.649 million) (UNDESA 2018b). None of them were a megacity in the year

2000. Notwithstanding these impressive figures, the majority of urban growth in ASEAN will happen in middle-sized cities, those with populations between 200,000 and 2 million inhabitants (ASEAN Secretariat 2018b).

In the course of rapid urbanization, AMS have been facing numerous and complex socio-economic and environmental challenges centred on cities and peri-urban areas. For that reason, and as a rapidly urbanizing region with growing environmental threats, AMS have paid special attention to the environmental sustainability of cities. The ASEAN Working Group on Environmentally Sustainable Cities (AWGESC) Working Plan points as a key challenge for ASEAN cities the "developing climate resilient and low carbon cities that support greenhouse gas reduction and climate resiliency" (ASEAN Secretariat 2016c, 39). At the same time, there are other important issues that need to be addressed to make cities more sustainable as identified by the AWGESC Working Plan, including waste management, access to green public spaces, as well as clean urban air, water, and land. The latter three aspects are the core of the indicators to assessing cities for the ASEAN Environmentally Sustainable Cities (ESC) Award. Moreover, sustainable cities need to consider integrated approaches to development that tackle not only environmental issues but also social and economic, as it has been recognized by the ASEAN Socio-cultural Community Blueprint 2025 (ASEAN Secretariat 2016b). However, there are also important challenges such as the lack of long-term planning in cities or the weakness of policy responses and practices. Overall, this points to the great diversity of challenges to accelerate the environmentally sustainable development of ASEAN cities, which would need to be tailored to respond to different development levels.

Figure 8.1 Percentage of population at mid-year residing in urban areas in AMS, 1990-2050



Source: (UNDESA 2018b)

Many, if not most, of the environmental issues described in this 6th ASEAN State of the Environment report have an urban dimension. Worldwide, cities are responsible for a large proportion of environmental impacts, from high energy consumption to air and water pollution to name a few (Newman 2006; UN-Habitat 2011). They are also responsible for the majority of GHG emissions. Cities are not simply the driving force behind environmental impacts, they are also where responses take place (UNESCAP and UN-Habitat 2019; UNESCAP 2021d). Moreover, historically, cities have been frontrunners in sustainable development, going ahead of national governments in aspects such as climate change adaptation and mitigation (Elmqvist et al. 2019). In consideration of the cross-cutting nature of cities as a laboratory of local and global challenges and solutions, this chapter does not apply the drivers-pressures-state-impacts-responses (DPSIR) model of previous chapters—cities are places and not environmental themes. Instead, this chapter puts more focus on responses and actions at the local level, and in particular, on good practices and initiatives advancing sustainable development in the region with a marked urban dimension, as well as responses to the challenges and current trends observed in ASEAN cities.

Given the wide diversity of cities in the ASEAN region, this chapter pays special attention to ASEAN-wide trends and guiding frameworks and programmes as they relate to sustainable urban development. When appropriate, there are references to good practices of cities or national programmes dealing with urban issues. However, the breadth and complexity of these programmes, the wide diversity of cities not only between AMS but also of cities within the same country, and the wide array of excellence in sustainable development displayed by ASEAN cities prevents a more detailed analysis within the limits of this chapter.

8.1.1 ASEAN Cities, a Primer

Cities in the ASEAN region have a significant challenge ahead: they must manage rapid population growth in a sustainable manner. It is important to acknowledge the diversity within the cities of AMS. The different development levels of AMS result in different rates of urbanization (or the percentage of their total population living in urban rather than rural areas), with countries with a higher GDP per capita usually showing higher levels of urbanization (Table 8.1). In 2020, Brunei Darussalam, Malaysia, and Singapore have more than 75% of their national population living in cities; they are also the three countries with higher GDP per capita. The second group of countries formed by Indonesia, the Philippines, and Thailand has urbanization rates of around 50%. Finally, Cambodia, Lao PDR, Myanmar, and Viet Nam have urbanization rates below 40%; they are also the countries with lower GDP per capita (Yap 2012).

Table 8.1 GDP per capita and urbanization rate of AMS in 2020

AMS	GDP Per Capita (international dollars) (2020)	Urbanization rate (%, 2020 forecast)
BRN	$62,244	78.3
KHM	$4,192	24.2
IDN	$11,445	56.6
LAO	$7,806	36.3
MYS	$26,435	77.2
MMR	$4,544	31.1
PHL	$7,954	47.4
SGP	$93,397	100
THA	$17,287	51.4
VNM	$8,200	37.3

Source: (Our World In Data 2021a; UNDESA 2018b)

The process of rapid urbanization in the ASEAN region, together with different levels of economic development (as shown in Table 8.1) adds an additional level of complexity to the tasks ahead of ASEAN countries. The diversity of the ASEAN region (in economic, cultural, and demographic terms) further multiplies the needs and levels of response to support sustainable development. However, above all, AMS are striving for better standards of sustainable living in their cities (ASEAN Secretariat 2018b). The challenge is to guarantee urban economic growth and reducing poverty, providing quality public services, guaranteeing access to public spaces and transport in a way that is not detrimental to the environment (Yap 2012).

Furthermore, urban development in the ASEAN region is creating an increasingly complex and unique patchwork of interlinked spatial forms. While some of the region's capitals continue their expansion and become megacities with more than 10 million people, there are still important segments of their populations living in slums in peri-urban areas (ASEAN Secretariat 2018b; UN-Habitat 2020). This is a pressing issue particularly in Myanmar, Cambodia, and the Philippines. Respectively, their proportion of urban population living in slum areas in 2018 were of 57.1%, 45.6%, and 44.3% (UN-Habitat 2020, 320). At the same time, the combination of urbanization, industrialization, and economic growth is ushering in new forms of urban development that challenge the traditional division between "urban" and "rural" areas. This new form of urbanization is commonly referred as 'desakota,' a term that combines the Indonesian words for "village" (desa) and "city" (kota). Desakota are densely populated rural areas "of an intense mixture of agricultural and non-agricultural activities that often stretch along corridors between large city cores" (McGee 2014, 124). Desakota creates a de facto spatial continuum linking cities and their peri-urban areas with other cities through an hybrid landscape which is neither urban nor rural (Cairns 2018). Emerging and distinct forms of urban development, such as the desakota, will need tailored and unique planning and governance solutions to manage urbanization—solutions beyond those traditionally implemented by Western countries (McGee 2008). ASEAN cities are expected to play an increasingly important role in shaping the region's sustainable future. Their actions toward climate change adaptation and mitigation, localizing and delivering the 2030 Agenda for Sustainable Development, reducing poverty and inequalities, advancing a circular economy, will decide whether the ASEAN region can meet its sustainable development objectives. Therefore, this chapter focuses on the present and future of ASEAN cities emphasizing the interconnectedness between the three pillars of sustainable development (social, economic, and environmental) and therefore, the importance of integrated approaches when implementing sustainable development policies in line with the ethos of the SDGs (Elder and Olsen 2019).

First, this chapter explores the ASEAN SDGs Frontrunner Cities Programme to illustrate good practices that cities are already implementing to improve their environmental performance. Second, the chapter discusses some of the most pressing challenges facing ASEAN cities and details some of the ongoing responses to those challenges. Third, the chapter focuses on the long-term planning of ASEAN cities and the implications to accelerating sustainable development. Finally, the chapter concludes by providing recommendations suggesting the way forward for cities in the region.

8.2 Current urban challenges and responses

As the introduction to this chapter has shown, AMS need to address the spill-over effects of rapid urbanization. AMS have paid special attention to promoting a more environmentally sustainable development of cities. For instance, the ASEAN Ministerial Meeting on Environment (AMME) began convening the AMS ministries of environment in 1981; AMME's activities in promoting cooperation on environmental issues are supported by ASOEN. ASOEN includes seven working groups in key priority areas, one of which focuses specifically on cities, namely, the ASEAN Working Group on Environmentally Sustainable Cities (AWGESC) (for more information, see Chapter 12). Fundamental to articulate responses to current challenges is the AWGESC Action Plan, whose two main objectives to be achieved over the next 10 years are: (1) "to ensure that cities and urban areas in ASEAN are environmentally sustainable, while meeting the social and economic needs of the people;" and (2) "To promote sustainable urbanisation and climate resilient cities in ASEAN towards a clean and green ASEAN" (ASEAN Secretariat 2016c, 41).

This section summarizes two current challenges ASEAN cities are facing, namely COVID-19 recovery and fighting climate change. Together with common urban environmental issues (such as waste and wastewater management, as highlighted in the previous section) building back better from the COVID-19 pandemic and fighting climate change are complex problems that are related to environmental dimensions of development but go beyond the scope of traditional environmental policies.

These two challenges stress the need to take broader perspectives to environmental challenges: in the current increasingly complex urban world in which problems are multifaceted and interconnected, siloed solutions to address environmental, social, or economic issues in isolation will not suffice. This is especially significant to ASEAN cities, which are managing rapid urbanization (and the associated increase in the consumption of resources, rising temperatures and urban heat island effects, GHG emission, or the loss of natural environments and biodiversity) while maintaining economic growth in a way that does not harm the environment. Therefore, AMS are encouraging the localization of the SDGs in ASEAN cities as well as increasing intra-regional connectivity to increase resilience and sustainability in the region. Although the tasks to localize the SDGs and increase intra-regional connectivity are not exclusive to cities, this section emphasizes the urban dimension of those challenges as well as the city-focused strategies develop to confront them.

8.2.1 COVID-19 recovery and cities

The COVID-19 pandemic has had far-reaching negative impacts on the ASEAN region. Although at first there were improvements in areas such as air pollution (due in part to restrictions put in place to limit social and economic activities to curb the spread of the virus), COVID-19 has increased solid waste (including medical waste and single-use plastics) among other negative impacts on the environment. Moreover, regarding social and economic aspects, COVID-19 has (i) taken thousands of lives (Ritchie et al. 2021);[8] (ii) disrupted supply chains and economic activity; (iii) halted progress towards increasing connectivity across AMS due to restrictions in cross-national movements among other factors; (iv) exacerbated existing socioeconomic inequalities; and (v) increased waste, including single-use plastics (Suriyankietkaew and Nimsai 2021; ERIA 2020). COVID-19 poses an ongoing threat to advancing sustainable development in ASEAN cities as local governments might relegate environmental concerns to a secondary position to address the loss of employment and economic activities consequence of the pandemic. At the same time, cities, which have played a major role in containing the spread of COVID-19, will be key agents in building a more sustainable post-COVID-19 ASEAN region (UN-Habitat 2021).

AMS have reiterated the "importance of promoting economic policies and growth including trade and investment, which contribute to sustainable development and tackling climate change, as well as addressing other economic, social, and environmental challenges" (ASEAN 2021e, 1). The ASEAN Comprehensive Recovery Framework (ASEAN Secretariat 2020a) recognizes the important role of building back better from the pandemic—that is, in a more sustainable manner. The framework proposes a wide range of initiatives to accelerate sustainable development in the ASEAN region. Some of them are especially relevant to cities, such as measures to improve infrastructure and to promote smart cities. The Framework recognizes the importance of "building green infrastructure and addressing basic infrastructure gaps" (ASEAN Secretariat 2020a, 39) as a way to simultaneously improve sustainability standards while also creating new jobs. The Framework also points out that new infrastructure projects should consider how they contribute to accelerating climate action. The recovery plan aligns as well with the Master Plan on ASEAN Connectivity (MPAC) 2025 (ASEAN Secretariat 2016d). Furthermore, the ASEAN Smart Cities Network (ASCN), which will be reviewed in greater detail in section 4 of this chapter, is poised to become a platform to share lessons learnt and to foster the cooperation between ASEAN cities in pursuing post-COVID-19 sustainable development.

[8] As of 5 December 2021, the confirmed deaths due to COVID-19 in AMS were: Brunei Darussalam, 98; Cambodia: 2,960; Indonesia: 143,867; Lao PDR: 207; Malaysia: 30,614; Myanmar: 19,141; Philippines: 49,386; Singapore: 759; Thailand: 20,966; Viet Nam: 26,260 (Ritchie et. al. 2021).

8.2.2 Climate change and cities

AMS are firmly committed to the Paris Agreement and are working to advance climate action in the region (ASEAN Secretariat 2021g). AMS have the important challenge of peaking GHG emissions in the near future while still managing rapid urbanization, industrialization, and population growth, all factors linked to increasing GHG emissions (Tarasawatpipat and Mekhum 2020). The significant urban dimension of climate change across AMS position cities as primary players in expediting actions toward climate change adaptation and mitigation, in line with the New Urban Agenda (UN-Habitat 2017). Moreover, ASEAN cities are exposed to natural disasters as well as to dangers posed by climate change, like rising sea levels, calling for urgent action (UNESCAP and UN-Habitat 2019).

The ASEAN Sustainable Urbanisation Strategy (ASUS) acknowledges that ASEAN cities need to work toward mitigating the impacts of climate change. The ASUS framework is articulated in six areas and 18 sub-areas. The area of 'built infrastructure' contains the sub-area of 'urban resilience' which targets the impacts deriving from climate change exacerbated city floods and deploying early warning systems (ASEAN Secretariat 2018b). This responds to the high risk of ASEAN coastal cities to storm surges, subsidence, and coastal flooding (Nicholls et al. 2008; ASEAN Secretariat 2018b). Already, several ASEAN cities have taken measures to improve resilience to city flooding in Ho Chi Minh, Jakarta, and Manila among others (ASEAN Secretariat 2018a). At the same time, there is a recent growing emphasis on decarbonization across ASEAN cities (ASEAN Secretariat 2021g). Both trends have been reflected in national plans to confront climate change, such as in the "Myanmar Climate Change Master Plan (2018-2030) (Ministry of Natural Resources and Environmental Conservation 2019)

8.2.3 Localizing the SDGs: Cities' actions

Continuing their excellent work in advancing the Millennium Development Goals (MDGs), AMS are fully committed to attain the SDGs by 2030 (IMF 2018a). The important role of cities in accelerating the localization of the 2030 Agenda has been widely acknowledged (Ortiz-Moya et al. 2020; Ortiz-Moya, Saraff Marcos, et al. 2021). For example, the Organisation for Economic Cooperation and Development (OECD) has estimated that cities are responsible for delivering about 65% of the targets for the 17 SDGs. (OECD, n.d.). Moreover, Antonio Guterres, Secretary-General of the United Nations, highlighted the leading role of local and regional governments in implementing the 2030 Agenda for Sustainable Development and the importance of creating "an enabling environment that maximizes the potential of cities and local authorities". In localizing the 2030 Agenda for Sustainable Development, AMS are prioritizing integrated solutions to the SDGs. Indeed, environmental concerns are included within all 17 SDGs, even ones considered as focusing on social or economic issues (Elder and Olsen 2019).

The importance of integrated approaches to the SDGs is reflected in local efforts to accelerate the localization of the 2030 Agenda. Moreover, the commitment of ASEAN cities to localizing the SDGs is shown in the region's first four Voluntary Local Reviews (VLRs), which were presented in 2021 (UN-Habitat, n.d.; UNDESA, n.d.; UCLG, n.d.). VLRs are a mechanism through which local and regional governments align their policies with the SDGs and national VNRs and monitor their progress toward achieving the 2030 Agenda for Sustainable Development. This movement was spearheaded in 2018 by four local governments: Kitakyushu, Shimokawa, and Toyama in Japan; and New York in the USA (Ortiz-Moya et al.

2020; UCLG and UN-Habitat 2020). Conducting a VLR goes beyond the review and monitoring of progress towards the SDGs; it demonstrates a city's dedication to equitable and integrated sustainable development. It allows to identify policy gaps, find synergies, and limit trade-offs between policies to localize the SDGs, in turn accelerating their attainment (UNESCAP 2020a).

In 2021, four ASEAN cities were the first to develop a VLR, i.e., Penang Island, Shah Alam, and Subang Jaya in Malaysia, and Surabaya City in Indonesia (Box 8.1). An important outcome of VLRs is how they help to reshape municipal governance structures to allow for greater policy coherence. Given that the 17 SDGs are interconnected, with multiple synergies and trade-offs linking all Goals, the VLR process encourages cities to work across department/siloes by encouraging a careful assessment of local strategies and how each of them contributes to the SDGs. This assessment usually entails departments to come together to discuss how their activities contribute to the SDGs, what helps to create avenues for continuous discussions on SDG implementation across-departments (Ortiz-Moya et al. 2020; UCLG and UN-Habitat 2020).

Box 8.1 Summary of VLRs presented by cities in the ASEAN region

Penang Island, Malaysia

Penang Island is working towards accelerating sustainable transitions and creating a low-carbon city. For that reason, and to show its commitment to advancing the SDGs, the city presented its first VLR in 2021. The VLR showcases good practices and challenges faced in localizing and delivering the 2030 Agenda. Penang Island faces the conundrum of managing urbanization and ensuring economic growth in a way that will limit the ill effects of gentrification and respects the environment. The VLR analyzes the impact of COVID-19, presents a roadmap to deliver the SDGs, and reviews progress toward 11 priority SDGs, namely Goals 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, and 17.

Shah Alam, Malaysia

Shah Alam presented its first VLR in 2021. The VLR describes the city's actions towards accelerating the delivery of the 2030 Agenda, highlighting progress to date as well as the challenges ahead. Shah Alam was already working on sustainable policies aligned with the ethos of the SDGs. The city's holistic approach to sustainable development includes working on social, economic, and environmental issues simultaneously. The report focuses on highlighting local actions and their contribution to achieving the 2030 Agenda. It also presents the city's roadmap to 2030 and how it aligns with the SDGs. The report provides in-depth reviews of five prioritized SDGs (Goals 1, 11, 12, 13, 15) as well as the way ahead for the city to deliver the promise of the 2030 Agenda.

Subang Jaya, Malaysia

Subang Jaya's first VLR showcases the strategies and actions the city is implementing to accelerate the localization and achievement of the SDGs. The VLR also demonstrates Subang Jaya's long-term commitment to the 2030 Agenda. The city's VLR details how some of its key projects are helping to advance particular SDGs. For example, the 'Community and Urban Farming' initiative works toward achieving SDGs 2, 11, 13, and 17. The VLR also reviews the progress towards seven global goals (SDGs 3, 5, 8, 11, 12, 13, and 16).

Surabaya City, Indonesia

Surabaya City released its first VLR in August 2021 to showcase its progress and challenges in the city's journey to implement the SDGs. The VLR also describes the impact COVID-19 has had on the city's progress toward the SDGs. The report details the policy and enabling environment supporting Surabaya's SDG actions and the policies relevant to the 2030 Agenda. Furthermore, the VLR report focuses on goals and targets of nine SDGs: Goals 3, 4, 5, 6, 8, 11, 12, 15, and 17. It concludes with a detailed analysis of the means of implementation available and the next steps to follow to accelerate the localization of the 2030 Agenda.

8.2.4 Sustainable territorial development: Increasing intraregional connectivity through the Master Plan on ASEAN Connectivity 2025

The Master Plan on ASEAN Connectivity (MPAC) 2025 was adopted by AMS in September 2016. It puts forward a vision for the region "to achieve a seamlessly and comprehensively connected and integrated ASEAN that will promote competitiveness, inclusiveness, and a greater sense of Community" (ASEAN Secretariat 2016d). It is ASEAN's main strategy to improve the region's hard (physical) and soft (institutional and people-to-people) linkages to foster the integration of AMS while respecting their heterogeneity. MPAC is expected to increase the cohesiveness of the ASEAN community and facilitate the movement of goods and people to ensure economic growth (ASEAN Secretariat 2016d).

The MPAC 2025 provides an ambitious roadmap to guide the development of the ASEAN region and the integration among the AMS. The MPAC emphasizes environmental concerns. For instance, in terms of physical infrastructure, the plan notes the important role of "environmentally sustainable land transport corridors" (ASEAN Secretariat 2016d, 19). Furthermore, as ASEAN cities continue growing, the MPAC 2025 also recognizes the need to rethink approaches to resource consumption and energy production in a sustainable manner. Nevertheless, there are ample opportunities for deploying affordable sustainable energy across the ASEAN region, like the potential to increase hydropower production capacity in AMS such as Myanmar (ASEAN Secretariat 2016d, 33).

The MPAC 2025 recognizes the role of cities in advancing the overall proposed vision. Two of the five strategic areas proposed by MPAC 2025 have a significant urban dimension—namely, 'sustainable Infrastructure' which includes the promotion of smart urbanization, and 'seamless logistics,' which takes into consideration transport infrastructure predominantly in cities. Sustainable infrastructure includes an initiative to "develop sustainable urbanization in ASEAN cities" that comprises eight key implementation measures such as "launch a smart transport initiative, linked to public transport and non-motorized transport across ASEAN cities" (ASEAN Secretariat 2016d, 98). The ASEAN Sustainable Urbanisation Strategy of 2018 (ASEAN Secretariat 2018b) is a key initiative of the MPAC 2025 to facilitate sustainable urbanization in ASEAN cities.

8.3 Long-term planning of cities

The magnitude of the challenges outlined in the previous sections has revealed the importance of developing long-term plans in ASEAN cities to guarantee environmentally sustainable urban development. Indeed, ASUS recognizes that one of the greater barriers facing ASEAN cities in advancing sustainable urbanization is the lack of long-term strategies to avoid unsustainable development (ASEAN Secretariat 2018b). For example, unplanned communities lack solid waste and wastewater management systems or access to public transport. This results in a reactive approach to urban planning, in which local governments react to existing problems instead of anticipating needs and planning accordingly to meet those needs. This will require additional capacity building efforts to address the current lack of planning capacity in ASEAN cities (ASEAN Secretariat 2018b). Therefore, ASUS provides two toolkits to help cities prioritise their sustainable urbanisation actions as well as develop comprehensive action plans or viable proposals relevant with their unique contexts. Nevertheless, the recognition of this shortcoming has increased efforts toward better and more strategic long-term planning in cities that prioritize integrated approaches to sustainable urban development. This section reviews three such efforts: the development of New Satellite Cities, the proliferation of smart cities in ASEAN, and the growing importance of data-driven city planning in connecting smart city initiatives with sustainability objectives.

8.3.1 ASEAN SDGs Frontrunner Cities Programme: Supporting local action to attain the 2030 Agenda

Rapid urbanization and industrialization are resulting in the multiplication of challenges related to the environment in ASEAN cities, many of them, spanning beyond municipal borders. The growth of cities entails the increase in resource consumption as well as of energy, consequently augmenting GHG emissions. It also leads to greater toxic emissions (such as water and air pollution). At the same time, cities need to increase their capacity to manage waste and wastewater to avoid environmental degradation that can negatively impact to biodiversity. These problems, common to worldwide cities, are more acute and visible when compounded by rapid urban growth, especially if happening in informal settlements or slums where urban poor concentrate, and public services are scarce. Local governments need to implement integrated responses to simultaneously guarantee social and economic development while improving environmental conditions.

The AWGESC has promoted sustainable urban development in ASEAN cities. For instance, the AWGESC, with funding from the Japan-ASEAN Integration Fund (JAIF), launched the ASEAN ESC (environmentally sustainable city) Model Cities Programme in 2011 to build up the capacity in selected cities in ASEAN countries for advancing sustainable development paying special attention to some of the challenges abovementioned (and significantly, improving waste and wastewater management). The programme is action oriented and intended to support pilot projects in cities to create a tipping point to advance a regional green movement. The ASEAN ESC Model Cities Programme had four phases in its first decade: phase one (2011-2012) included 12 cities; phase 2 (2014-2015) counted 18 participating cities; and phase 3 (2016-2017) increased the number to 21 cities.

The fourth phase of the programme entailed its reformulation to recognize the increasing influence of the 2030 Agenda for Sustainable Development (in short, the 2030 Agenda) and its 17 SDGs. Although the SDGs were conceived with national governments in mind (Fox and Macleod 2021), with the sole exception of SDG 11 on Sustainable Cities and Communities, it has been estimated that about 65% of the 169 targets comprised by the SDGs will not be achieved without the active participation of local governments (OECD 2020a). Therefore, the programme was renamed the ASEAN SDGs Frontrunner Cities Programme (ASEAN SDGs-Frontrunner Cities Programme n.d.) in 2018 further highlighting the importance of the SDGs as a guiding framework for sustainable city development. The ASEAN SDGs-FC Programme supported planning and implement of actions to contribute to sustainability in 24 cities across eight ASEAN countries from 2018 to 2020, as shown in Table 8.2.

Table 8.2 List of SDGs frontrunner cities in ASEAN

AMS	Cities
KHM	Kep City, Kampo City, Pursat
IDN	Banjarmasin, Banyuwangi, Malang
LAO	Luang Prabang, Kaysone-Phomvihane, Xamneua
MYS	Kuala Langat, Shah Alam
MMR	Bagan, Nay Pyi Taw, Yangon, Mandalay
PHL	San Carlos, Valenzuela
THA	Udon Thani, Phuket, Ban Sang, Takhli, Chaman, Wiengtheong
VNM	Hai Phong

Source: (ASEAN SDGs-Frontrunner Cities Programme n.d.)

The ASEAN SDGs-FC Programme was developed to accelerate the localization of the SDGs in ASEAN cities in a way that addresses the capacity gaps of local governments. At its core, the programme emphasizes the idea that social, economic, and environmental concerns are indivisible, as it is highlighted by the 2030 Agenda for Sustainable Development. As such, environmental targets are embedded in social and economic ones and vice versa (Elder and King 2018; Elder and Olsen 2019). Therefore, the programme promotes integrated strategies that simultaneously act upon the three dimensions of sustainable development. Participating cities proposed pilot projects and activities focusing on prioritized SDGs based on the local needs and context. A secondary objective of the ASEAN SDGs-FC Programme was to support the contribution of cities towards the voluntary national reports (VNRs) of progress towards the realization of the SDGs of AMS.

The proposed activities displayed an overall preference towards pragmatic approaches to SDG localization. Although there is a wide range among the activities supported throughout the programme, there are two salient themes: improving solid waste management and upgrading greening of public spaces. In terms of improving solid waste management, the activities presented by cities included, among others, the promotion of the 3Rs principles through awareness raising campaigns to reduce waste generation, encourage the reuse of goods and other resources, and promote recycling.

These activities were also directed towards tackling one of the most pressing issues for the ASEAN region, namely, the problem of marine plastic debris. Regarding sustainable management and the improvement of public spaces, activities included greening existing public spaces, upgrading their facilities (for example, by installing solar-powered LED lighting systems), as well as building the capacity of municipal staff in managing public spaces.

The SDGs-FC Programme has encouraged activities maximizing co-benefits across different SDGs and working across the three dimensions of sustainable development. While progress toward SDG11, on Sustainable Cities and Communities, has been central to most activities, there has been additional progress towards other interrelated SDGs, such as SDG6 (Clean Water and Sanitation) and SDG 15 (Life on Land) among others.

Throughout its four phases and ten years of history, the ASEAN ESC Model Cities Programme first, and the ASEAN SDGs-FC Programme later, progressively increased from 12 cities in 2011 to 24 in 2018. While the combined population of the 12 cities selected in the first phase totalled some 12 million people, the combined population of the cities selected for phase 4 was roughly 28 million people, equivalent to 5% of the total population of the ASEAN region. This is significant because an important component of most proposed activities has been awareness raising campaigns in areas as diverse as the reduction of single use plastics, recycling, or the protection of natural spaces. Indeed, to achieve progress towards these important issues requires the active participation of citizens through more sustainable everyday life practices. The programme promotes solutions to environmental challenges from the bottom up, stemming from local governments. At its core, through its varied pilot project, the SDGs-FC Programme hopes to inspire action in other ASEAN cities facing similar challenges, fostering peer-to-peer learning between cities in AMS, de facto scaling up the range of the programme in the future. This is reflected in the SDGs-FC Programme's motto, "from islands of excellence to a sea of change."

The COVID-19 pandemic, however, has had a negative impact on many of the proposed activities, especially on those in which large gatherings of people were needed, such as capacity building workshops or awareness raising campaigns. It also slowed down the development of other activities, such as those needing new construction or public works. Nevertheless, participating cities strived to overcome the limitations imposed by the restrictions needed to curb the spread of COVID-19 and continue their efforts towards localizing the SDGs. The SDGs-FC Programme has funded multiple exemplary good practices in sustainable urban management that can be deployed in other cities facing similar challenges (Box 8.2).

Box 8.2 Examples of good practices from the SDGs-FC Programme

Banjarmasin, Indonesia

Banjarmasin focused on reducing single-used plastics and lowering the number of single-use plastic bags in the city's traditional markets. The project upgraded six existing traditional markets and encouraged their users (through an awareness raising campaign) to use Bakul Purun traditional bags (made of weaved purun plants). The project also promoted recycling by creating value from waste in dedicated waste recycling centers.

San Carlos, Philippines

The project focuses on constructing a new wastewater management facility in Sipaway Island, an island part of the City of San Carlos located 3.5km away from the mainland. Sipaway Island is one of San Carlos' main tourist attractions but the lack of a wastewater management system on the island threatens its future sustainable development. For example, untreated water is released directly into the ocean, damaging marine ecosystems but also the local economy by threatening the livelihood of fishers as well as the local touristic industry. By installing a wastewater management facility on the island, the project simultaneously helps progress towards SDG 6, Clean Water and Sanitation; SDG 12, Responsible Consumption and Production; SDG 13, Climate Action; and SDG 14, Life Below Water.

Udon Thani, Thailand

As a rapidly growing city, Udon Thani faces the challenge of managing municipal waste. The current lack of waste management facilities is extremely damaging to the environment; of the 160 tonnes of solid waste generated daily in the city, only 0.15% is recycled, with the remaining waste being disposed of in the city's single sanitary landfill. Udon Thani's project focused on managing solid waste at the household level. To do so, the project implemented a series of capacity building workshops for staff and local communities on issues such as how to reduce waste, waste separation, and recycling. Rather than prescribing solutions, the workshops empowered local communities to devise mechanisms to support waste separation and recycling tailored to their unique needs. The project was implemented in seven pilot communities.

Xamneua, Lao PDR

Xamneua is experiencing rapid population growth; this entails the parallel growth of solid waste and wastewater, which if left unmanaged can lead to environmental degradation and damage to the surrounding ecosystems. The city also faces increasing air pollution as well as a lack of public parks with green areas. Xamneua has implemented a project to simultaneously improve waste management while also upgrading green public spaces. The principles of the 3Rs inform the city's new solid waste management system. On top of the installation of new trash bins to facilitate waste separation, there were a series of workshops in 12 urban villages, one municipal market, and two secondary schools on how to manage waste. Also, new ornamental trees and flowers were planted in the city's main park. Overall, these activities contributed to advance the localization of SDGs 11 and 12, yielding a more sustainable community based upon the circular economy principles.

Source: (W. C. Teoh 2021)

The examples outlined in Box 8.2 illustrate how the SDGs-FC Programme has promoted integrated approaches to sustainable development in which policies to accelerate the localization of social and economic SDGs go hand in hand with environmental ones. The SDGs-FC Programme has increased awareness about the SDGs among local stakeholders and improved a wide range environmental condition (such as waste and wastewater management). Moreover, the Programme has created a network of cities hoping to increase peer-to-peer learning that can potentially lead to an organic scaling up of actions as more cities adopt strategies similar to those implemented by participating cities. Overall, the SDGs-FC Programme underscores the key role of cities in delivering the 2030 Agenda as well as the need to implement integrated approaches to do so.

8.3.2 New and satellite city development

The development of new towns is becoming a mechanism to control the ill effects of uncontrolled urbanization. Contrary to unplanned and spontaneous communities lacking basic public services, waste management, or access to green public spaces, these new planned communities are designed with environmental concerns in mind from the beginning. Best practices include designing public transport networks and waste management systems. There are ample examples throughout history of new towns in ASEAN countries. For instance, the now vibrant city of Subang Jaya in Malaysia, or the planning area of Queenstown in Singapore were developed in the second half of the twentieth century. Following this long-established trend, there are numerous New Town developments underway across some ASEAN countries. At present, New Clark City is being built in the Philippines in the Clark Special Economic Zone, in the region of Central Luzon. New Clark City is strategically located to make the most of existing infrastructure of the former US military base. The city will be developed based on sustainable principles, with public transport and a network of green spaces to reduce air pollution (Republic of the Philippines Bases Conversion and Development Authority 2018). Phu Quoc in Viet Nam, a rapidly developing tourist destination, will redevelop the site of its former airport into a new mixed-uses district (Saigoneer 2017).

There is a long history of relocating national capitals (Rossman 2017). To alleviate congestion, some AMS have launched ambitious decentralization plans to relocate national capitals. For example, Myanmar has relocated capital functions to the newly planned city of Nay Pyi Taw, which now hosts most of the government functions previously located in Yangon, and officially became the capital of the country in 2005. Furthermore, Indonesia is planning to move capital functions to a newly developed capital city called Nusantara from the densely populated island of Java to the less populous island of Borneo, and in particular, to the province of East Kalimantan (UNESCAP and UN-Habitat 2019; ABC/wires 2022).

8.3.3 Smart Cities in ASEAN: the ASEAN Smart Cities Network (ASCN)

Given the rapid urbanization of AMS and the ongoing efforts to promote smart cities in the region, the ASEAN Smart Cities Network (ASCN) was proposed in 2018 to coordinate smart city solutions across AMS and thus, contributing to strengthen community building (ASEAN Secretariat 2018d). The ASCN's main goal is to "improve the lives of ASEAN's peoples and promote new business opportunities and innovation in smart city development, using all means including technology" (ASEAN Secretariat 2018a, 1). Activities of the ASCN are facilitated by the "ASEAN Smart Cities Framework" (ASEAN Secretariat 2018a). The framework is articulated in three strategic outcomes ('competitive economy,' 'sustainable environment,' and 'high quality of life'), two urban systems ('integrated master planning and development' and 'dynamic and adaptive urban governance') and will include one or more of six focus areas ('civic and social,' 'health and well-being,' 'safety and security,' 'quality environment,' 'built infrastructure,' and 'industry and innovation'). Finally, the ASEAN Smart Cities Framework recognizes two key enablers, namely 'technological and digital solutions' and 'partnership and funding' (Centre for Liveable Cities 2018).

The strategic outcome on sustainable environment promulgates that "a smart city could incorporate a sustainable, green and resilient growth agenda that promotes the science-based use of, and support for, green technology and energy, as well as promote sustainable consumption and production through innovative policies" (ASEAN Secretariat 2018a, 2). The focus area on quality environment includes three development focus areas: 'clean environment,' 'resource access and management,' and 'urban resilience.' There are 26 pilot cities participating in the ASCN across the 10 AMS (Figure 8.2), including a wide variety of city-sizes, locations, and main challenges. Each pilot city has developed an 'Smart City Action Plan' with a clear vision for the future, focus areas, strategic targets, and outlining concrete smart city projects, altogether advancing sustainable urban development (Box 8.3).

Figure 8.2 Map showing the 26 selected pilot cities participating in the ASCN

Source: (Centre for Liveable Cities 2018)

Box 8.3 Examples of projects being developed under the ASEAN Smart Cities Network

Bandar Seri Begawan, Brunei Darussalam

The proposal centres on the Kampong Ayer heritage district of Bandar Seri Begawan. As one of Bandar Seri Begawan's main tourist destinations, the Smart City project aims at maximizing the competitiveness of the area by increasing employment opportunities and health and well-being. One of the two Smart City projects include the implementation of sustainable waste management practices to restore the quality of the waters of the Brunei River.

Da Nang, Viet Nam

The city aims at becoming a smart, liveable, and sustainable city by 2030. To achieve this goal, Da Nang is 'becoming smarter' in six different focus areas: (1) smart governance; (2) smart living; (3) smart mobility; (4) smart environment; (5) smart citizens; and (6) smart economy. For example, Da Nang intends to implement an intelligent traffic control system to enhance traffic conditions and reduce congestion in the city.

Singapore

Singapore is seeking to transform itself through technology by digitizing its government, economy, and society. The end goal is to develop a state-of-the-art digital infrastructure in the city. Consequently, Singapore is working towards improving electronic payment systems while also building a National Digital Identity including the use of digital signatures to facilitate online activities.

Yangon, Myanmar

Yangon's Smart City Action Plan seeks to increase quality of life standards in the city by improving three key areas: (1) Civic and Social; (2) Health and Well-being; and (3) Built Infrastructure. To achieve this objective, the plan promotes the conservation of the downtown area and the upgrading of its streetscape and infrastructure in a sustainable manner. The project also strives to improve traffic conditions.

An important component of smart city solutions is data-driven city planning. Indeed, to better develop smart city plans it is needed to enjoy enough spatial data at the municipal level to inform evidence-based planning. The World Bank launched a programme to provide Technical Assistance to Cities, referred to as City Planning Labs (CPL). At its core, this programme recognizes the importance of geospatial data in managing urban growth by providing a reference framework to inform urban planning decisions that maximize existing resources while leveraging the positive impact of urbanization. CPL works on creating a Municipal Spatial Data Infrastructure (MSDI) platform to support evidence-based urban planning, which is being tested in three partner cities in Indonesia, namely, Semarang, Denpasar, and Balikpapan. The MSDI is defined as "the platform that facilitates the organization, sharing and utilization of geospatial information to tackle the challenges to achieve sustainable urban development. It is the cornerstone of any strategy for cities aspiring to embrace digital transformation and for the long-term success of smart city initiatives" (World Bank 2021f, 1).

To operationalize the implementation of the MSDI platform, CPL together with Singapore Land Authority (SLA) have developed a framework based upon four interdependent pillars: (1) institutional arrangements; (2) people; (3) data; and (4) systems. In short, this framework is referred to as IPDS framework. The IPDS is comprehensive, since it takes into consideration regulatory and governance aspects together with technological innovations, and scalable, meaning that cities can leverage the benefits of MSDI regardless of their capacity levels and technological levels. The IPDS framework will structure the creation of MSDI Roadmaps as a joint effort between CPL and partner cities. Such MSDI Roadmaps must consider the interactions across the four pillars of the IPDS framework to allow for short-, mid- and long-term planning in cities.

There are three partner cities in Indonesia, which have been testing how to implement the MSDI on the ground and have develop MSDI Roadmaps. The process to develop the MSDI Roadmaps of Balikpapan, Denpasar, and Semarang consisted of four steps: (1) "establish a baseline and define problems: MSDI readiness assessment;" (2) "define a benchmark and highlight concrete opportunities;" (3) "develop an MSDI implementation roadmap with prioritised recommendations;" and (4) "develop a monitoring and evaluation (M&E) framework" (World Bank 2021f, 9).

To give one example, the city of Semarang was the first city in Indonesia to partner with CPL and establish a data governance system. Nevertheless, Semarang had already in place MSDI related initiatives such as a Smart City Initiative previously launched by the Mayor. Following this, "an MSDI policy framework was established through the efforts of the key city agencies, especially BAPPEDA (City Planning Agency), DISKOMINFO (ICT Agency) and DISTARU (Spatial Planning Agency)" (World Bank 2021j, 122). This has allowed the MSDI platform to integrate with existing strategies, such as the aforementioned Smart City Initiative. Overall, Semarang hopes to develop further its MSDI capacities to allow for cross-sectoral collaborations between different departments based on geospatial information. The MSDI framework is ultimately bringing together smart city solutions with sustainable development objectives, by providing a tool for evidence-led policymaking to support the city's green policies.

8.3.4 Green spaces for health and well-being

The contribution of urban green spaces to health and well-being has long been acknowledged. Green spaces in cities, including parks, rivers and waterfronts, urban farms, or tree-lined streets can contribute to pollution mitigation such by removing pollutants from the air, provide thermal comfort especially in hotter seasons, as well as capture carbon, overall providing long-term advantages that go as far as "more than twice their planting and maintenance costs" (Brown and Mijic 2019, 2). At the same time, access to parks and green spaces increases the physical activity of citizens resulting in an overall improvement of their well-being (Petrunoff et al. 2021). Moreover, green spaces provide further benefits for urban dwellers, including effects on mental health issues. Indeed, research has shown how access to nature during COVID-19 lockdowns "reduced the likelihood of reporting symptoms of depression and anxiety" (Pouso et al. 2021, 8). Overall, it is paramount to guarantee access to green spaces to urban populations to safeguard their well-being.

In this regard, the Health and Well-being area of the ASUS framework pays special attention to the importance of other public services, and in particular, of green spaces to achieve higher levels of well-being in ASEAN cities (ASEAN Secretariat 2018b). Nevertheless, the ASUS recognizes that in the context of rapid population growth and urbanization pressures it is important for cities to plan for appropriate land-use allocation to ensure that enough land is dedicated to urban green spaces. In line with these efforts, the AWGESC included a New Thematic Area on Urban Biodiversity and Green Spaces and proposed a list of indicators to measure its implementation in ASEAN cities. For instance, one of the proposed indicators, indicator No. 3, measures the percentage of population living within 400 metres of green spaces, which underlies the importance of green spaces for Health and Well Being.

At the same time, the preservation and enhancement of green spaces are also being considered from other perspectives. For example, as part of its Smart City project, the city of Luang Prabang is working to protect and restore its wetlands currently threatened by rapid urbanization. The city's smart city plan includes implementing an "Urban Drainage and Sewage System to improve the drainage situation, reduce water pollution, enhance the capacity of the wetlands to provide ecosystem services, and boost the storm water retention capacity" (Centre for Liveable Cities 2018, 37). This, in turn, will increase opportunities to improve the access to green spaces as well as to develop additional economic activities such as eco-tourism.

More recently, ASOEN endorsed ad-referendum on January 20, 2022, the ASEAN Work Programme on Urban Biodiversity and Greenery 2022-2032. This programme is a direct response to the Programme 1 on Sustainable Urban Planning, Development and Implementation outlined in the AWGESC Action Plan 2017-2025; a key component of this programme is to promote urban green areas and biodiversity. Moreover, this also responds to the ASEAN Working Group on Nature Conservation and Biodiversity (AWGNB) Action Plan 2017-2025, which also recognises urban biodiversity as a key area to be enhance in ASEAN cities. Overall, the ASEAN Work Programme on Urban Biodiversity and Greenery fills a gap not addressed by other sustainable urbanisation programmes—such as ASUS (2018) or ASCN (2018). The ASEAN Work Programme on Urban Biodiversity and Greenery broadly directs actions on urban biodiversity and greenery, recommending updating of existing programmes tackling similar issues. The Programme comprises three main action areas, namely: (1) Local Biodiversity Strategy and Action Plan; (2) Nature-based Solutions; and (3) Monitoring, Evaluation and Reporting. The implementation of the programme will result in improving urban green spaces and protect urban biodiversity in ASEAN cities in the mid-term.

8.4 Way forward

The ASEAN region presents a patchwork of development stages, city sizes, and urbanization patterns. This chapter has presented current urbanization trends in AMS, the most pressing challenges facing ASEAN cities, and current programmes and guiding frameworks easing sustainable urban development. It has also illustrated this with good practices from different ASEAN cities hoping to inspire other cities to take similar actions.

As ASEAN cities continue their rapid growth in population and economic output, they are also facing complex challenges in advancing sustainable development. Cities already need to improve solid waste and wastewater management systems, control air pollution, or alleviate traffic congestions. In looking into the future, not only do ASEAN cities need to plan for increasing populations, providing sustainable forms of transport and affordable housing options but also, they will need to confront the increasing threats posed by climate change, increased intra-regional connectivity, accelerated localization of the SDGs, and supporting post-COVID-19 recovery efforts. Overall, this wide range of interrelated problems calls for integrated responses simultaneously addressing social, economic, and environmental concerns that go beyond the more traditional siloed approach to local policymaking.

Although the tasks ahead of ASEAN cities are multiple and complex, there are various frameworks and initiatives put forward by AMS to guide sustainable urban development in the region. Notably, the Master Plan on ASEAN Connectivity 2025, the ASEAN Sustainable Urbanisation Strategy, and the ASEAN Smart Cities Network will be pivotal elements in making ongoing urbanization more sustainable. Moreover, initiatives such as the SDGs Frontrunner Cities Programme are further strengthening efforts to deliver the promises of the 2030 Agenda to all people in ASEAN. But on moving forward, ASEAN cities can explore additional ways to integrate responses to such complex issues. For example, the 2030 Agenda for

Sustainable Development, which is already being localized by several ASEAN cities, could be given a more prominent role in local strategies, as for example, by conducting a VLR.

SDG 11 on cities includes important environment-related targets highlighting sustainable urbanization, sustainable transport, reducing the environmental impact of cities including air pollution and waste management, and promoting green public spaces; these targets are also linked with economic and social well-being. Moreover, localization of all of the SDGs, for example SDG 6 on water and 7 on energy, will help cities to develop more integrated approaches to sustainability.

However, to further accelerate the delivery of the 2030 Agenda, ASEAN cities can be inspired by the Circulating and Ecological Sphere (CES), a novel idea intended to find synergies between the SDGs, decarbonization, and the circular economy already put in practice in Asia that emphasizes the local context when planning for sustainable solutions (Mitra et al. 2021; Ortiz-Moya, Kataoka, et al. 2021). The CES promotes interconnectedness at different scales (for example between rural and urban areas, within nations, and within the ASEAN region) to create a form of development in harmony with nature. The CES also encourages nature-based solutions to climate mitigation and adaptation, helping to preserve biodiversity. There is already a CES platform including Thailand, Viet Nam, and Philippines.

Recognizing the diversity displayed by ASEAN cities, there are some clear priorities to be addressed in the short-, mid-, and long-term to accelerate sustainable transitions of ASEAN cities.

In the short term, ASEAN cities are advised to enhance their long-term planning. At present, even though many mid- and large-sized cities have long-term planning systems, ASEAN cities need to strengthen their long-term planning capacity and mechanisms to be able to anticipate, rather than react to, the environmental problems associated with rapid population growth.

First, strengthening long-term planning capacity should be based on evidence-based decision-making as well as adopting a participatory approach to the planning process. First, evidence-based decision-making should be based on a back-casting approach in which cities decide their desirable future to then, identify the steps necessary to reach that future. In this regard, cities are better advised to present their own long-term visions based on a careful assessment of the main problems they are facing at the moment as well as anticipating those they will face in the future; this analysis should recognize population size and development stage. Through back-casting, for example, cities aiming at achieving carbon neutrality by 2050 may discover that they already enjoy a well-developed public transport network and an efficient waste management system, but these will be insufficient to serve the expected population growth. Based on this conclusion, long-term planning should recognize the need to expand the public transport network to future urbanizing areas and expand the city's capacity to manage waste.

At the same time, strengthening capacity for long-term planning will facilitate designing integrated policies. Given the wide range of challenges facing ASEAN cities, designing strategies that maximize co-benefits by creating synergies between policy objectives and reducing trade-offs will be fundamental to accelerate sustainable development. For example, the integrated management of urban growth will allow to find synergies between issues of air pollution and urban greenery and biodiversity, creating win-win situations for ASEAN cities. Long-term planning will also help increase their resilience to natural disasters and other unforeseen events. Finally, enhanced long-term planning capacity will help to mitigate climate change (for example, by taking into consideration the most optimal sustainable transport modes when planning for urban expansion) and also help to adapt to its negative effects while curbing GHG emissions. Finally, and equally important, in strengthening long-term planning capacity, cities are advised to consider participatory planning approaches to democratize their urban management systems to cater to the diverse voices of local communities and respond to their necessities.

Second, ASEAN cities are better advised to enhance their long-term planning mechanisms. When thinking about how to establish mechanisms for long-term urban planning, cities are further advised to consider creating frameworks conductive to increasing policy coherence and cross-departmental work; this is a crucial aspect given the interconnected nature of present-day issues as demonstrated by, for example, the 2030 Agenda, whose 17 SDGs are deeply interlinked. Moreover, it is crucial to think about how ongoing strategies can help to further strengthen sustainable development in the region, for instance, by intensifying the connection between sustainable development and smart city projects. Importantly, in implementing long-term planning, ASEAN cities should remember the SDGs' motto of "leaving no one behind" to continue building the ASEAN community. Concepts such as the abovementioned CES idea, or novel policy tools like VLRs (which has been already discussed in this Chapter), hold the potential to serve as mechanisms to articulate long-term planning efforts for cities while simultaneously maximizing co-benefits and increase policy coherence. Finally, developing strong visions for the future should inform medium- and long-term strategies that are tailored to the specific needs and desired outcomes of each city.

In the medium term, ASEAN Cities are advised to simultaneously address two different set of issues. On the first hand, problems of consolidated urban areas, those that are already urbanized and functioning but lack key services. On the other hand, to plan for controlling urban expansion as the city's population continues rapidly growing. As it might be expected, issues in the mid-term will naturally stem from the process of establishing and/or updating their long-term planning strategies. Therefore, solutions in the mid-term will vary from city to city.

In general, when regenerating consolidated urban areas (such as historical city centres, existing slums or residential areas, etc.) cities are advised to look into the key areas highlighted by different guiding frameworks from ASEAN (including but not limited to ASUS, the Master Plan on ASEAN Connectivity, the ASEAN Work Programme on Urban Biodiversity and Greenery 2022-2032, or the AWGESC Action Plan) as well as other global frameworks (such as the New Urban Agenda, the 2030 Agenda for Sustainable Development, or the Paris Agreement). Among the aspects needing special attention will be securing safe and quality green public spaces, providing reliable public transport, and improving waste and wastewater management systems.

Nevertheless, in the context of rapid population growth, the regeneration of consolidated urban areas needs to be combined with sustainable forms of urban expansion. At present, many of the issues of many cities in the region come from the rapid and uncontrolled urbanization. Although this might be one of the greatest challenges in the mid-term, guiding urban expansion based on long-term vision should limit the detrimental effects of uncontrolled urbanization in a cost-effective manner—simply because it is more effective to prepare for an expansion than to try to catch up with providing services to areas built without control or planning.

In the long term, there is one main area needing further consideration by ASEAN cities. ASEAN cities are advised to develop review and follow-up mechanisms to monitor the implementation of their long-term visions. To begin with, successful policymaking and implementation relies on effective policy appraisal mechanisms. By reviewing and following-up on implemented policies cities are capable to adjust and fine tune ongoing strategies that are falling short of delivering the desired outcomes as well as of identifying new issues that emerge but where not accounted for when the long-term vision was developed.

In conclusion, ASEAN cities are facing great challenges in regard to their sustainable development, but at the same time, there are tremendous opportunities to accelerate their sustainable development efforts into the future to create more just, equal, environmentally sustainable, and prosperous cities. At present, there are many good initiatives and guiding frameworks to accelerate the sustainable development of ASEAN cities. Such initiatives should continue while redoubling implementation efforts.

Chapter 9
Environmental Education and Education for Sustainable Development in ASEAN

Main Messages

- Environmental education (EE) and education for sustainable development (ESD) are needed to develop individuals' and communities' capacities through transformative education to build sustainable environments, economies, and societies through reconfiguring the relationship between people, the environment, the economy, and society.
- AMS face various challenges when implementing EE/ESD programmes such as overloaded educational programmes, resource constraints, and insufficient implementation guidelines. EE/ESD in the ASEAN region is neither universal nor harmonized.
- The ASEAN Working Group on Environmental Education (AWGEE)'s Action Plan prioritizes the following: the ASEAN Eco-Schools Programme; the ASEAN Green Higher Education Programme; Regional Communication, Education and Public Awareness; and Sustainable Consumption and Production.
- There are limited data to assess the state of EE/ESD in ASEAN holistically. A better framework or scheme for accelerating the understanding and sharing of the status of EE/ESD in the region is needed, including the content of EE/ESD for each area and level; educational methods used; assistance from governments, businesses, nongovernmental organizations (NGOs), and international organizations; and challenges in planning and implementation.
- Many areas of EE/ESD in each country could be improved. Governments should strengthen their support of educators and educational institutions, such as financing, provision of materials and training courses for educators.
- It is also important to help educators and institutes to localize EE/ESD learning objectives and contents to be more easily understood by the local stakeholders. It is also desirable to facilitate networking and exchanges among practitioners and researchers and increased cooperation among NGOs, local governments, and businesses.
- EE/ESD are enablers of the Sustainable Development Goals (SDGs) and should be mainstreamed in the planning, programming, budgeting and implementation across all SDG programmes and projects. Implementation of SDG target 4.7 on education for sustainable development would help to address all the environmental issues in the region.

Environmental education (EE) and education for sustainable development (ESD) seek to develop individual and societal capacities to build sustainable environments, economies, and societies through reconfiguring the relationship between society, the environment, and the economy. This chapter examines the status and way forward of EE and ESD in the ASEAN region.

The chapter starts with a brief review of the historical development of the concepts of EE and ESD. Then, it introduces policies and practices promoting EE and ESD with examples from some AMS. The third section addresses regional cooperation on EE and ESD. The concluding section examines the challenges of EE/ESD implementation and provides a few suggestions for further strengthening EE/ESD at national and regional levels.

9.1 Environmental Education and Education for Sustainable Development

Governments, NGOs, and educators in the region have implemented EE and ESD since the late 20th Century. As shown in the latter part of the chapter, the topics covered in national education policies and implementation have changed over time, reflecting the critical issues relating to the socioeconomic development in each country, so objectives and methodologies have not always been aligned with international discussions. Before exploring concrete policy cases, it is worth quickly reflecting on the historical development of these concepts, to help understand the special characteristics of EE/ESD in the region.

Environmental education dates to the late 1960s “(A)s a response to environmental problems caused through processes of modernity such as industrialization, consumerism, and urbanization. Its precursors included traditions of nature study, natural history, and conservation education” (Hume and Barry 2015, 7:733).

Environmental pollution has been widely recognized in industrialized societies, leading to the urgent call to change the ways individuals and enterprises behave in the national and global economy. Countries like the United Kingdom started exploring environment-related topics in formal education. The international community has also recognized the need to educate people about environmental protection. In 1972, the Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration) reaffirmed the importance of EE. The 19th principle of the declaration says:

“Education in environmental matters is essential to broaden the basis for an enlightened opinion and responsible conduct by individuals, enterprises, and communities in protecting and improving the environment in its full human dimension” (United Nations 1972).

Against this backdrop, EE in its early days aimed to provide people with the knowledge of natural science to enable them to recognize that human beings are inseparable parts of nature and to act responsibly to protect the ecological environment. Hume and Barry (2015) referred to Stapp and pointed out two objectives of EE, namely, “to produce a motivated and knowledgeable citizenry concerning the biophysical environment, its problems, and their solution” and “to ensure that individuals acquired a clear understanding that man is an inseparable part of a system, consisting of man, culture and the biophysical environment, and that man has the ability to alter the relationships of this system” (Stapp 1969, 34; Hume and Barry 2015, 7:734).

Such objectives of EE remained for a few decades. However, in the face of the deepened understanding of the complex and interconnected causes of environmental problems, and the new concepts of “sustainability” and “sustainable development”, the scope of EE in those early years needed to be broadened.

The long association of EE with science education (Gough 2013, 10) only began to change in the 1990s with the emergence of more socioecological approaches, which saw the natural science perspective as simplistic and inadequate to address the complex multi-layered problems of the environment (Kyburz-Gruber 2013; Hume and Barry 2015, 7:734).

The concept of sustainability addresses the intertwined systems of the environment, economy, and society. Changes in the relationship between nature and human societies in the modern industrialized world have been the primary cause of environmental problems, as EE has rightly addressed. However, such changes coincided with changes in relationships among people, organizations, and societies. Solutions to environmental problems are thus interconnected with other challenges such as poverty reduction, economic growth, social participation, gender equality, human rights, and cultural diversity. In other words, specific behaviours of individuals or enterprises that are detrimental to the environment and the structural issues associated with modern economic development have led to multi-dimensional challenges that need to be addressed. The discussions on education in the international community in the late 1980s and the 1990s broadened the scope to embrace sustainable development. “Sustainability is, in the final analysis, a moral and ethical imperative in which cultural diversity and traditional knowledge need to be respected” (UNESCO 1997; Hume and Barry 2015, 7:735).

It is impossible to grow individuals' capacity to tackle such intertwined problems only by providing scientific knowledge of the environment and environmental problems. Sterling (2014) noted the early (and still predominant) “environmental responsibility” view of sustainability education where the major aim was instrumental: changing unsustainable behaviour through addressing gaps in environmental awareness (Sterling 2004, 51). Later studies, such as (Kollmuss and Agyeman 2002), demonstrated the limitations of such a linear “deficit” model, and this has been reflected in an increasing emphasis on processes of learning as well as outcomes seen in, for example, socioecological approaches to education involving constructive, reflective, critical, and participatory elements (Kyburz-Gruber 2013; Hume and Barry 2015, 7:734).

Individual learners and societies can contribute to the resolution of specific environmental problems by developing capacities to select appropriate choices in concrete situations of decision-making, such as consumption or waste generation. However, when they deal with more complex challenges of (un)sustainable development, they need a broader set of capacities to capture the structural issues which constrain people and organizations in unsustainable conditions. They also need to examine these issues critically and change them through constructive dialogue and collaboration with others. Thus, the discussion of sustainability or sustainable development fostered the broadening of the scope of EE by addressing (i) the complex and intertwined challenges of an unsustainable environment, economy, and society; and (ii) a broader set of capacities of people and societies to work as citizens who jointly build sustainability.

The world's first intergovernmental conference on environmental education was organized by the United Nations Educational, Scientific, and Cultural Organisation (UNESCO) in cooperation with United Nations Environment Programme (UNEP) and was convened in Tbilisi, Georgia in October 1977. The Tbilisi Declaration constitutes the framework, principles, and guidelines for environmental education at all levels—local, national, regional, and international—and for all age groups both inside and outside the formal school system. It noted the important role of environmental education in the preservation and improvement of the world’s environment, as well as in the sound and balanced development of the world’s communities.

ESD was launched by the report of the World Commission on Environment and Development (WCED), Our Common Future (World Commission on Environment and Development 1987) It was propelled forward by the 1992 World Conference on Environment and Development in Rio de Janeiro and was the focus of attention again at the World Summit on Sustainable Development at Johannesburg in 2002. Through numerous additional conferences throughout this period, concerted efforts have been made to transform environmental education into education for sustainable development. In December 2002, the United Nations passed Resolution 57/254, which declared a Decade of Education for Sustainable Development beginning in 2005 (Jickling and Wals 2008).

ESD addresses various issues of sustainability and sustainable development. Most of the existing resources on ESD start with describing the present conditions of the environmental, social, and economic conditions threatening the sustainability of humanity and the planet. For example, UNESCO's Roadmap for ESD 2030 provides a concise introduction to the climate change issues (UNESCO 2020). The UNESCO ESD for 2030 framework addresses five priority action areas, namely: (1) advancing policy; (2) transforming learning environments; (3) building capacities of educators; (4) empowering and mobilizing youth; and (5) accelerating local level solutions. Other problems, such as higher quality of life for all, responsible production and consumption patterns, gender equality, and peace, are also considered essential challenges to address in the pathways toward sustainable development.

It is vital to grow the capacity of all societal actors to identify and understand the challenges they face and take actions against such mixed challenges. "Education for Sustainable Development (ESD) empowers learners of all ages with the knowledge, skills, values, and attitudes to address the interconnected global challenges we are facing, including climate change, environmental degradation, loss of biodiversity, poverty, and inequality," (UNESCO, n.d.).

These issues are interconnected in a complicated manner: for example, lack of access to safe drinking water in a community is not just about the water supply system but also about the way community members allocate water to family needs and other demands or the way families and communities distribute work among women and men or older and younger people. Both technical and societal transformation is essential, requiring us to consider what, where, and how we develop and share knowledge, skills, and values among the members of the society. Therefore, the UNESCO citation above is followed by the importance of individual and collective capacities to cause transformations.

Learning must prepare students and learners of all ages to find solutions for the challenges of today and the future. Education should be transformative and allow us to make informed decisions and take individual and collective action to change our societies and care for the planet (UNESCO n.d.). For such a reason, ESD is set both as Target 4.7 under SDG4 on Quality Education but also is recognized as a key enabler of all SDGs and can achieve its purpose by transforming society. EE/ESD should be mainstreamed in the planning, programming, budgeting and implementation across all SDG programmes and projects. UNESCO's General Conference at its 40th Session approved Education for Sustainable Development: Towards achieving the SDGs (ESD for 2030), which was acknowledged by the UN General Assembly at its 74th Session in 2019. ESD for 2030 builds upon the lessons learned from the Global Action Programme on ESD (GAP 2015-2019), emphasizing education's contribution to the achievement of the SDGs. The essential reflections that informed ESD 2030 are as follows.

Transformative action: Fundamental changes required for a sustainable future start with individual behaviour. ESD needs to place emphasis on how each learner undertakes transformative actions for sustainability, including the importance of opportunities to expose learners to reality, and how their behaviour influences societal transformation towards a sustainable future. ESD in action is citizenship in action.

Structural changes: ESD must pay attention to the deep structural causes of unsustainable development. A balance between economic growth and sustainable development is needed and ESD should encourage learners to explore alternative values to those of consumer societies, as well as having a structural view on how to address ESD in the context of extreme poverty and vulnerable situations.

The technological future: ESD must respond to the opportunities and challenges brought about by technological advances. Some 'old' problems will be resolved through technology, but new challenges and risks will arise. Critical thinking and sustainability values become ever more relevant, as the task of teaching ESD may become more challenging with the illusion that technologies can resolve most sustainability problems (UNESCO 2020).

9.2 EE/ESD at the national level in ASEAN

At the national level, AMS have diversified approaches to the planning and implementation of EE/ESD. A few countries have enacted laws or issued national action plans promoting EE or ESD, but others implement EE/ESD under the frameworks of existing laws and strategies for the environment, climate change, biodiversity conservation, or education for sustainable development. Moreover, many AMS promote EE/ESD in collaboration with (or even delegate to) international organizations, education and research institutes, civil society organizations, and the private sector. Such diversified approaches make it challenging to capture the status of EE/ESD in the region comprehensively. Therefore, with few exceptions, such as Nomura and Abe (Nomura and Abe 2008) and UNESCO (UNESCO 2011; 2021b), no existing studies have researched the policies and practices of EE/ESD in more than four AMS in a thorough manner. Therefore, the chapter relies on the policy reports published by governments and international organizations and studiesthat focus on either policies or implementation in one or a few AMS.

9.2.1 Historical development of EE/ESD

The historical development of EE/ESD in ASEAN took different paths in each AMS. In some AMS, the governments' as well as civil societies' efforts to promote sustainable development launched EE and then ESD, supported by specific legislation. In other cases, EE/ESD practices spread through bottom-up efforts by civil society sometimes supported by the business sector and international organizations while the governments placed EE/ESD in a more general context of their educational or environmental policies. Both cases were aligned with the first priority area of the UNESCO ESD for 2030 framework, i.e., "Advancing Policy".

Legal backing for EE/ESD

In some AMS, there is a specific legal basis for EE/ESD. For example, the Philippines has several legal frameworks to support EE/ESD. The Philippines is recognized as a country that has been promoting EE/ESD since the last century. It has successfully developed the formal education system, leading to a relatively higher school enrolment ratio than the other AMS (more than 90% for primary schools in the 1980s). As early as the 1970s, school curricula at all levels introduced EE against the backdrop of the emerging environment pollution problems (Antonio, Bass, and Gasgonia 2012).

The Government of the Philippines implemented education and awareness-raising campaigns on environmental issues. It also developed the first National Action Plan on Environment Education in 1989 (Valencia 2018), which led to the national scale initiatives supported under the National Framework of Environment Action 1992-2002 (Hoffmann and Muttarak 2020; Valencia 2018). Since the 1990s, the Government has integrated sustainable development at all levels. The Philippines Agenda 21 was set up in 1996, and the Extended Agenda 21 set the course towards sustainable development in the country.

The 2008 Republic Act 9512 of the Philippines on Environmental Awareness and Education directs concerned actors to integrate EE into public and private schools' curricula at all levels, including day care, preschool, non-formal, technical, vocational, professional, indigenous learning, and out-of-school youth courses (Valencia 2018). The 2011-2016 Strategic Plan of the Commission on Higher Education also specifies the implementation of ESD in higher educational institutes (Balanay and Halog, n.d.). The Republic Act 9729 on Mainstreaming Climate Change (Climate Change Act 2009) directed the Department of Education to mainstream climate change into basic education curricula. The Republic Act 10121 on Disaster Risk Reduction and Management in 2010 also mandates the Department of Education and the Commission on Higher Education to integrate DRR education into the school curricula of secondary and tertiary levels (Valencia 2018).

Viet Nam's national government's policy to promote EE/ESD aimed to mainstream ESD through various milestones. In 2001, the Ministry of Education and Training carried out a project to introduce EE in formal education. In 2005, the National Decade of Education for Sustainable Development Committee was established. The Government also developed the national data collection indicators for monitoring and reporting on ESD. Meanwhile, the Hanoi National University of Education launched the Centre for Research and Promotion of ESD with support from the National Commission for UNESCO and the UNESCO Office in Viet Nam. Such efforts resulted in the endorsement of the National Action Plan on ESD in Viet Nam 2010-2014 in 2009. While Viet Nam is recognized as one of the most vulnerable countries to the impacts of Climate Change, the Action Plan supports climate change mitigation and disaster risk reduction through education at all levels, from the elementary to university levels (Kieu, Tracey, and Gannon 2016).

Linkages to overarching education and environment policies

Some AMS promote EE/ESD implementation without specific action plans or laws on EE/ESD. They often do so under the existing frameworks of national sustainable development, environment protection, or education policies. Malaysia and Indonesia are two notable examples.

For example, Malaysia has introduced various measures for sustainable development in its development "Blueprints" and other fundamental policies since the 1970s. One of the earliest cases involved the New Economic Policy aiming to eradicate poverty and social imbalances through sustainable economic growth, ensure access to basic infrastructure and utilities, access to education and healthcare services, and mainstream environmental conservation (Mokshein 2019). Specific laws were enacted to achieve these objectives, such as the Environmental Quality Act in 1974, National Forest Act 1984, and the National Environment Policy 2002. Recent research also mentions the 1998 National Policy on Biodiversity, 2004 National Integrity Policy, and the 9th, 10th, and 11th Malaysia Plans as the policies supporting the development of EE/ESD in Malaysia (UNESCO 2011).

Malaysia's National Environment Policy 2002 includes provisions for education and awareness-raising aligned with the recommendations of Agenda 21, such as adopting a holistic approach towards EE and training in formal and informal education, integrating environment and sustainable development into primary, secondary, and tertiary education, reviewing curricula, promoting non-formal education, and strengthening the role of the media in communicating environment-related information (Aminrad et al. 2012; Ministry of Science, Technology and the Environment 2002).

The national education system integrated EE as early as 1991 with a curriculum entitled “Man and the Environment” implemented in elementary schools, and environmental issues have also been taught in many other subjects in both primary and secondary schools, such as geography, biology, chemistry, and humanities (Aminrad et al. 2012; Ninomiya-lim et al. 2019; Mokshein 2019). The national education policy framework, however, including the Malaysia Education Blueprint (MEB, 2013-2025) does not necessarily designate EE/ESD as a central focus. The MEB does not have a section dedicated to EE or ESD, but rather emphasizes objectives such as universal enrolment, increased quality, reducing achievement gaps among students, fostering national unity, and maximizing the government’s return on investment. The blueprint envisions the development of Malaysians “with knowledge, critical thinking skills, leadership skills, language proficiency, ethics and spirituality, and national identity to succeed in the 21st century” (UNESCO 2021b, 16). Such interests of the Malaysian Government are reflected in its VNR to UN SDGs (2017), which reported only three indicators related to SDG 4, namely, the enrolment ratio of primary, secondary, and tertiary education (Mokshein 2019). Thus, it appears that EE/ESD is promoted under the overarching objectives of the Malaysian education policy to provide universal access to quality education and grow human resources that will help Malaysia improve its competitiveness in the global society and economy.

While EE/ESD has gradually been introduced to all levels of education, Malaysia made efforts to develop the capacities of teachers through the integration of EE in teacher training at higher education institutes from 2001 (Ho and Azizi 2009; Ninomiya-lim et al. 2019). According to Ninomiya-Lim et al. (2019), almost all 20 public universities and 45 private universities have courses on environment or natural resources. An increasing number of universities and colleges have become “green campuses” (Ninomiya-lim et al. 2019, 38).

Indonesia has promoted EE since the 1970s, kickstarted initially by international NGOs, including the Worldwide Fund for Nature (WWF). The earliest cases were WWF projects in 1974 (Nomora and Abe 2005). Since then, NGOs, both international (e.g., WWF, Nature Conservancy) and Indonesian NGOs (e.g., WALHI) have actively worked on EE (Parker and Prabawa-sear 2020). The Environmental Education Network (Jaringan Pendidikan Lingkungan: JPL) was established in 1996 and networked NGOs nationwide to mobilize resources and facilitate information sharing (Nomora and Abe 2005). EE in Indonesia has since become closer to ESD by linking with socioeconomic development issues such as democratization, community development, and indigenous people’s rights (Nomura 2009). Such an expansion started from the spread of the environmental movement, whose activists began engaging with EE curriculum development and implementation, as well as linking with grassroots communities and politicizing their activities. As a result, a range of locally urgent issues of unsustainable socioeconomic development was introduced in the EE curricula (Nomura 2009). Universities played a crucial role in the early years by establishing Environmental Study Centres (ESCs) to raise environmental awareness among academics in Indonesia (Setiawan and Hadi 2007; Parker and Prabawa-sear 2020). Nomura (2009) reports that more than 100 ESCs are hosted in national and private universities and conduct various initiatives such as environmental assessment and community development (Nomura 2009).

9.2.2 Scope of curriculum content for EE/ESD

History of EE/ESD topics

EE/ESD in each AMS has reflected contemporary development priorities. The Philippines and Indonesia were among the first AMS to introduce EE. Initially, EE aimed to provide scientific knowledge and raise awareness among people about urgent environmental problems, especially pollution associated with economic development and population growth (Antonio, Bass, and Gasgonia 2012; Nomura 2009). In the 1990s, EE came closer to what is considered ESD in international discussions by addressing issues related to the triple bottom lines for sustainable development. Indonesia, the Philippines, and Malaysia have taken up topics such as poverty reduction, community development, human rights, education for the indigenous population, and gender equality in EE/ESD practices. The development and enhancement of the curricula are aligned with the second priority area of the UNESCO ESD for 2030 framework, namely, “transforming learning environments”.

EE/ESD topics in the 21st Century

In the 21st century, climate change, biodiversity loss and disaster risk reduction (DRR) became common topics in EE/ESD in AMS. In the Philippines, for example, EE/ESD has covered critical issues of (un)sustainable development. The Philippines has also mandated the mainstreaming of climate and DRR in formal education through the 2009 Act on Climate Change and the 2010 Act on Disaster Risk Reduction and Management (Valencia 2018). Eco-Kids, a project launched through cooperation between the Department of Education, HSBC, and WWF Philippines, provides modules on Climate Change, Energy Conservation and Renewable Energy, and Waste Management to public elementary school students. As of 2021, the programme was implemented in 15 public schools in urban Manila with the involvement of 10,000 students. More projects on climate change mitigation, adaptation, and DRR are planned at the primary and secondary levels (UNESCO 2021b, 21–22).

In Viet Nam, a joint project by UNESCO, Ministry of Education and Training (MOET), NGOs, and private companies provided education on climate change, biodiversity, DRR and other issues such as sustainable agriculture, water resources, health and nutrition, and gender equality (Kieu, Tracey, and Gannon 2016) (see Box 9.1). Increased attention to the issues of climate change and DRR, indicate concerns among AMS and local communities, which are vulnerable to the impacts of climate change, such as sea-level rise, changes in rainfall patterns, and extreme weather conditions.

Likewise, as Indonesia is exposed to so many natural disasters, disaster risk reduction has been chosen as one of the themes of ESD in an effort to strengthen national policies on education for disaster management and preparedness (UNESCO 2021b, 6). However, EE or ESD are still optional subjects in the 2013 regulation of the Ministry of Education and Culture (Miyake et al. 2014). The education curriculum renewed in 2013 does not mention EE or ESD specifically, but these issues can be taught in relation to other subjects (Parker and Prabawa-sear 2020).

Box 9.1 Selected EE/ESD programmes on DRR

The Philippines

The Republic of the Philippines Department of Education launched a programme of "Mainstreaming of Disaster Risk Reduction Management in the School System" following the Hyogo Framework of Actions. The programme provides resource manuals for school administrators and teachers to build disaster-resilient schools. It also promotes the coverage of DRR in the elementary and secondary schools' curricula, school mapping exercise, school water and electrical facilities assessment, earthquake, and fire drills, as well as dissemination campaign for energy and water conservation. The 2010 Act on DRR and Management mandated the national education agencies to integrate DRR and management into school curricula of secondary and tertiary levels.

Viet Nam

A project implemented between UNESCO, Samsung, and MOET in Thua Thien Province (Ministry of Education and Training, UNESCO, and Samsung ESD Initiative 2015) focused on developing curricula on natural disasters, climate change, and biodiversity. It also created E-learning courses for these topics and supported the formulation of the local DRR strategy. According to UNESCO, more than 1,000 schools took advantage of the toolkits developed in this initiative (UNESCO 2016; Bui 2020).

Following this, at least 33 other organizations conducted pilot projects related to ESD, "focusing on sustainable agriculture, water resources management and biodiversity protection, gender education and HIV, health and hygiene education, climate change and education for DRR" (Kieu, Tracey, and Gannon 2016, 856).

9.2.3 Green Schools

In the implementation of EE/ESD plans, some AMS have put in place initiatives to pilot EE/ESD curricula in schools or celebrate outstanding educational institutions' EE/ESD efforts, hoping to further encourage the integration of environment-relevant topics into the curricula. Some of these programmes are described below.

The Philippines: National search for sustainable and eco-friendly schools

The National Search for Sustainable and Eco-Friendly schools, a programme implemented jointly by the Department of Natural Resources, Department of Education and Smart Communications, has been running since 2009. The programme requests schools to submit their activities integrating environment and sustainability into school curricula, research, administration, and programmes, and encourages schools through awards (Department of Environment and Natural Resources 2017; Valencia 2018).

The scope of "the national search" shows that EE/ESD in the Philippines is not just about knowledge provision and awareness-raising on environmental problems. The current National Environmental Education Action Plan 2018-2040 aims "to educate the young to play their role as responsible citizens in achieving the SDGs grounded in national needs, culture and context and to enhance sustainable practices as a common culture among Filipinos" (Department of Environment and Natural Resources 2017, 23). It outlines a broad range of actions, including vocational education, out-of-school education, and lifelong education. It also covers some key climate change issues and disaster risk reduction. Its broad scope is "based on the neo-model of Environmental Education in the Philippines". Integration of the SDGs in the Action Plan addresses environmental, social, and economic issues, recognizing that they are interconnected and equally important in sustainable development (Department of Environment and Natural Resources 2017, 23).

Malaysia: Sustainable School Environment Award

In Malaysia, the Sustainable School Environment Award (SLAAS), a programme for primary and secondary schools, was launched in 2005 by the then-named Ministry of Education, Ministry of Natural Resources and Environment (now known as the Ministry of Environment and Water) with the cooperation of the Ministry of Education and the Institute of Environment and Development at Malaysia National University (Mahat and Idrus 2016). Schools are evaluated based on five main components, namely school management, the curriculum, co-curricular activities, greening activities, and "special elements" (Ministry of Environment and Water Malaysia 2022). Another related initiative is the School Nature Club (Kelab Pencinta Alam: KPA) (Loubser et al. 2014). In 2021, the Department of Education published a module for the School Nature Club as a guide for teachers to raise awareness among children and foster environmentally sustainable behaviour. This module will also be a part of the evaluation for SLAAS.

Indonesia: Green and Healthy School Programme

The Green and Healthy School Programme (Adiwiyata), launched in 2006 by the Ministry of Environment, is a well-known programme in Indonesia (One Planet Network 2015). The programme encourages curriculum development, school management improvement, and implementation of out-of-school education (Jalal 2014). Incorporating the principles of participation and sustainability, the programme places primary importance on developing schools' capacity to manage the learning environment, which enables the students to become responsible for the environment. The Adiwiyata programme does not usually call its activities EE or ESD, but it is considered as a means to achieve SDG 4.7 (Parker and Prabawa-sear 2020).

Singapore: Nurturing Stewards of the Environment

In line with the national sustainability agenda under the Singapore Green Plan 2030, the Ministry of Education (MOE) Singapore will work with schools and educational institutions to promote sustainable living, empower students to play their part for the environment, and strengthen the country's green efforts.

Part of this initiative is introducing an Eco Stewardship Programme (ESP) to nurture all Singaporean schools and students as Eco Stewards. The ESP builds on current environmental efforts in all schools, from primary to pre-university levels, through the 4 Cs – Curriculum, Campus, Culture and Community.

MOE will step up plans to harness solar energy, reduce energy usage and waste generation in Singaporean schools, and work towards a two-thirds reduction of net carbon emissions from schools by 2030. Public education on sustainability will be promoted through the new Science Centre. MOE will also build on existing sustainability efforts by Institutes of Higher Learning (IHLs), such as engaging in IHL-industry partnerships to provide opportunities for applied learning and contributing to sustainability-related research.

9.2.4 Challenges in implementing EE/ESD

AMS face various challenges when implementing EE/ESD programmes. Especially, implementing ESD curricula in formal education is often difficult because of overloaded educational programmes and resource constraints, as is the case in Viet Nam and Indonesia (T. P. Nguyen 2019; Miyake et al. 2014). As a result, in some contexts, the quality of EE/ESD is highly variable because of the range in capacities and resources of teachers and schools. While locally customized content and activities developed by local schools can effectively engage learners and grow their capacities as responsible citizens to create a sustainable environment, economy, and society, these positive effects are limited when schools and teachers do not have sufficient resources and support.

AMS also struggle with the lack of clear guidelines for implementing EE/ESD. For instance, in Viet Nam, the UNESCO office noted that the purposes, roadmaps, means of implementation and consistent system were not identified even though the country's 2017 National SDGs Action Plan reaffirmed the essential role of ESD in achieving sustainable development (UNESCO Hanoi 2019, 32; T. P. Nguyen, Leder, and Schruefer 2021, 315). Likewise, in Malaysia, the MOE has produced guidelines for EE/ESD, but educators in classrooms and out-of-school activities still struggle to implement them because they are not concrete enough (Pudin 2015).

AMS could further address "Building capacities of educators", one of the five priority action areas specified in the UNESCO ESD for 2030 framework. Insufficient educators' training on EE/ESD is a key challenge shared by many of AMS. Educators do not often receive appropriate training on the contents of environmental or sustainability issues, and they are often not ready to introduce student-centred and open-ended learning methods. While educators are often overloaded by curricula and limited resources, lack of training both on the contents and methods may substantially limit the positive impacts of EE/ESD.

Each AMS may also experience country-specific challenges to full-fledged mainstreaming of EE/ESD. For example, in the case of Viet Nam, although the organizational and institutional structures have been established, "most practical work in ESD to date has been carried out by NGO-led" programmes (Kieu, Tracey, and Gannon 2016, 857) and cooperation among ministries and stakeholders could be strengthened. Understanding the national as well as local issues within AMS and incorporating them into the EE/ESD curricula are also important, as EE/ESD is implemented at the local level. This will enable AMS to strengthen the fifth priority action area of the UNESCO ESD for 2030 Framework, namely "accelerating local level solutions."

Box 9.2 The Impacts of COVID-19 on EE/ESD

The COVID-19 pandemic has had an enormous impact on EE/ESD in primary, secondary and higher education institutes, as well as on EE/ESD in community education. According to a survey conducted by ProSPER.Net, HEIs faced many challenges in carrying out international student programmes, such as sending students abroad, conducting field studies, and accepting new international students from abroad (International Association of Universities, 2020). Online lectures were incorporated, but most respondents reported that faculty training on online lectures was lacking. Meanwhile, the Asia-Pacific Regional Centres of Expertise on ESD (RCE) survey (Noguchi, forthcoming) details the impact on community education. Communities faced a series of challenges by the pandemic, including lockdowns, market closures, and the digitization of work and learning. While digitization proceeded quickly in some areas, not everyone was able to benefit from it. With regards to EE/ESD in communities, digitization allowed lecture-style training, workshops, and information sharing to continue. However, it became extremely difficult to carry out activities focusing on practice and experience, such as outdoor education of the natural environment and agriculture, and community-based disaster recovery. Government support measures are needed at all levels. Guidelines for safe activities, capacity-building support for educators and practitioners, and networking to share response measures would be helpful.

9.3 Regional cooperation on EE/ESD

9.3.1 ASEAN Working Group on Environmental Education (AWGEE) and AWGEE Action Plan

The ASEAN Secretariat, AMS, and other stakeholders have created several networks facilitating EE/ESD over more than two decades. AWGEE has been mandated "to promote coordination and collaboration among various relevant ASEAN sectoral bodies and dialogue partners to ensure a well-coordinated and integrated approach to promoting environmental education in the AMS, and ASEAN Dialogue Partners" (Environment Division of the ASEAN Secretariat n.d.). Moreover, three ASEAN Environmental Education Action Plans (AEEAPs) were developed, covering 2000-2005, 2008-2012, and 2014-2018. The AEEAPs set the priority areas and activities on EE/ESD at the national and regional levels and complemented the ASEAN Work Plan on Education. AEEAP 2014-2018 specified actions in four target areas, namely, (i) formal sector, (ii) non-formal sector, (iii) institutional and human resources capacity building, and (iv) networking, collaboration and communication (ASEAN Secretariat 2014).

Guided by the AEEAPs, ASEAN has carried out several international programmes, including the ASEAN Eco-schools Programme, ASEAN Green Higher Education Programme, and many communication initiatives such as ASEAN+3 Youth Environment Forum (2007-), and ASEAN Youth Eco-champions award (2012, 2015 and 2019). The ASEAN+3 Leadership Programme focused on Sustainable Consumption and Production (2007-2018) (Environment Division of the ASEAN Secretariat n.d.). The ASEAN-Plus-Three Leadership Programme on Sustainable Consumption and Production, in the context of EE/ESD, has been one of ASEAN's flagship activities implemented annually since 2008 under the environmental education stream, to contribute to the implementation of the AEEAP 2008-2012 and its successor plan 2014-2018, and as a priority for the decade-long AWGEE Action Plan 2016-2025.

AEEAP was an agreed plan of action for the region-wide development and promotion of Environmental Education for Sustainable Development as a key mechanism towards the achievement of a 'Clean and Green ASEAN'. Initially, the programme was implemented in partnership with the United Nations University Institute of Advanced Studies later known as United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS). In the later years, several related partner organizations and programmes, such as EU SWITCH Asia, United Nations Industrial Development Organisation (UNIDO) and Hanns Seidel Foundation (HSF), among others, also participated in the programme's implementation. Over 200 participants have participated in the programme from AMS and dialogue partner countries (China, Japan, and the Republic of Korea). Due to the COVID-19 pandemic, the programme has been temporarily halted. Resumed offering of the programme is envisaged in due course with a modified format and curriculum.

The AWGEE Action Plan for 2016-2025, currently being implemented, outlines four programmatic areas that complement the AEEAP 2014-2018, namely: (i) ASEAN Eco-Schools Programme; (ii) ASEAN Green Higher Education Programme; (iii) Regional Communication, Education and Public Awareness; and (iv) Sustainable Consumption and Production (ASEAN Secretariat 2016c). See Table 9.1 for a summary of key activities under each programmatic area.

Table 9.1 Programmes and activities of the AWGEE Action Plan 2016-2025

Programme	Key Activities
ASEAN Eco-Schools Programme	• Review and improve existing ASEAN Guidelines on Eco-Schools • Confer ASEAN Eco-Schools Award to select eco-schools in AMS • Establish an ASEAN network and forum for eco-schools • Conduct sister schools exchange or pilot project • Conduct a baseline assessment and stocktaking on the extent to which EE is incorporated in school and higher education curricula • Organize a workshop or seminar to develop learning and teaching modules on EE • Organize a symposium to promote and expand the implementation of EE through partnership with ESC Model Cities Programme
ASEAN Green Higher Education Programme	• Develop ASEAN guidelines and criteria for green higher education institutions • Confer ASEAN green higher education institutions award to selected institutions • Organize a workshop to review and improve on existing ASEAN Guidelines on Eco-Schools • Establish an ASEAN network and forum for eco-schools
Regional Communication, Education and Public Awareness	• Enrich the content of the ASEAN Environmental Education Inventory Database (AEEID) and update data and information regularly • Redesign the concept of AEEID to be more attractive • Conduct promotional activities for AEEID • Develop an ASEAN training manual on EE for educators • Conduct teacher and lecturer trainings on EE • Participate and contribute proactively to global initiatives and frameworks related to EE • Conduct an ASEAN Youth Environment Forum • Develop a recognition scheme for youth eco-champions • Support regional youth-led environmental initiatives
Sustainable Consumption and Production (SCP)	• Conduct ASEAN leadership programme for policymakers and business leaders on SCP • Develop joint initiative on SCP with private sector as part of corporate social responsibility • Conduct ASEAN forum for multi-stakeholders to promote awareness and participation on SCP-related practices • Produce education and promotional materials on SCP

Selected priority programmes and activities for AWGEE

The ASEAN Eco-Schools Programme supports schools to create a school culture geared towards environmental protection and conservation through management, curricula and greening and clearing activities. The programme has administered three sets of awards in 2012, 2015, and 2019.

The ASEAN+3 Youth Environment Forum (AYEF) was first initiated by Brunei Darussalam in 2007 and has been organized regularly to promote awareness and enhance the participation and cooperation of youth in environmental protection efforts. The latest AYEF was held in 2019 in Phuket, Thailand.

The ASEAN Youth Eco-Champions Award (AYECA) was launched in 2019 in Cambodia in conjunction with the 3rd ASEAN Eco-Schools Award Presentation Ceremony during the ASEAN Environment Day. AYECA recognizes proactive youths making outstanding contributions to environmental protection in junior and senior categories.

The ASEAN Environmental Education Inventory Database (AEEID) was developed with support from UNEP and HSF. It was launched in 2003 as a part of the 1st AEEAP and updated in 2013. However, in view of streamlining ASEAN's digital platforms on ASEAN cooperation on environment, the 11th AWGEE meeting supported the integration of AEEID with the proposed ASEAN initiative on knowledge management systems and strategic communication or the ASEAN Environment Knowledge Hub.

Additionally, some new initiatives carried out since 2020 addressed recent challenges in the sustainability of environment and societies in AMS. For instance, a series of interactive webinars titled ASEAN Youth and COVID-19: Success Stories and the Way Forward was organized four times in 2020 covering the topics of response, resilience, future of work, and building back better. The ASEAN Youth Climate Action Initiative (ASEANyouCAN) provided a platform for ASEAN youth engagement and contributions on national, regional, and international policy formulation on climate change. It held a dialogue with the ASEAN Ministerial Meeting on the Environment at the 16th AMME in October 2021. These new initiatives enhance the opportunities for youth in ASEAN to cooperate among themselves as well as with key stakeholders such as policymakers to address the latest environmental challenges.

9.3.2 Networks of educators and researchers

Several networks of educators, practitioners, and researchers contribute to the knowledge sharing and capacity building of for EE/ESD in Asia. These networks also implemented or supported the implementation of some of the activities of the AEEAPs.

Regional Centres of Expertise on ESD

A Regional Centre of Expertise (RCE) is a network of existing formal, nonformal and informal education organizations mobilized to deliver ESD in the region or locality where it is situated. It creates a platform for dialogue among regional/local ESD stakeholders and for exchanging information, experience, and good practices on ESD. It develops the regional/local knowledge base and assists in promoting vertical alignment of curricula from primary through university education and in linking formal, nonformal and informal sectors of the education community. RCEs form the global learning space for sustainable development. The Roadmap for the RCE Community 2021-2030 has four strategic priority areas, namely: "serving as local and regional hubs for ESD and showing leadership for innovation"; "strengthening the association of RCE activities with SDGs and ESD framework"; "expanding knowledge sharing and outreach"; and "monitoring progress of RCE achievements" (UNU-IAS 2021). UNU-IAS hosts the Global RCE Service Centre with the support of the Ministry of the Environment of Japan.

Promotion of Sustainability in Postgraduate Education and Research Network (ProSPER.Net)

Led by United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS), ProSPER.Net is an alliance of leading higher education institutions (HEIs) in the Asia and Pacific region. UNU-IAS, the Government of Japan and several HEIs launched the network in 2008. It aims to enable the HEIs to help lead societal transformation (UNU-IAS 2014) and is committed to integrating sustainable development into curricula, building the capacity of educations and other professionals, and providing policy advice on sustainability. The network conducts several programmes, including joint research, capacity development, and implementation of the Young Researchers' School and the Leadership Programme focusing on Sustainable Development for young professionals. The network has also played a leading role in developing learning cases for the ASEAN+3 Leadership Programme on Sustainable Consumption and Production covering sustainability issues such as social entrepreneurship, public policy, poverty reduction, etc. UNU-IAS hosts the ProSPER.Net Secretariat with the support of the Ministry of the Environment of Japan.

UNESCO Associated Schools Project Network (ASPnet)

ASPnet is another important network supporting the promotion of EE/ESD in the region. It was established in 1953 by 33 schools in 15 countries globally and expanded to include 10,000 schools from 181 countries. The network's main objective is the promotion of Global Citizenship Education (GCE) and ESD. Many AMS have national focal points and 10 to 200 participating schools. The ASPnet Strategy 2014-2021 aimed to support the achievement of the SDGs in a changing world. Three specific objectives were to (i) integrate GCE and ESD into the teaching and learning processes of ASPnet schools; (ii) experiment with innovative approaches to GCE and ESD in ASPnet schools; and (iii) strengthen the sharing of information, experience, and good practices.

Some of the activities set out in the ASPnet Strategy include the following (UNESCO 2021a):

1. Organizing the International ASPnet Student's Forum
2. Providing Open Educational Resource Materials on GCE and ESD
3. Launching new flagship projects on GCE and ESD, including biodiversity, climate change and disaster risk reduction
4. Developing a student guidebook

Under the context of the Global Action Programme (GAP), ASPnet promoted the Whole School Approach by conducting pilot projects and providing guidance to the national coordinators. The whole-school approach to ESD promotes sustainability "in every aspect of school life", such as "teaching content and methodology, school governance and cooperation with partners and the broader communities as well as campus and facility management" (UNESCO 2017, 2). The pilot set Climate Change as a particular thematic focus. Twelve countries, including Indonesia, joined discussions to prepare the pilot project in which ten schools were selected. In 2017, 13 additional countries joined, including Lao PDR, and the number of participating schools increased to 130. Participating schools set up a cross-school climate action team, conducted the assessment, developed and implemented action plans, and monitored progress and achievements. They also engaged with other ASPnet Schools through the provided online tools.

ASEAN University Network Thematic Network on Ecological Education and Culture (AUN-EEC)

The AUN-EEC, established in 2018 and hosted by Ateneo de Manila University in the Philippines, aims to "develop a generation of Southeast Asians who will have the mindset and competencies to conserve and preserve the environment through ecological education" (AUN Secretariat, n.d.). The network proposes curricula and teaching materials for education in ecology, promote sustainable lifestyles among students and faculty, and raise awareness on critical issues (AUN Secretariat, n.d.).

9.4 Way forward

9.4.1 Policy framework and institutional arrangements

As detailed above, at the national level, some AMS (e.g., the Philippines and Viet Nam) have action plans or laws specifically promoting EE or ESD, while others (e.g., Malaysia and Indonesia) utilize other relevant policies and frameworks, such as education, climate change or environment, to promote EE/ESD. However, the former approach does not necessarily ensure more effective implementation than the latter. What is more important than the existence of a law or plan titled "ESD" is whether the government provides the necessary guidance and financial support to the key stakeholders, including the local governments, educational and research institutes, and educators working on EE/ESD on the ground.

Most AMS have promoted EE/ESD through cross-sectoral collaboration engaging with NGOs, international organizations, universities, and businesses. The topics covered in EE/ESD were determined by international discussions, which focused on the need to develop learners' capacities for environment protection and sustainable development, as well as by nationally and locally identified priorities for sustainable socioeconomic development. However, neither the public nor private sectors can mobilize the necessary skills and other resources by themselves. Indonesia and Malaysia are not the only cases where the networks of local and national NGOs and educators played the leading role in promoting EE/ESD. International organizations, researchers and private companies also played an essential role in EE/ESD. They brought in the necessary resources, such as finance, knowledge, and materials, and they shared experiences and lessons for more effective planning and implementation given ever-changing priorities of (un)sustainable development. Governments often had multiple roles in promoting constructive multi-sector collaboration for EE/ESD. These include setting the overall direction and national priorities for EE/ESD, providing essential resources, (i.e., finance, materials, and tools), building capacity of educational institutions and educators, and setting up forums to facilitate further exchange and sharing of information among the actors working on EE/ESD. Development of a specifically designed action plan or law for EE/ESD could be recommended to guide the relevant agencies to perform such roles.

9.4.2 Common language of EE/ESD

The terms used in AMS by stakeholders engaged in concrete projects/initiatives that can be considered ESD are often not the same as those for ESD in international discussions. In fact, AMS have many activities and policies that are not specifically designated as ESD, although they clearly incorporate ESD principles (UNESCO 2014; T. P. Nguyen 2017, 5). Of course, internationally discussed concepts are often reinterpreted or substituted with similar domestic concepts to better fit the specific national circumstances or government objectives. However, the differences in meanings or terminology often cause difficulties in understanding the local situation and making comparisons between different countries. Of course, it is not necessary to harmonize the terminology of ESD or align it with other contexts, but it is important to enable the governments and other key stakeholders to identify where they could support these initiatives.

9.4.3 Pedagogical approaches

As noted earlier, the transition from EE to ESD had two primary foci. First, the discourses of sustainability and sustainable development made clear the necessity to address the structural issues interlinking various problems such as poverty, lack of access to basic human needs (including education) and gender inequality, simultaneously with pollution and resource depletion. Secondly, to address such structural problems, people and societies need more scientific knowledge and awareness on the issues and to develop other capacities including critical thinking, practical skills, communication, and collaboration with others toward participating in, or leading, the necessary societal changes. Thus, diversification of teaching and learning approaches is crucial. In short, the purposes of education evolved from the development of learners who have decent knowledge and intentions to protect the environment toward the development of individuals and societies who could critically examine the pertinent socioeconomic patterns that lead to interlinked challenges and assume active roles in transforming them. As enablers and integrators of SDGs, HEIs should view EE/ESD as transformative education and learning experiences and promote community engagement and local level actions. The approach is participatory, multi-methodological, value-driven, and holistic.

Some official documents on EE/ESD embed such extended purposes. The MEB and higher education blueprint envision Malaysians equipped with relevant knowledge and skills (including critical thinking, leadership, etc.) to meet the economic needs domestically and internationally (UNESCO 2021b, 16). Similarly, the Philippines' National EE Action Plan 2018-2040 aims "to educate the young to play their role as responsible citizens in achieving the SDGs grounded in national needs, culture and context and to enhance sustainable practices as a common culture among Filipinos" (Department of Environment and Natural Resources 2017, 23).The Basic Education Act emphasizes the need to empower learners to work with local and global communities, use creative and critical thinking, and be willing to transform others and oneself (UNESCO 2021b, 29).

While such objectives point to the need for new pedagogical approaches, it is not easy to put these approaches into action and empowering learners to use creative and critical thinking and lead societal transformation.

Environment-related content in curricula is especially limited in areas with insufficient capacities of teachers and schools to implement new approaches. Teachers in such areas often do not receive training in student-centred, open-ended learning and have limited confidence in their knowledge of the topic, making textbook and rote learning more likely (Parker and Prabawa-sear 2020, 87). This situation is made more difficult by the already overloaded curricula and limited resources, which leave little room for additional environment-related content. When it is already burdensome for educators to provide additional content in a top-down manner, considering and experimenting with diversified learning/teaching methods to foster creative and critical thinking is even more challenging. As such, some research on pedagogical practices at the local level observe that top-down education (named as a "banking" concept by Freire (1970) still dominates, and active/interactive learning methods are not common (Freire 1970).

For example, a survey of over 480 students in training programmes for ESD in Teacher Training Institutes (TTIs) and their lecturers revealed that even in higher education institutes, "teaching methods are predominantly lecture-based (50-70%), although the use of more interactive methods has been encouraged by MOET" (Kieu, Tracey, and Gannon 2016, 860). The lecturers indicated that the large class enrolments, often exceeding 50 students in a class, limited facilities (videos, projectors, crowded rooms) and heavy curriculum requirements are the main obstacles. About 92% of 480 respondents negatively evaluated their university's sustainability-related courses, citing a lack of interactive teaching and learning, excessive content, and poor facilities (Kieu, Tracey, and Gannon 2016, 865–66). Thus, MOET’s goal to replace top-down teaching with more interactive pedagogies still is a long way from being achieved. To encourage more interactive pedagogical approaches, schools should promote knowledge exchange between lecturers, and intensify cooperation between university departments and other university groups.

Lastly, understanding complex systems such as natural ecosystems or complex supply chains is sometimes challenging to many students as well as educators (Parker and Prabawa-sear 2020, 92), so effective pedagogical approaches are very important.

9.4.4 Accelerating the understanding and sharing of the status of EE/ESD

EE/ESD in the ASEAN region is neither universal nor harmonized. Each country aligns EE/ESD with global issues such as climate change and biodiversity and with nationally or locally urgent issues such as poverty alleviation, economic development, gender equality, and disaster risk mitigation. At the same time, many countries have set goals to develop critical thinking, creativity, and collaboration skills in order to develop human resources that contribute to achieving the SDGs and the transformation to sustainable societies. However, teachers and educational institutions do not always have the necessary skills and resources, and often have difficulties moving away from the classic top-down (banking model of) education. Many areas of EE/ESD in each country could be improved. Governments should strengthen their support of educators and educational institutions, such as financing, provision of materials and training courses for educators. It is also important to help educators and institutes to localise EE/ESD learning objectives and contents to be more easily understood by the local stakeholders. It is also desirable to facilitate networking and exchanges among practitioners and researchers and increased cooperation among NGOs, local governments, and businesses.

What is most needed at present is a better framework or scheme for accelerating the understanding and sharing of the status of EE/ESD in the region. What is the focus of EE/ESD in each area and level? What educational methods are used? What assistance is available from governments, businesses, NGOs, and international organizations? What are the challenges in planning and implementation? How effective are these EE/ESD programmes in promoting sustainable development, and how do we measure their efficacy? These questions often come up among practitioners, researchers, and policymakers, but are difficult to answer since comprehensive data collection and sharing is unavailable. Collection and dissemination of relevant information are the first steps, followed by the analysis of policies and practices to identify the “gaps” where policies and other support are needed to address the challenges of improved and more widespread implementation of EE/ESD at all levels. Many existing studies emphasize the necessity of strengthening the capacity and increasing the available resources of communities and teachers, who are often overloaded and not equipped with sufficient skills and assistance. Enhanced exchange and sharing of knowledge and resources among governments, educators, researchers, civil society organizations and private companies could strengthen support to EE/ESD practitioners. Then, learners in the ASEAN region could be empowered to be more active citizens who co-create sustainable societies both within and across AMS.

9.4.5 Enabling SDG localization and community engagement

Finally, EE/ESD are critical enablers of SDG implementation and localization.

To successfully implement the SDGs, a sense of ownership among local authorities, civil society and the academic communities is paramount (UNU-IAS 2022). Participatory and integrated approaches are essential to empower civil society to develop and take ownership of a shared vision of sustainability. As part of their outreach, HEIs could play a key role by supporting local authorities and communities across formal, non-formal and informal education sectors. EE/ESD good practices regarding community engagement could inform community learning processes, community-based research and services, and knowledge exchange, and ultimately help overcome the challenges facing SDG implementation.

The challenges in advancing EE/ESD in the local context could be addressed by further research that identifies gaps between local sustainability practices and global and national SDG policies. With this knowledge, HEIs could play an instrumental role in helping stakeholders translate the globally agreed Agenda 2030 into specific sustainability actions on the ground. To engage in research that is more locally relevant, it is crucial for HEIs to network with each other, and bring together various stakeholders within and outside their communities. In efforts to localize the SDGs, HEIs should view transformative education and learning through the lens of value-driven local relevancy, applying participatory, bottom-up, multi-methodological and multi-stakeholder approaches. Ultimately, local SDG implementation should be predicated on the empowerment of community members and facilitated by multi-stakeholder partnerships and institutional support.

Chapter 10
Circular Economy

Main Messages

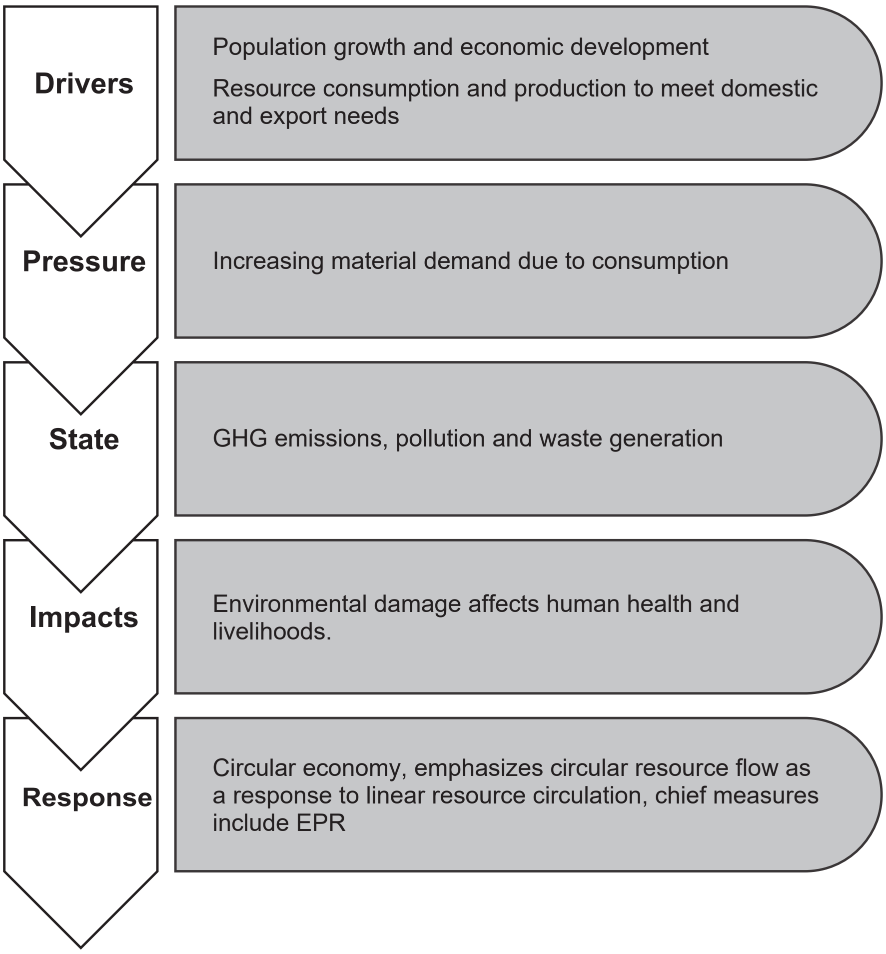
- The drivers of resource consumption are population growth and economic development, leading to unsustainable consumption and production in the ASEAN region.
- Increased consumption will lead to higher material extraction and processing. The current model of resource consumption has a linear flow (production→consumption→waste) and will lead to various negative environmental impacts, including GHG emissions, land pollution, water pollution, and waste, which will impact human health and disrupt the global supply chain by increasing natural hazards and risks due to climate change.
- Some AMS are taking a comprehensive approach to promote recycling through product design and extended producer responsibility (EPR), expanding the market for circular economy (CE) products and services beyond waste issues alone.
- Material resource efficiency, circular economy strategies, and the role of secondary goods and EPR need to be strengthened and incorporated as part of the ASEAN sustainable consumption and production (SCP) framework to build a regional circular flow.
- Green public procurement with a single ASEAN-wide standard or several standards that could be harmonized would provide incentives for the private sector to embrace circular economy principles.
- Supporting and enabling policies are needed including on sustainable lifestyles and infrastructure; these should protect vulnerable people and incorporate gender-sensitive perspectives. More research is needed to design better policy instruments in the region.
- Regional cooperation is needed to coordinate among upstream and downstream stakeholders to create a regional circular economy and related enabling mechanisms. For example developing an ASEAN-wide EPR framework or green public procurement with a single ASEAN-wide standard or several standards that could be harmonized would provide incentives for the private sector to embrace circular economy principles.
- The ASEAN Working Groups on Chemicals and Waste (AWGCW) and on Natural Resources and Biodiversity (AWGNCB) could jointly promote integrated circular economy approaches for ASEAN.
- Implementation of SDG 12 on SCP would greatly facilitate the development of a circular economy in the region, especially when combined with the targets on sustainable industrialization and infrastructure in SDG 9.

10.1 Introduction

This chapter emphasizes the importance of a circular economy and circular resource flows. ASEAN requires more materials to meet its consumption demand as its population, income, and trade flows increase (World Bank 2021e). ASEAN is also a global manufacturing hub and a part of the global value chain. Material demand and consumption are expected to increase significantly (UNEP 2011b).

The chapter illustrates the impact of resource consumption using a DPSIR framework and highlights the importance of a circular economy (Figure 10.1). The chief drivers of resource consumption are population growth and economic development. These drivers increase the consumption of resources and exert pressure to increase production to satisfy consumer demand. The current linear production model is based on a linear flow in which higher demand and consumption increases production which results in more pollution and harmful impacts on the environment. The impacts also affect human health and the global supply chain. This chapter proposes accelerated adoption of a circular economy strategy, which emphasizes the circular flow of resources (Visvanathan and Anbumozhi 2018; ERIA 2016; Delegation of the European Union to ASEAN n.d.; Akenji et al. 2019; Nishimura 2019).

Figure 10.1 DPSIR framework applied to resource consumption



Source: authors

10.2 Material consumption in the ASEAN region

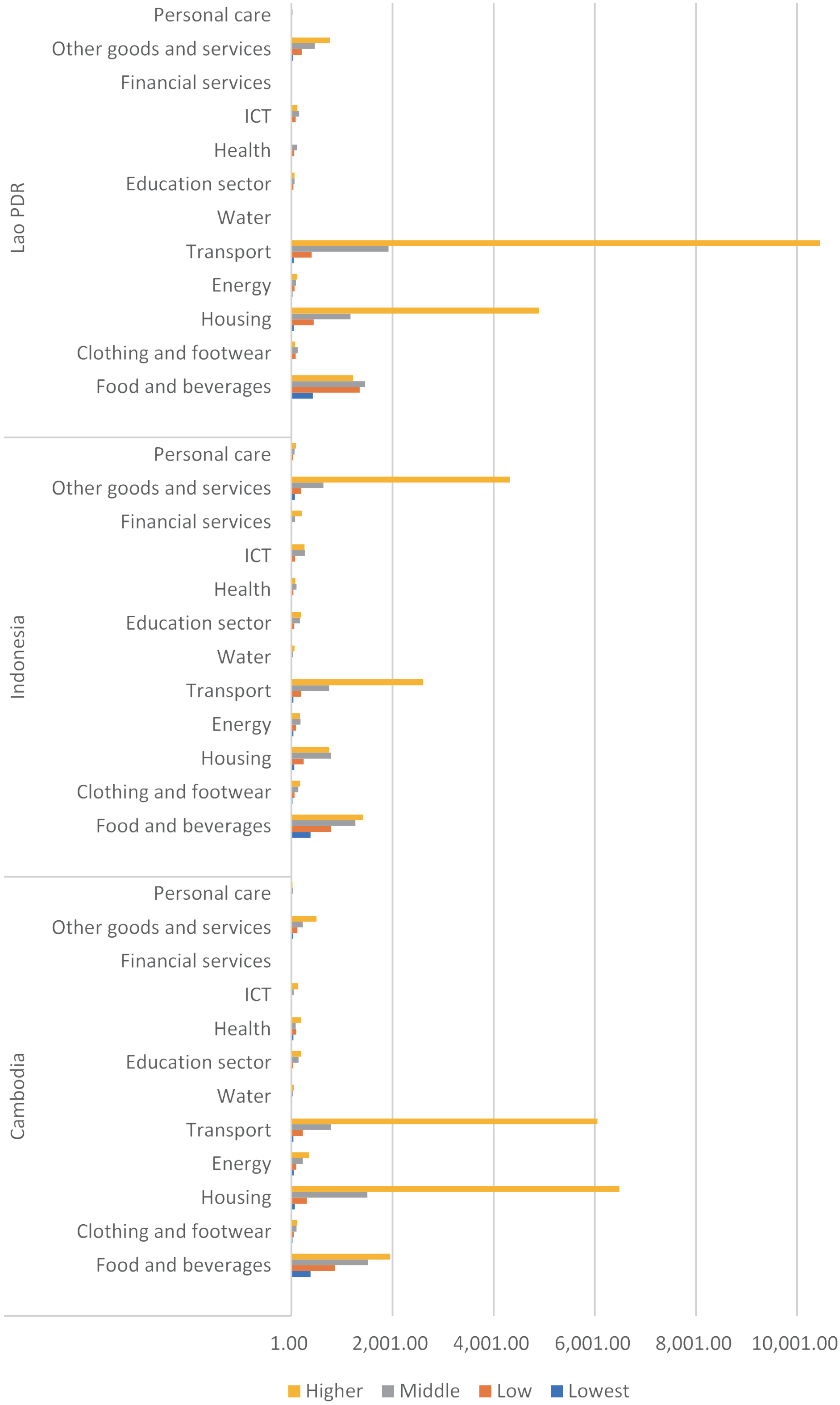
This section covers the linear consumption model and highlights the increasing material consumption and production in the ASEAN region due to population and economic growth. The consumption patterns will change as ASEAN urbanizes and industrializes, and becomes more integrated with the global economy. Increased consumption needs to be supported with increased production of resources. So, this chapter categorizes both consumption and production as drivers and production also as a pressure. These drivers lead to increased pollution and waste that adversely affects and puts pressures on the environment.

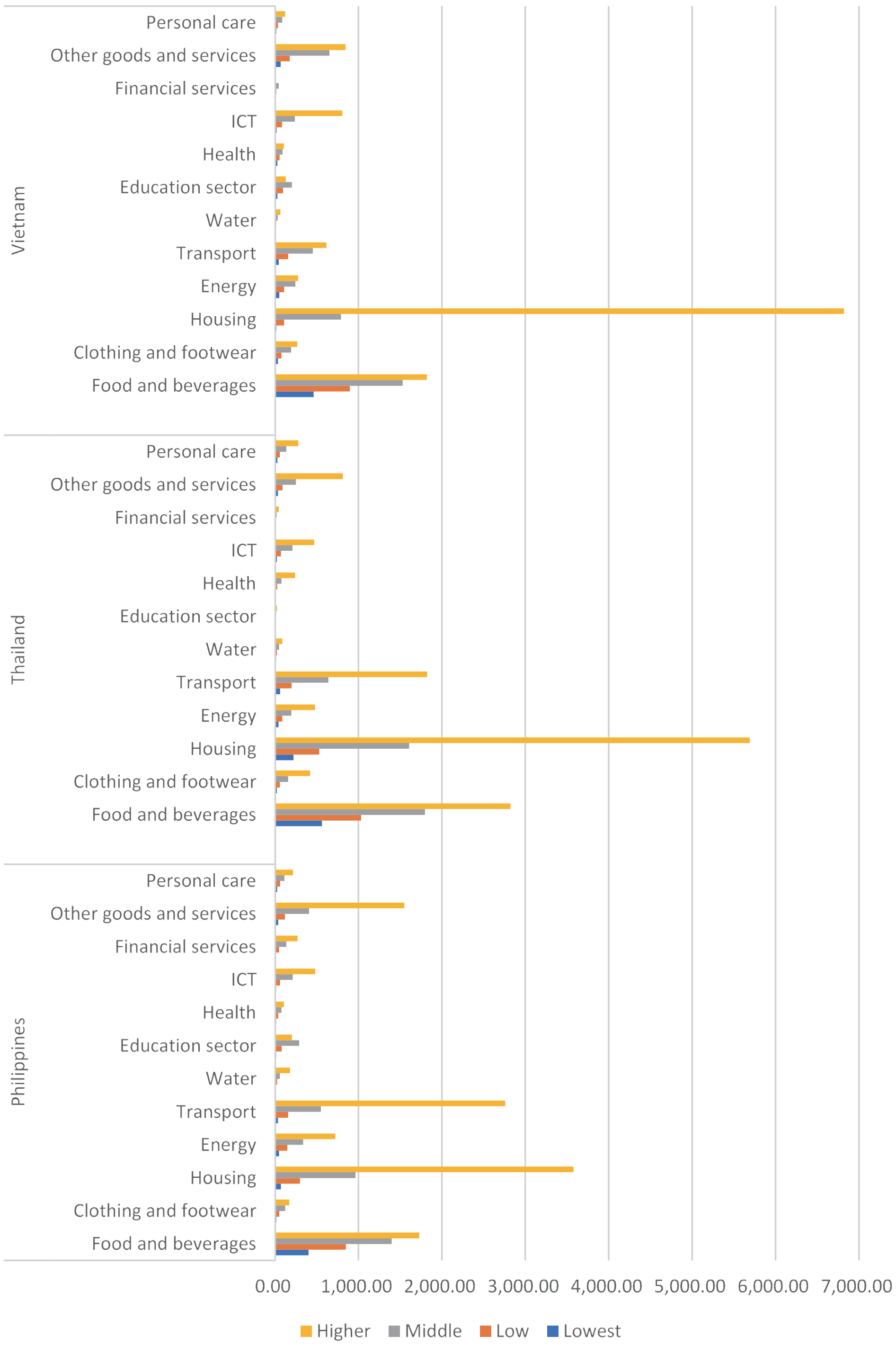
10.2.1 Drivers – changing consumption

Population growth and increasing affluence of the population in the ASEAN region has increased the pace of resource consumption (World Bank 2021c; 2021h). Different AMS are in various stages of economic development and the UN classifies all AMS as developing countries. ASEAN is one of the fastest-growing regions in the world and expected to soon become the fourth-largest economy in the world.

Continued population growth in the region is expected to result in continued increasing resource consumption. Currently, the per-capita resource consumption is lower in developing countries than developed countries (World Bank 2021d). Major consumption categories in AMS include housing, transportation, and food and beverages, followed by consumption of other goods and services (Figure 10.2). While the overall level of consumption remains smaller in developing countries compared to developed countries, there is a considerable gap between the consumption profiles of the lowest and highest income levels in AMS. Nonetheless, economic theory suggests that, as disposable income increases, the level of consumption of the lower-income people would increase further (UNEP 2011a).

Figure 10.2 Per capita consumption in US$ purchasing power parity (PPP) in six AMS





Source: (World Bank 2021d)

Note: Higher, middle, low, and lowest denote the consumption categories.The lowest consumption segment corresponds to the bottom half of the global distribution (50th percentile and below); low consumption corresponds to the 51th–75th percentiles; the middle consumption segment to the 76th–90th percentiles; and the higher consumption segment is above the 91st percentile.

A shift in consumption patterns

As discussed in the previous section, further socio-economic development due to industrialization, urbanization, and higher disposable incomes will increase resource consumption in the ASEAN region. For example, the current consumption of Indonesia's lowest and highest income levels is shown in Figure 10.3 and Figure 10.4. The consumption of the lowest income level is small and dominated by food. The consumption profile of the highest income level is more diversified, with food consumption shrinking as a share of consumption and dominated by housing, transport, and food and beverages. Energy and other expenses contribute more than 5% of the total consumption in the lowest and highest consumption levels. As disposable income increases in the ASEAN region, consumption will shift to material-intensive sectors such as housing, transport, energy, and other goods.

Figure 10.3 per capita consumption shares of the lowest consumption level in Indonesia

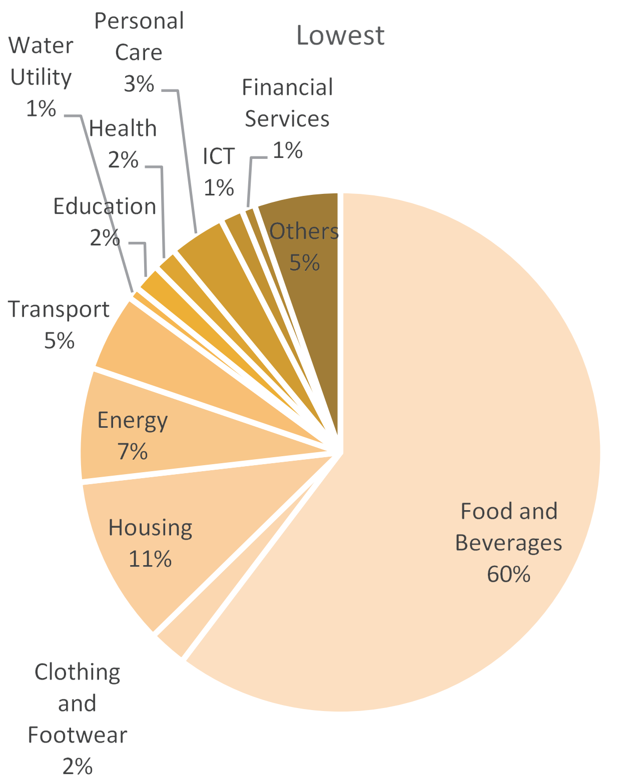
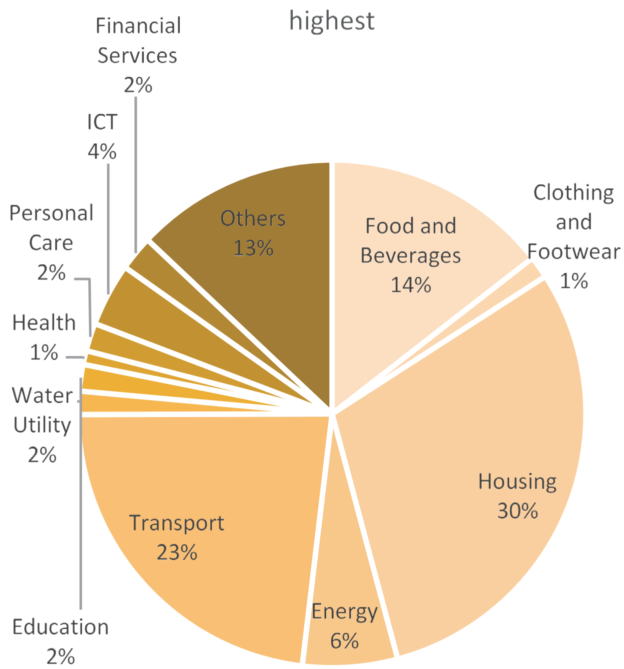


Figure 10.4 per capita consumption shares of the highest consumption level in Indonesia



Source: (World Bank 2021d)

10.2.2 Pressures – Increased demand for materials

Metal and mineral needs for the transition in consumer consumption

As Asia moves to net-zero policies and decarbonization, higher demand for related materials will result from investments in renewable energy (RE) technology and EVs. It is estimated that low carbon technology such as electric vehicles and supply-side technology that emits zero or low GHG emissions would require 600 million tonnes of metal resources (IRP 2017). Moreover, the International Energy Agency (IEA) estimated that electric vehicles will require six times more material than conventional ones, and wind-powered electricity generation plants will require nine times more materials than conventional gas-powered plants (IEA 2021b).

RE and EV technologies need resources, such as critical materials and metals, to make batteries, windmills, solar panels etc. The growth of such technology requires investment in mining critical materials and metals to support the decarbonization of the economy. The ASEAN region will play an important role as a producer of minerals and as a manufacturing hub. Moreover, in several AMS, the role of EVs and RE is set to increase (ASEAN International Conference on Energy and Environment 2021; ASEAN Centre for Energy 2020b; Jin 2021) and result in increased consumption of related minerals and metals.

Metal and mineral needs for the infrastructure transition

ADB has estimated that in addition to building new infrastructure, climate-proofing the transport sector could cost an estimated US$ 37 billion yearly (ADB 2017a). Developing Asia needs massive investment; for example, the ADB report notes that 400 million, 300 million and 1.5 billion people lack access to electricity, safe drinking water, and basic sanitation, respectively. ADB estimated that US$ 22.6 trillion (or US$ 26.2 trillion including climate mitigation and adaptation costs) in investments will be needed in Asia from 2016 to 2030.

Maintaining as well as constructing new public infrastructure, including elevating roads, requires a tremendous amount of cement and steel. Increased mining and production would increase GHG emissions and result in other negative environmental impacts, especially in resource-producing countries. It is estimated that cement consumption will increase to 4,200 Mt/yr. in 2050. Cement clinker production is also expected to increase, and the clinker ovens are fuelled by coal, natural gas, or bioenergy. As Asia expands its infrastructure, the global demand for construction steel is estimated to grow to 2,160 Mt/yr. by 2050 (Van Ruijven et al. 2016).

Specifically, in the ASEAN region, the top three steel consuming countries are Viet Nam, Thailand, and Indonesia. Steel consumption in the ASEAN-6 in 2019 was about 80 million tonnes, while production was 42.8 million tonnes (Tham and Yeoh 2020). With the RCEP, more production capacity from Japan is expected to shift to the ASEAN region; and Chinese investment in real estate in the ASEAN region is also expected to increase (ASEAN-Japan Centre 2022).

As ASEAN transitions to renewable energy and electrifies the transportation, industry, and building sectors, the region's demand for various metals will increase. Several EV, solar photovoltaic (PV) and windmill (RE technology), and silicon wafer chip manufacturers are located in East Asia and ASEAN; ASEAN stakeholders are an essential part of the global value chains, and their actions are critical to the sustainability of these value chains.

Plastics (from fossil fuels)

Increased plastic consumption is causing marine plastic pollution (MPP), including in ASEAN (Jambeck et al. 2015). Growing concerns about MPP have generated international interest in reducing fossil-based plastic consumption. Various policies related to plastics have been announced in the ASEAN region (ASEAN Secretariat 2019c), including measures to reduce fossil-based plastics, promote plastic circularity, and use substitutes such as bio-based plastic. However, as plastics are ubiquitous, their use is predicted to increase in Asia, especially in South Asia and South-East Asia.

While reducing fossil-based plastic and increased circularity of plastic are good approaches to reduce GHG emissions, substituting fossil-based plastic with bio-based plastic, such as paper packaging, could cause other environmental impacts (UNEP 2018a). Primary raw materials for bio-based plastic are sugarcane, corn, etc. These alternatives have several limitations and could cause more harm than benefit, for example, they might affect or disrupt food production (Colwill et al. 2012).

Food

Food production depends on land, water, and energy resources. Processing, transport, storage, retailing and disposal of the food produced requires large amounts of energy. As a result, between 21% and 37% of the world's GHGs come from the production, processing, distribution, consumption, and disposal of food (IPCC 2020). Among AMS, Thailand, Indonesia, Viet Nam, and Malaysia have comparative advantages in agri-food production (Mizik 2021). The expansion of livestock farming has been accompanied by extensive land-use changes and is an important contributor to the increase in GHGs, and other environmental impacts. In Southeast Asian countries, especially Viet Nam, Timor-Leste, Thailand, Philippines, Myanmar, Malaysia, Lao PDR, Indonesia, and Cambodia, agricultural expansion has continued as more lands were diverted for agriculture purposes (Vadrevu et al. 2019). Agriculture is among the top-five CO_2 emitting sectors in AMS, except for in Singapore and Brunei Darussalam, and it is the largest CO_2 emitting sector in two AMS (Cambodia and Lao PDR) (ASEAN Secretariat 2021g).

10.2.3 State and trends - increased resource consumption

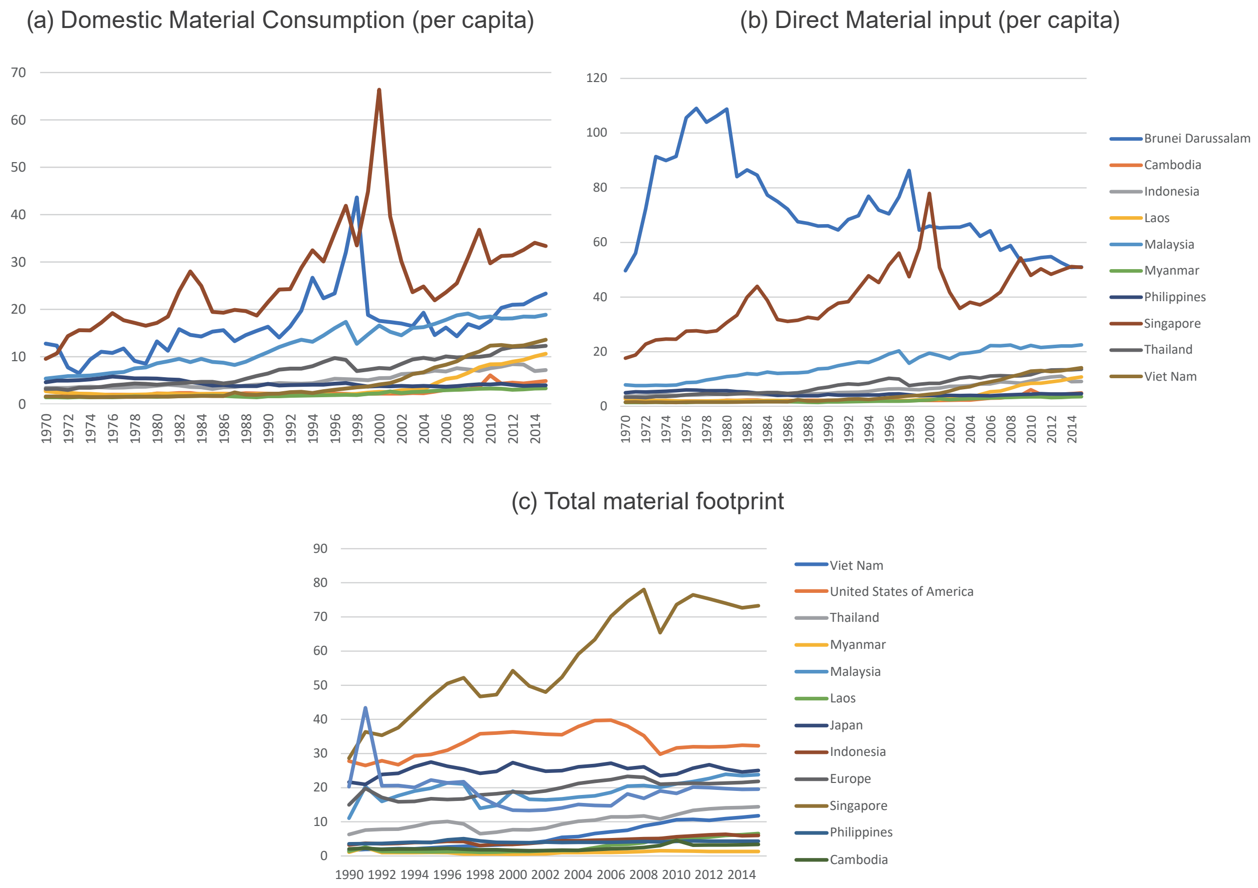
Increased per-capita incomes will lead to increased consumption, resulting in increased production of goods and services. Domestic material consumption and its related material footprint (including embedded resources such as minerals, non-minerals, biomass, and fossil fuels) in both trade and domestic consumption has been increasing in individual ASEAN countries. This causes various pressures on the environment and health.

Production and consumption - material footprint

Figure 10.5 (a) and Figure 10.5 (b) show the per-capita Domestic Material Consumption (DMC) and Direct Material input (DMI). DMC and DMI illustrate the per-capita material consumed and used for production in the country. Figure 10.5 (c) shows the material footprint of total consumption in AMS and benchmarks it with the United States, Europe, and Japan. Material consumption of high-income countries and middle-income countries such as Malaysia have a higher material footprint than lower-income AMS. Generally, the per capita material consumption is correlated with per capita incomes.

As ASEAN’s GDP and per capita income continue to rise, AMS material footprints will also increase. For example, Thailand and Viet Nam will quickly catch up with Malaysia. Other ASEAN economies such as Indonesia, Philippines, Cambodia, Lao PDR will also have a higher material output as the disposable income of their consumers increases and the countries expand their role in the global value chain (IRP 2021).

Figure 10.5 (a) – Domestic material consumption (per capita) in the ASEAN region (MF tonnes per capita); (b) – Direct material input (per capita) in the ASEAN region (MF tonnes per capita); (c) –Total material footprint (per capita) in the ASEAN region (MF tonnes per capita)



Source: (IRP 2021)

10.2.4 Impacts

Unsustainable consumption and production in a linear economy leads to pollution during manufacturing, mining, agriculture, and other processes, for example, air pollution, natural hazards, and water risks. Increased consumption also leads to commodity-driven land-use changes in the ASEAN region. The accumulated waste and pollution due to resource consumption adversely impacts the environment, including increased risk of extreme rainfall and drought due to climate change, and water stress and land degradation/ landslides due to deforestation.

These negative environment impacts will also affect human health and livelihood opportunities. Air pollution leads to lower lifespans, and environmental quality can affect livelihoods, especially for low-income populations. The occurrence of natural disasters and water stress can disrupt human livelihoods as well as global supply chains. Natural hazards can directly affect human habitat, health and livelihoods, and water stress and lack of water availability can put health and social progress at risk.

Waste management and public health

Waste generation trends, mentioned in section 7.4, causes various negative impacts, including health (see section 7.5). AMS are playing an important role in the global circular economy, especially the waste aspect. E-waste that is dumped in landfills will cause pollution in watercourses (Neeratanaphan et al. 2017). Informal recycling is causing pollution including high levels of lead, with significant health impacts (Kiddee and Decharat 2018). The region requires increased investment in waste processing facilities, including landfills and recycling facilities.

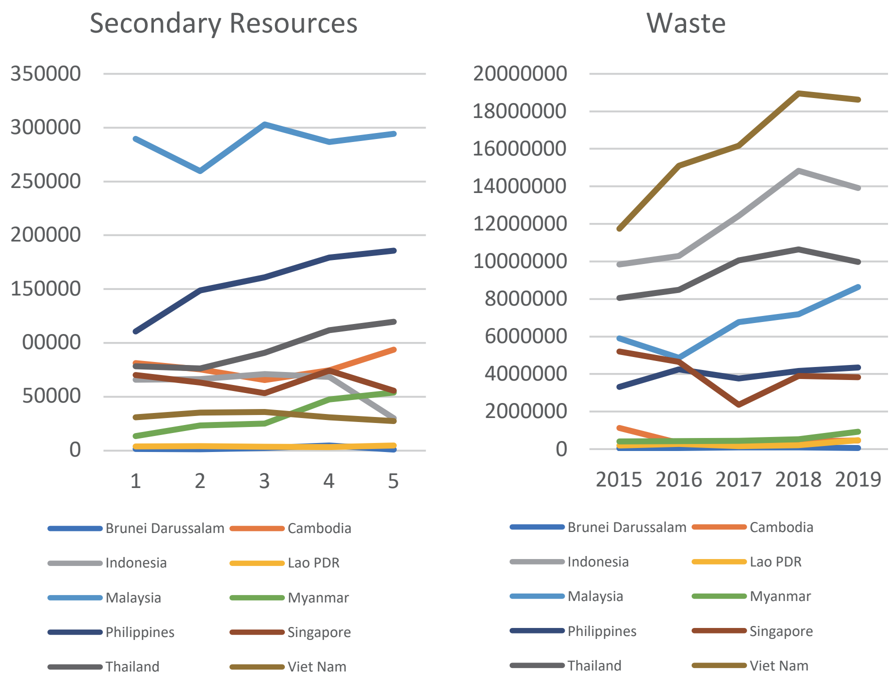
Thus, waste management and public health legislation have been linked: in the past, waste management laws and policies have been shaped by realizing the connection between good waste management and good health (Hondo, Arthur, and Gamaralalage 2020; Ministry of the Environment Japan, n.d.). Proper waste disposal and recycling infrastructure are critical to ensure the human health of the population in AMS is protected, and several policy measures to address this were listed in Chapter 7. Such efforts will also help reduce plastic leakage to the ocean and enhance resource efficiency.

Globalized waste management: impacts of imports

Waste, both legal and illegal, is being imported from other countries and is an increasing concern in the ASEAN region (Diss 2019; UNODC 2022). Historically, the global waste trade has involved higher-income countries exporting waste to lower-income countries because it is more economical. In 2018, China banned the importation of several types of waste, redirecting some of this waste to AMS (Uhm 2021). Some AMS have introduced legislation to regulate the importation of certain waste types, such as plastics (Ministry of the Environment Japan 2020). Despite these efforts, waste trafficking remains a challenge (UNODC 2022).

The amount of secondary resources—materials that have been used or recycled and sold for reuse—and waste imported to AMS is shown in Figure 10.6, highlighting the important role that ASEAN plays in the global circular economy. For example, Viet Nam, Thailand, and Indonesia import waste and help recycle and dispose of it. The import of secondary resources is comparatively limited and needs to improve; Malaysia and the Philippines play a prominent role in this (Chatham House Circular Economy Trade Database 2020).

Figure 10.6 Imports of secondary resources and waste (US$ 1000)



Source: (Chatham House Circular Economy Trade Database 2020)

It is hoped that increased use of secondary resources and waste recycling will reduce the primary material demand, resulting in reduced demand for virgin materials. This can further result in reduced resource extraction and reduced resources used to process them. However, recycling waste also consumes energy and resources, so lifecycle analysis and other approaches are needed to ascertain whether recycling of resources consumes more energy than needed to produce virgin materials. As a centre of global recycling, ASEAN will play a significant role in the global and regional circular resource flow. Institutional development for environmental sound recycling facilities is needed.

Climate impacts associated with GHG emissions from production and consumption

Carbon emissions from various production processes contribute to global climate change, and due to their small population size relative to emissions and/or limited access to renewable energy, the per capita carbon emissions of high-income countries like Singapore and Brunei Darussalam are very high. Furthermore, as a result of its export-oriented economy, Singapore's embodied resource consumption contributes to high carbon emissions. Other countries have lower carbon emissions per capita, less than three tonnes CO_2eq/capita.

The AR6 report of the IPCC has emphasised several demand-side mitigation measures, including opportunities to reduce GHG emissions from consumption (IPCC 2022), while countries in Europe, such as Sweden, are contemplating targets on reducing consumption-based environmental impacts from imported goods (Morgan 2022).

For Singapore, there are tremendous opportunities to reduce embodied carbon emissions by engaging with exporting countries (Sachs et al. 2021; Global Carbon Project 2021). See Chapter 3 for more information.

Impacts due to climate change and extreme events

Climate change will increase the risk of extreme events, and coupled with deforestation and land-use change, the impact on human settlements and global supply chains will further increase. The ASEAN region is prone to natural hazards; for example, the Philippines, Indonesia, and Viet Nam were among the top 10 countries in terms of global occurrence of natural disasters from 2010 to 2020 (Table 10.1). The region is also prone to coastal and riverine flooding and droughts. Climate change and extreme events will increase social and economic impacts, especially in the Philippines, Indonesia, and Viet Nam. Reducing carbon emissions and investment in climate adaptation, especially green and climate-friendly infrastructure, can mitigate some of these impacts (Centre for Research on the Epidemiology of Disasters 2021). Refer to Chapter 3 for more information.

Table 10.1 Occurrence of natural disasters 2010 to 2020

Country	Occurrences
China	308
United States of America	256
Philippines	180
India	172
Indonesia	165
Japan	84
Viet Nam	78
Mexico	73
Pakistan	68
Afghanistan	65

Source: (Centre for Research on the Epidemiology of Disasters 2021)

Note: Natural disasters: earthquakes, volcanic activities, mass movements (dry), floods, landslides, storms, extreme temperatures, droughts, and wildfires.

Land use change, deforestation, and agriculture

The demand for agricultural commodity products such as palm oil, soya beans, and to a limited extent, mining is leading to land-use change in AMS. Forest loss in Timor-Leste, Myanmar, Indonesia, and Cambodia has been linked to agriculture (Marlier et al. 2015) including large scale commercial plantations (Vijay et al. 2016; Wilcove and Koh 2010; Ziegler, Fox, and Xu 2009). Agricultural intensity and area under cultivation is increasing in the region; for example, (Seneviratne et al. 2021b) note that “the area harvested increased by a factor of 1.73, the production by 4.95, cereal yield by 2.86, irrigated areas by 2.83 and the nitrogen fertilizer consumption by 40.09”. The intensification of agriculture leads to soil degradation and negatively impacts water quality.

Furthermore, mining is also considered an important contributor to deforestation, and in the tropical region, South East Asia has the highest rate of deforestation due to mining (Hughes 2017). Among mining activities, mining of limestone and underground minerals is prevalent. As mining for minerals and metals is expected to increase due to urbanization and decarbonization of the economy, mitigating the harmful impacts of mining is extremely important. Among the metals needed for decarbonization such as cobalt, lithium, aluminium, silver, steel, nickel, lead, and zinc (IEA 2021c), Indonesia has one of the largest world global nickel deposits and is one of the major producers of nickel (National Minerals Information Center 2022).

Overconsumption of food

As mentioned in Chapter 7, FAO's 'Food Waste Index Report 2021' listed the amount of food wasted in the ASEAN (UNEP 2021e). The contribution of food waste to climate change differs considerably among countries; for example, 810 $kgCO_2e$ per person per year of GHGs is associated with food waste in industrialized Asia, and 350 $kgCO_2e$ in South and South-East Asia. The increase in food waste by 2030 is expected to occur mainly in developing regions (Hegnsholt et al. 2018). In the EU, households and processing contributed 53% and 19% to total food waste, while outside food preparation services contributed 12%. The production stage accounted for 11% of food waste while the retail/wholesale stage accounted for the rest (Teng and Trethewie 2012; Nicastro and Carillo 2021). Teng and Trethewie noted that the pattern in ASEAN could be similar (Teng and Trethewie 2012).

Plastic leakage and fisheries

Contamination from plastic pollution deteriorates ocean health and is a significant source of pollution in the ASEAN region. For example, (Meijer et al. 2021) found rivers from the Philippines, Malaysia, Indonesia, Viet Nam, Thailand, and Myanmar are significant contributors to ocean plastic leakage. Estimates of plastic leakage are presented in Chapter 7 and are based on the correlation of monitored results and explanatory variables such as population, the rate of mismanaged waste, etc. Continued leakage into the oceans will inevitably affect fisheries.

The link between plastic leakage and its health impacts needs to be studied further, as detailed information is currently limited. However, this is an important topic, as fish consumption is a critical source of proteins in the ASEAN region (SEAFDEC 2018).

Near-shore fisheries in the ASEAN region are overfished (Pomeroy et al. 2016), and continued IUU fishing is leading to overfishing in the region (SEAFDEC 2015). Plastic pollution could affect fisheries; however, related data on the topic is limited, and more research is critical. Consumption of plastics consumed by fish could impact human health; however, current research has not found any significant impact on human health from marine plastic pollution.

Soil pollution and water stress by industry

A report by the Food and Agriculture Organization of the United Nations (FAO) and UNEP citing studies by (Ding 2019; Phenrat et al. 2016) (FAO and UNEP 2021) observed that pollution from trace elements is high. A growing number of chemical and mining industries in the ASEAN region cause land and soil pollution. (Simmons et al. 2005) found cadmium pollution in paddy fields, for example. Arsenic and cyanide pollution due to gold mining have also been reported.

Water stress, a condition in which demand for water exceeds the available amount, can harm human health, social development, and economic development, including global supply chains. Droughts induced due to climate change and deforestation will amplify water stress in the region. Water stress is critical in some AMS, and industrialization, urbanization, and climate change can exacerbate it. In the worst case, (Satoh et al. 2017) suggest that 20% of the total population could be affected by water stress in 2050 in Indonesia and the Philippines, and 10% of the population could be affected in Thailand and Viet Nam. Deforestation will amplify these trends, especially in the Philippines, Indonesia, Thailand, and Viet Nam. Reduction in resource extraction can reduce some of these impacts.

The Ocean Health Index captures the state of marine water by comparing data on chemicals and excessive nutrients (eutrophication), human pathogens, and trash. Since the index captures the contamination from land-based sources, the index is also a tool to understand the state of the land environment. Indonesia, Cambodia, the Philippines, and Thailand have shown a marginal increase in the index score, reflecting an improving trend. However, in Singapore, Myanmar and Brunei, the index scores have declined. The state of the environment is improving in many AMS, and more efforts are needed to improve progress (Ocean Health Index 2021; Sachs et al. 2021).

10.2.5 Responses

The previous section showed how linear resource consumption leads to waste and pollution, affecting human health and livelihoods. Many studies have emphasized the importance of the circular economy to address these issues. Circular economy approaches, such as the 3Rs, emphasize reduction in the use of resources, re-design of products, reuse or repurposing of resources, and recycling of resources. These approaches will lead to lower consumption of resources and result in lower waste generation and pollution, thereby reducing negative impacts on humans. The next section discusses the current policies and measures which are implemented in the ASEAN region and shows current trends in the use of secondary resources and waste. The chapter also explains how the ASEAN countries can strengthen policies to promote the circular economy and mainstream CE approaches into other sectors and policy areas.

National policies and measures

This section briefly surveys the policy trends related to SCP and CE in the ASEAN region. Since SCP and CE are broad concepts, the chapter reviews the policies and related initiatives by focusing on plastics to examine the region's circular approaches in more detail. Plastics are highlighted here, as plastic pollution is an immediate concern, and AMS announced the "Regional Action Plan to Tackle Plastic Pollution" to address the issue.

Overall, several ASEAN countries have policies related to SCP/CE, although in emerging economies, the extent of these policies is still limited. Table 10.2 lists some examples of SCP/CE policies and related measures taken by the ASEAN countries and also briefly touches on the development of alternatives and public purchasing of plastics as a specific example.

Table 10.2 Examples of key policy actions related to CE/RE/Plastics

Comprehensive CE/ SCP policy	Extended Producer Responsibility (EPR)	Alternative materials development (case of plastics)	Public purchasing for CE (case of plastics)	Others
- Action Plan for Sustainable Consumption and Production (Philippines) - Resource Sustainability Act (Singapore); - Singapore Green Plan 2030 (Singapore) - Circular Economy Roadmap for Plastics (Malaysia – draft) - Bio-Circular-Green Economic Model (Thailand) - Zero Waste Masterplan (Singapore)	- EPR roadmap (Indonesia - draft) - Polluter pays principle (Malaysia's Environmental Quality Act) - Resource Sustainability Act (Singapore)	- Public-private cooperation for developing biomaterials as plastic alternatives - e.g., use of bio-based straws for packaged beverages (Thailand, Indonesia, Malaysia)	- Set of eco-label indicators for biodegradable / compostable plastic packages (Malaysia) - International cooperation-based projects (e.g., SWITCH-Asia in Myanmar)	- Charge fee / taxation on single use plastic products (e.g., plastic bags) (introduced in most of the countries) - Comprehensive Action Plan for marine litter/ marine plastic / single use plastics (e.g., Indonesia, Philippines, Thailand) - Singapore) - Say Yes to Waste Less Campaign (Singapore) - National Recycling Programme (Singapore)

Source: authors

As seen in Table 10.2, comprehensive policies with the title of SCP/CE seem to be present only in emerging market economies such as Malaysia, Indonesia, Singapore, and Thailand. For example, Malaysia is taking a nation-wide sustainability policy approach, aiming for "Sustainable Malaysia 2030" (Ministry of Environment and Water Malaysia 2021). In line with this holistic vision, Malaysia is about to publish the Circular Economy Roadmap for Plastics, which includes pollution charges, mandatory EPR implementation, and measures to strengthen markets for alternative products (in this case, alternative materials for plastics). Thailand has also developed a Bio-Circular-Green Economic Model for research and application to policy. Malaysia has established a Roadmap to ban single-use plastics ban 2030. In this model, CE is combined with bio-economy and green economy as part of the national strategy under Thailand 4.0. Singapore's Resource Sustainability Act (2019) imposes obligations relating to the collection and treatment of electrical and electronic waste and food waste, requires reporting of packaging materials imported into or used in Singapore, regulates persons operating producer responsibility schemes and promotes resource sustainability (Government of Singapore 2019a). Singapore introduced the EPR scheme for e-waste on 1 July 2021 and is planning to adopt the EPR approach for packaging waste management as part of the measures under the Zero Waste Masterplan and the Singapore Green Plan 2030 (Ministry of the Environment and Water Resources 2019; Government of Singapore 2021). Although such EPR related legislation is still limited, several countries are in the process of drafting the implementation plans to introduce EPR in an official form. Viet Nam recently approved the National Strategy and National Action Plan on Green Growth for the period of 2021 – 2030 which requires the integration of CE principles in many sectors (Government of Viet Nam and Online Newspaper of the Government of the Socialist Republic of Viet Nam 2021). The Act on Environmental Protection and the Decree 08/2022 mandated that the CE National Action Plan will be developed and released by the end of 2023, and the CE National Action Plan is expected to complement the existing National SCP Action Plan (Government of Viet Nam 2022).

Plastics is a good case to illustrate how the circular approach has been promoted. For example, public-private cooperation on alternative materials is actively encouraged in countries like Thailand, Indonesia, and Malaysia. In addition, economic instruments for developing markets for circular products (e.g., recycled products, products with bio-based materials) are also encouraged particularly in the government purchasing process by setting the eco-label indicators for these circular plastic products in countries like Malaysia and Myanmar.

Gaps in policy development at the national level

Since CE/SCP require holistic system changes, waste management cannot be the only solution. However, it is also true that proper waste management is a necessary foundation for CE/SCP, and there are still many issues to be addressed with regards to waste management in most AMS, especially appropriate waste related data collection and proper waste management (Ministry of the Environment Japan 2021a; Fauna & Flora International Cambodia 2020). Without solving these fundamental waste issues, it will not be possible to achieve CE/SCP. However, as this short policy review points out, ASEAN countries already have begun to move beyond basic waste issues and started to develop comprehensive approaches to promoting recycling through product design and EPR, as well as expanding the market for CE products and services. To make further progress, it will be important to develop policy approaches addressing the whole life cycle of products as required by the CE/SCP agenda, as well as to further improve conventional waste management. It is hoped that the experiences of ASEAN emerging market economies can help to promote these approaches in the other ASEAN countries.

10.3 Conclusions

In 2013, the ASEAN Ministers Responsible for Environment announced the "Joint Statement on the Implementation of Sustainable Consumption and Production in ASEAN”, which emphasized the importance of SCP policies in the ASEAN region and called for an 'exchange of information, experiences, and best practices on Sustainable Consumption and Production’ (ASEAN Cooperation on Environment 2013). Responding to this call, this report lists several measures that could be implemented in AMS, highlighting the role of material resource efficiency and circular economy efforts - the role of EPR, markets for recycling goods and public green procurement.

10.3.1 Systemic and integrated approaches for resource efficiency

Increasing material demand for primary resources needs to be reduced using material resource efficiency and circular economy strategies. These strategies should be developed along with policies for other resource-related issues in an integrated manner, for example, decarbonisation. Material efficiency strategies, including circular economy and resource-saving approaches, could have a large potential to further reduce GHG emissions in the areas of housing and vehicles (IRP 2020; Pauliuk et al. 2021).

Several options and measures in different sectors are presented as follows.

- Building material-efficient homes: this will require reduced floor space and more use of wood. More intensive use of space will reduce energy consumption from heating and cooling homes. In order to promote this, effective policies are needed, especially revised building codes (IRP 2020).
- SDG 9's aim to develop quality, reliable, sustainable, and resilient infrastructure to support economic development and human wellbeing requires resource efficient urban infrastructure. The construction sector contributes to close to half of the total global material footprint. On the planning side, recommendations include transit-oriented development, small street blocks, and mixed-use planning, which are key to integrated sustainable urban planning (IRP 2018), as well as infrastructure retrofitting and maintenance of existing infrastructure whenever possible (UNEP 2019d). For example, service-based models are expanding as companies provide maintenance and waste management services, thereby improving energy efficiency and creating closed product loops (WBCSD 2021).
- Building material-efficient cars: these use less material by design, and material substitution by replacing steel with aluminium will reduce energy consumption. Further, a shift toward smaller vehicles and ridesharing will decrease energy usage (IRP 2020).
- Recycling of materials by industry: recycling glass, paper, metals, and plastics, will reduce the need for virgin materials. Similarly, as demand for material needed to produce renewable energy equipment increases (Carrara et al. 2020), metal recycling is an essential solution. However, a careful analysis of lifecycle costs needs to be conducted, since recycling is not always the best solution.
- Increased use of secondary resources in industries: industrial symbiosis principles need to be employed, such as the use of secondary resources (Ali et al. 2021), that is, the waste of an industrial process should be used as an input or resource for other industrial processes as much as possible, for example, within eco-industrial parks.
- Maintaining and improving the value-retention process (reuse, repair, remanufacturing): recycling, reuse, and remanufacturing have been widely practised in developing countries. For example, the repurposing of automobiles is one of the biggest industries in the Philippines. Production of Jeepneys, which are local minibuses assembled from parts of used automobiles, is one such example.

To facilitate these approaches, additional policy measures are needed. Policies need to promote systematic changes in socio-technical systems driving consumption and production, addressing both lifestyles and infrastructure (Hotta, Tasaki, and Koide 2021). Policies should set long-term goals, provide financial investment, create an enabling business environment, and promote innovation and communicate sustainable options to public/consumers. Investments can shape business models and infrastructure to support a circular economy, and new practices and behavioural patterns will also help to move towards a circular economy.

10.3.2 Build a regional circular flow in the ASEAN region

Several systemic and integrated approaches were listed in the previous section. Regional cooperation is important to enhance the efficiency and effectiveness of these approaches. This section elaborates on the steps needed to build a regional circular flow in the ASEAN region.

Regional frameworks

A gap analysis study on Circular Economy and Plastics in AMS (Akenji et al. 2019) identified four gaps: information and knowledge, policy and governance, technical capacity, and markets and finance. Regarding plastic pollution, this study recommended developing technical standards and guidelines for circularity, addressing harmful chemicals, creating an ASEAN framework for research and innovation, and region-wide collaboration to address common problems.

ASEAN has already adopted several measures. The Framework for Circular Economy for the ASEAN Economic Community (AEC) (ASEAN Secretariat 2021j) has five strategic areas, as follows: standard harmonization and mutual recognition of circular products and services; trade openness and trade facilitation in circular goods and services; enhanced role of innovation, digitalization, and emerging/green technologies; competitive sustainable finance and innovative ESG investments; and efficient use of energy and other resources. In ASEAN's taxonomy, circular economy perspectives are already reflected. National efforts for CE policy developments should be aligned with the direction of the ASEAN Framework for Circular Economy and its related activities.

The objective of the ASEAN Circular Economy Stakeholder Platform (Figure 10.7) is to help achieve sustainable consumption and production in the ASEAN region by accelerating a transition to a circular economy. Some of the approaches of this framework are as follows:

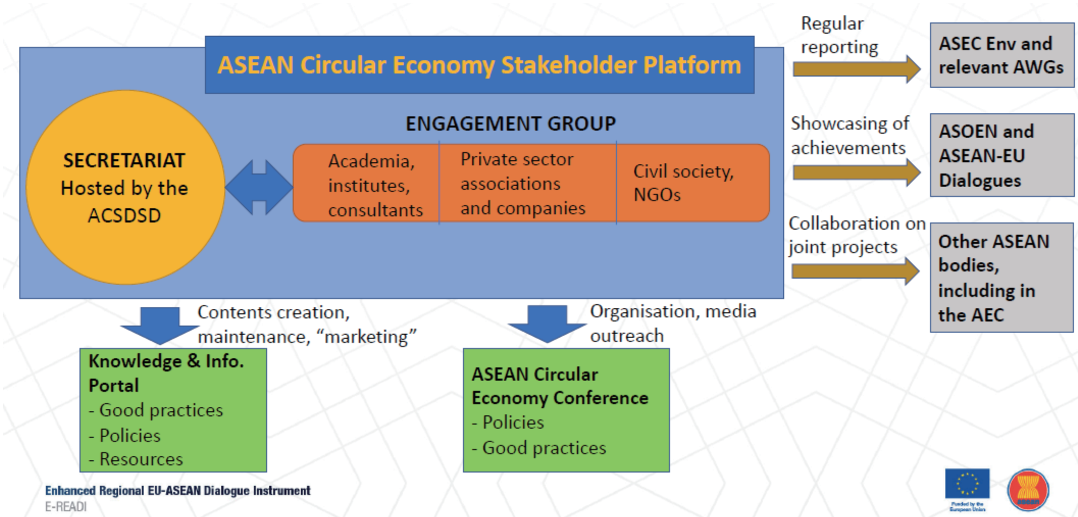
1. Raising awareness of the relevance and benefits of a CE approach for the AMS;

2. Promoting a holistic understanding of the CE as a strategic approach to resilient and sustainable development, including cross-sectoral coordination relating to the AEC Circular Economy Framework, and upcoming activities under the Team Europe Initiative (TEI);

3. Identifying and promoting government policies at the regional and national levels, as well as business practices, that can enable a CE transition; and

4. Strengthening the exchange of experiences between ASEAN and the EU, and other regional initiatives.

Figure 10.7 Circular Economy Stakeholder Platform



ASEAN is also currently preparing a draft circular economy implementation plan of the AEC with the Economic Research Institute for ASEAN and East Asia (ERIA). The draft plan calls for standardisation of products, trade openness, implementation of sustainable finance, digitisation and efficient use of energy and resources (ASEAN Secretariat 2021j).

These measures are crucial to achieve ASEAN's transition to a circular economy in alignment with global discussions. As ASEAN is a major player in global supply chains, it should engage in strategic discussions with the global community, such as the ASEAN+ framework. In parallel, participation of industry is needed to develop region-wide rules to implement CE/SCP principles and policies discussed in this chapter.

Better information and data is needed in order to for a regional CE framework to be effective and to assess progress. Developing an assessment indicator framework and relevant capacity development for AMS needs to be considered and could be promoted with the cooperation of partner countries and international organisations. Indicators should be developed based on ASEAN's unique circumstances. Specific forums and initiatives in this area will be needed.

A scoping study on the SCP framework in ASEAN recommended an emphasis on common goals-key priorities and goals - with different paths for individual AMS (APRSCP and SWITCH-Asia RPAC 2021). Furthermore, the study stressed that the ASEAN SCP framework could bring together knowledge, policy, and technical know-how. To implement these goals, SCP policies should be incorporated into the ASEAN Economic Community Blueprint and the ASCC Blueprint (APRSCP and SWITCH-Asia RPAC 2021). In addition, supporting institutions and connecting structures—linking the various ASEAN working groups and organizations—would be needed to support implementation.

The combination of circular economy and SCP approaches could create a framework encompassing the whole value-chain. Based on these inputs, the framework has been developed, and the major points are summarized in Box 10.1.

Box 10.1 ASEAN SCP Framework

ASEAN SCP Framework

The framework recommends a phased Implementation Plan. In the first year, AWGEE will start working, for example, on Goal 4, an action plan on sustainable lifestyles. The AWGEE will link with ASOEN Working Groups and ASEAN Bodies in years 2 and 3, respectively. In the final year, the Action Plans will be finalized based on the SCP Framework and consultation. ASEAN has developed four goals as listed with specific measures that have been recommended.

Measure and support progress in SDG12
- Sustainability reporting by corporations and state enterprises
- Public awareness on sustainability
- Regional consultations and capacity building for national statistics authority.
- Regional guidance for reporting on SCP/ SDG12 targets.

Increase productivity and decrease losses in food systems
- Good practices for minimizing food loss and food waste - encouraging investments and development on good practices in food systems
- Knowledge sharing and bridging the expertise with practical application of good practices – ASEAN Technical Working group on Agricultural Research and Development (ATWGARD)
- Consumer education on sustainable consumption.
- Encouraging sustainable practices at retailers & food establishments with guidance documents

Establish good practices for green products and guidelines for Green Public Procurement (GPP)
- Consumer information on green products (product information/ labelling).
- Green product certifications and National Green Product Directory
- Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) for SMEs
- Regional guidance on good practices for the practice of GPP

Promote sustainable lifestyles in urban and rural settings.
- Regional guidance on good practices for sustainable lifestyles
- Household guidance on sustainable lifestyles

Public support, technology needs and investment

Compared to incineration and landfilling, recycling and reuse have more significant potential to create jobs (UNIDO, n.d.). ASEAN is the global centre of recycling resources; it provides tremendous opportunities to build world-class facilities to recycle materials. Recycling in the region could be expanded to achieve significant economies of scale, helping both the global and local economies. However, the flow of goods needs to be legal, and the waste well sorted so that their recyclability remains high. If illegal trade and low-quality waste are exported to ASEAN, public support for importing waste and recycling in the ASEAN region will erode. The public has a "not in my backyard" (NIMBY) view regarding recycling facilities, but architectural innovation and multipurpose use can help to gain public support for them. The recycled materials will also support other domestic industries and contribute to regional resource flows.

AMS require technology and investments in several related sectors, for example, waste management, recycling, product development, and deployment of cleaner low-carbon technologies such as PV and EV. Investment in infrastructure and energy efficiency in ASEAN amounted to US$ 1,800 billion and US$ 400 billion respectively (UNEP 2017). Based on such figures, DBS and UNEP estimate the amount of green investment required will be about US$ 200 billion per year until 2030. However, the current annual investment flow is only US$ 40 billion (UNEP 2017).

International donor agencies and multilateral and bilateral government funding need to be directed towards such initiatives. The rise of ESG and impact investing also provides additional avenues to access technology and know-how. The ASEAN Catalytic Green Finance Facility (ACGF) under AMS and ADB can play a vital role in securing and making available such funds (ADB 2022a).

National efforts, enabling policies and circumstances

National efforts to develop circular economy policies need to be based on national circumstances and levels of economic development in individual ASEAN countries. As shown in the previous section, Thailand and Viet Nam have already started to develop their circular economies based on their national circumstances. In global supply chains, ASEAN exports and imports both resources and products, so integrated policy approaches are needed for national policy development. In addition to waste management and natural resource conservation policies, sustainable product policies should also be developed considering circular economy, climate change and biodiversity.

ASEAN is a major player in global supply chains, so the global policy environment, including EU policy initiatives such as 'Fit for 55%' and circular economy policies, including sustainable product policy, can provide incentives for companies in ASEAN to steer towards the manufacture of green products. The role of eco-design, secondary goods, green procurement and EPR are also important.

Sustainable product policy, which encourages the use of eco-design principles in the product design process, has been promoted in the EU (European Commission 2021a). It aims to increase material efficiency, recyclability, repairability, and uptake of secondary materials, etc. These steps could increase the potential of the circular economy.

EPR systems have been applied to standardized, homogeneous products, such as beverage containers in the consumer sector and pallets in the industrial sector. EPR systems are challenging to implement, and onerous to regulate and monitor, even in developed countries. To encourage recycling, it is important to develop the capacity to regulate, monitor and verify the implementation of EPR systems. It is important to keep transaction costs low. Certification schemes can also help (Henlock et al. 2014). For example, Singapore has announced an Extended Producer Responsibility (EPR) System for E-waste Management and ASEAN launched ASEAN Roadmaps Towards Sustainable and Energy Efficient Buildings and Cooling in Southeast Asia (IEA 2021a; ASEAN Centre for Energy 2020c). There are steps in the right direction. In addition to eco-design and EPR schemes, sustainable product standards and Green Public Procurement could support markets for circular designed products including the use of recycled contents. Several ASEAN countries are developing ecolabels, and with mutual recognition, the ecolabels could expand markets for recyclables. AMS are also working with the European Union (EU) on the following value chains: textiles and leather; buildings and construction; plastics; agriculture and seafood. The main objective is to support the private sector to integrate sustainable and circular solutions into their operations (EU 2022). Such steps would expand the market for recycled goods and reused products and promote a shift towards services.

Efforts are required to coordinate among upstream and downstream stakeholders to create a circular economy. For example, creating ecolabels and manufactured products requires coordination between standard-setting organizations and producers. Similarly, EPR systems require coordination between producers who will pay for waste management/recycling and recyclers who will process the discarded goods.

Furthermore, ASEAN could supplement national policies with regional cooperation measures. For example, a single ASEAN-wide EPR framework could be developed, or national EPR systems could be harmonized (Henlock et al. 2014). Such steps will also help showcase ASEAN's sustainability credentials to export markets and allow ASEAN to become a key part of 'sustainable' global supply chains.

Several supporting mechanisms are needed, for example, a multi-stakeholder partnership (MSP) platform with industry participation to develop private sector business models, including related market development, and a mechanism to implement EPR. Academia needs to develop innovative technologies and processes. Governments need to provide support to business to transition to CE-business models. The public also has a large role in leading the transition to sustainable lifestyles. The Circular Economy Stakeholder Platform of ASEAN has a key role in promoting collaboration and mutual understanding.

This chapter described some of the advantages of a circular economy: resources/energy savings, better public health through strengthened solid waste management, and green jobs / green economy. There are also concerns, for example: reduced demand for linear economy based goods and services and potentially increased recycling and reuse costs. Care should be taken to avoid negative impacts on people who are vulnerable or with low incomes. Also, gender-related perspectives also should be incorporated into policies to promote the circular economy.

10.4 Way forward

This chapter used the DPSIR framework to analyze the main factors contributing to unsustainable consumption and production in ASEAN, and policy responses of AMS and ASEAN. The chapter presented several examples of growing GHG emissions, pollution, and waste generation issues in the region. It explained the risks and possible impacts on human health and supply chain disruptions. The current policy measures in the ASEAN region were surveyed, and it was noted that AMS have started taking a more comprehensive approach beyond waste issues.

For effective policy development and coordination within ASEAN, establishment of joint work between the ASEAN Working Groups on Chemicals and Waste (AWGCW) and on Natural Resources and Biodiversity (AWGNCB) could be an option to discuss integrated circular economy approaches for ASEAN. Discussion of Environment-Governance-Social (ESG) for industry in related WGs is also important to effectively implement the ASEAN circular Economy framework. It is also important to strengthen the MSP platform and engage diverse stakeholders to holistically transform from linear production to circular production, especially with local business and non-governmental actors. An integrated and inclusive framework, that incorporates concerns of economically weaker sectors and gender perspectives needs to be explored, understood and incorporated into policy.

More research is needed at the ASEAN / regional level to support policy design and implementation. There are various challenges and obstacles to implementing circular economy policies, especially cost considerations.

SDGs

Sustainable Development Goals

Chapter 11
Sustainable Development Goals

Main Messages

- The SDGs encourage countries to develop synergies between the environment and the social and economic dimensions of sustainable development. This could help gain more support for environmental measures by the public as well as a broader range of policymakers.
- AMS have extensively engaged with the SDG process, developing data and indicators and preparing VNRs to report on their progress to the HLPF.
- Businesses, NGOs, youth and other stakeholders have engaged in SDG implementation in ASEAN.
- AMS are making steady progress on all SDGs, but even this progress is unlikely to be enough to achieve the SDGs by 2030.
- AMS have adopted a range of policies to address environment-related SDGs according to their VNRs. The VNRs also seem to under report relevant environmental policies.
- Nevertheless, assessments of progress on environment-related SDGs across the region have shown that progress has been insufficient, although the challenges are well known, and action to address them has been insufficient.
- Responses to environment-related SDG targets should be accelerated.
- SDGs could be an effective way to help guide the activities of the ASEAN Working Groups, since the SDG topics are similar to the WG focus areas.
- Capacity to gather SDG-related environmental data should be strengthened.

11.1 Introduction

SDGs facilitate a holistic and integrated approach to sustainable development. SDGs move beyond the old paradigm which highlighted trade-offs between the environment and the social and economic dimensions and encourage countries to develop synergies between them.

Important environmental targets are included in nearly all SDGs, not just the ones which focus mainly on the environment (SDGs 12-15) (UNEP 2021c; Elder and Olsen 2019), as illustrated in Table 11.1. These include targets on disaster resilience (1.5), sustainable agriculture (2.4), air pollution (3.3), water and energy (most targets under SDGs 6 and 7), sustainable transport (11.2), waste management and environmental impact of cities (11.6), and others. The most important targets related to environment and economy may be 8.4 on “decoupling economic growth from environmental degradation” and 9.1, 9.2 and 9.4 on sustainable infrastructure, industrialization, and resource efficiency.

Table 11.1 Environment-related SDG targets

Target No.	Content related to environment	Target No.	Content related to environment
1.5	Resilience to climate and environmental shocks and disasters	7.b.	Infrastructure and technology
2.4	Sustainable food production systems	8.4	Resource efficiency & decoupling economic growth from environmental degradation
2.5	Genetic diversity	8.8	Labour rights and safe working environment
3.3	Deaths and illness from pollution	8.9	Sustainable tourism
3.9	Water-borne diseases	9.1	Sustainable and resilient infrastructure
4.7	Education for sustainable development	9.2	Sustainable industrialization
5.a	Women's equal rights to economic resources, property, natural resources	9.4	Sustainability upgrading and resource efficiency
6.1	Access, safe water	9.a	Finance, technical, & technological support for sustainable & resilient infrastructure
6.2	Sanitation	11.1	Adequate, safe, affordable housing
6.3	Water quality	11.2	Sustainable transport
6.4	Use-efficiency, scarcity	11.3	Inclusive and sustainable urbanization
6.5	Integrated water management	11.4	Protect & safeguard cultural & natural heritage
6.6	Ecosystems	11.6	Environmental impact, air quality, waste management
6.a	Capacity building	11.7	Green and public spaces
6.b	Local participation	11.a	National and regional development planning
7.2	Renewable energy	11.b	Integrated policies on inclusion, resource efficiency, climate mitigation & adaptation, resilience, disaster risk management
7.3	Energy efficiency	11.c	Support for sustainable & resilient buildings
7.a	Related investment	12-15: All	(Except 14. a)

Note: a, b, and c indicate means of implementation targets under each SDG.

Source: (Elder and Olsen 2019)

The rest of this chapter discusses the issue of regional progress on environment-related SDGs and AMS efforts to implement the SDGs as reported in their VNRs, explains how SDGs can be used to promote integrated approaches to sustainable development, and suggests how the ASEAN Working Groups could link their work with SDGs.

11.2 ASEAN progress on selected environmental SDGs

11.2.1 Engagement in SDG processes

AMS have extensively engaged with the SDG process, including development of indicators and data and preparing Voluntary National Reviews (VNRs) to present their progress at the annual High-Level Political Forum (HLPF). Nine ASEAN Member States have submitted Voluntary National Reviews (VNRs) of their SDG implementation to the High-Level Political Forum (HLPF). Indonesia has submitted three VNRs, and four AMS have submitted two VNRs (Lao PDR, Malaysia, Philippines, and Thailand). AMS also participate in regional SDG forums such as the Asia-Pacific Forum on Sustainable Development (APFSD) coordinated by UNESCAP and regional Environment Ministers Meetings coordinated by UNEP.

Near the beginning of the SDG process, ESCAP and ASEAN, in cooperation with the Kingdom of Thailand, produced a report on complementarities between the SDGs and the ASEAN Community Vision 2025. This report did not focus comprehensively on the environment, but it highlighted two key environmental areas, natural resource management and SCP (ASEAN-Thailand 2018).

A review of the VNRs showed that many AMS have established government coordination structures for implementing the SDGs, adopted holistic or whole-of-government approaches, linked or coordinated their national plans and strategies with the SDGs, and held multistakeholder consultations in the process of preparing their VNRs (Elder 2020). Moreover, in their VNRs, AMS reported many environment-related SDG implementation policies which were widely distributed among SDGs; many of these policies were national action plans and strategies, laws, and regulations (Elder and Ellis 2022).

AMS have established high level bodies to coordinate the SDGs (Elder 2020). Lao PDR for instance has set up a National SDG Secretariat in charge of the VNRs. Malaysia's National Steering Committee, chaired by the Director General of country's Economic Planning Unit, is nested under the country's National SDG Council. In the Philippines, the National Economic and Development Authority (NEDA) led the preparation process. Thailand has the Sub-Committee on the Advancement of the SDGs, under the National Committee for Sustainable Development (CSD). In Viet Nam, the Ministry of Planning and Investment (MPI), Planning-Finance Departments of other ministries and related agencies and provincial Departments of Planning and Investment (DPI), as well as the National Assembly, Viet Nam Fatherland Front and other social organizations are engaged with the SDGs and VNR. Brunei set up a Special Committee, co-chaired at the ministerial level by the Ministry of Finance and Economy (MOFE) and Ministry of Foreign Affairs (MFA) for the creation of the 2020 VNR report. Cambodia's Ministry of Planning in is charge. Singapore has an Inter-Ministry Committee on SDGs (IMC- SDGs), which oversees preparations for the VNR and monitors SDG implementation. The IMC-SDGs is co-chaired by the Ministry of Foreign Affairs and the Ministry of Sustainability and the Environment.

Some AMS received UN support to develop their VNRs. Many countries held UN-supported national workshops to develop their VNRs. AMS which produced more than one VNR, expanded multistakeholder participation in the process over time.

11.2.2 Progress on environment-related SDG targets

Many have observed that progress on SDGs has been insufficient, especially as related to the environment (Independent Group of Scientists 2019; Sachs et al. 2020; UNEP 2021c), including in the Asia-Pacific (UNESCAP 2019; 2020b). An International Monetary Fund (IMF) study also identified environmental sustainability as a challenge for SDGs in ASEAN (IMF 2018b). Data and indicators are also still major challenges for many countries, including AMS.

At the regional level, and for the entire Asia-Pacific, SDG trends are captured annually by UNESCAP, as the organization has published annual SDG progress reports since 2017.

In 2017, the regional SDG Progress Report said "implementation across the SDGs needs to be scaled up substantially, especially in critical areas where the region seems to be regressing, namely on reducing inequalities and on promoting peaceful societies, access to justice and strong institutions. While the region is making satisfactory progress on a few SDGs in the social domain, it is only fully on target to achieving one by 2030" (UNESCAP 2017). In 2019, the picture had not improved. The annual report stated "…on its current trajectory, Asia and the Pacific will not achieve any of the 17 Sustainable Development Goals (SDGs) by 2030" (UNESCAP 2019). In 2020, the start of the SDGs' so-called 'decade of action', the annual report said that "…despite significant progress on some goals such as quality education (Goal 4), without extra efforts, the region is likely to miss all 17 goals by 2030. In particular, the region needs to reverse trends on responsible consumption and production (Goal 12) and climate action (Goal 13) where the region is going backwards" (UNESCAP 2020b).

The message of stalled progress was largely repeated in 2021 and 2022. The 2021 report stated "…the Asia-Pacific region is not on track to achieve any of the 17 SDGs by 2030. On its current trajectory, the region may achieve less than 10% of the SDG targets. There is therefore an added urgency…" (UNESCAP 2021b). The 2022 report concluded that "…progress towards the SDGs in the Asia-Pacific region has slowed as the COVID-19 pandemic and climate change have exacerbated development challenges. The region is not on track to achieve any of the 17 SDGs" (UNESCAP 2022).

The UNESCAP SDG Progress Reports do not officially cover the ASEAN subregion, but the reports do have subregional chapters or sections. Here the Southeast-Asian subregion consists of all AMS plus Timor-Leste. SOER6 will use this to closely approximate an ASEAN-wide assessment of the subregion's SDG achievement. This could suggest where more focus would help accelerate progress on the SDGs in general and on the environment in particular.

In 2017, the report stated that South-East Asia was on track to achieve SDGs 7, 9, and 11, but that the SDGs on climate and oceans (SDGs 13 and 14) were not progressing (UNESCAP 2017). In 2019, the report stated that the region regressed on SDGs 13 and 15, among others (UNESCAP 2019). In 2020 the environmental findings included for instance that the share of renewable energy in South-East Asia declined. Declining share of forested areas was another concern. "The net change rate of forest area is negative in […] Cambodia, Indonesia, [and] Myanmar" (UNESCAP 2020b). In 2021, the report found that the Southeast-Asian subregion progressed very slowly regarding the environment-related SDGs including SDGs 7,11,12 and 13. The report also indicated that the subregion's achievement of SDGs 13 and 14 was in fact regressing (UNESCAP 2021b). These trends continued in 2022; the UN stated that the subregion is off track to achieve any of the SDGs by 2030, and highlighted concerns about regression on SDGs 6,11,12,13, and 14 (UNESCAP 2022).

Most VNRs of AMS reported some highlights of progress on environment-related SDGs and targets, including some quantitative information such as the amount of food waste, extent of protected areas, energy intensity, etc. However, this information was usually not compiled in a data appendix or linked with official SDG indicators, so it is difficult to access for use in systematic comparisons. The major exception is Indonesia, which included a statistical annex of over 200 pages in its 2021 VNR (Republic of Indonesia 2021). This annex contained 51 environment-related official SDG indicators distributed among eight SDGs as shown in Table 11.2. Many of the indicators included data for more than one year, up to five years.

Table 11.2 Environment-related indicators in Indonesia's 2021 VNR

SDG	No. of Indicators
2 (Agriculture)	1
6 (Water)	6
7 (Energy)	2
11 (Cities)	9
12 (Sust. Cons. & Prod.)	13
13 (Climate)	6
14 (Oceans)	5
15 (Land)	9
Total	51

Source: (Republic of Indonesia 2021)

11.2.3 SDG environment-related implementation policies and efforts

AMS have a significant number of policies implementing the environment-related SDGs according to a study of the policies listed in the AMS VNRs as of 2020 (Elder 2020). These are shown below in Table 11.3. There was not a large variation in the number of policies for each SDG, mostly ranging between 5% and 8%. The low share of policies for SDGs 6 and 7 may be related to the year that these SDGs were highlighted at the HLPF, and which countries issued VNRs that year. The second highest number of policies was for SDG 13 on climate (8%). Overall, about one-third of the policies listed in AMS VNRs were related to the environment. Of course, the number of by itself policies is not a very good measure of effort since some are considerably more substantial than others, and the degree of implementation and effectiveness may vary widely.

Table 11.3 Policies in AMS VNRs by SDG

SDG	Number of policies	Percent of total
8	131	8%
13	127	8%
16	122	8%
4	116	7%
5	109	7%
11	105	7%
10	101	6%
1	97	6%
14	95	6%
12	93	6%
15	91	6%
9	80	5%
3	75	5%
17	70	4%
2	69	4%
7	46	3%
6	40	3%
Total Env.	597	38%
Total	1,567	

Note: Environment related SDGs are highlighted in green.

Source: (Elder 2020)

Also, the study found that countries probably under-reported policies, especially in the environmental area. One major example air pollution, which is directly mentioned in three SDGs (3, 11, 12) and indirectly related to another six targets (Elder and Zusman 2016). However, even though all AMS have air pollution policies (Elder 2015b), few mentioned them in their VNRs. Policies related to water, SCP, chemicals, and waste also appear to be under-reported, even though the AMS have related policies (UNCRD 2018b; Ministry of the Environment Japan and IGES 2019; Akenji et al. 2019).

Most AMS VNRs have very little information about domestic financing of SDGs (Elder 2020). This does not mean that the AMS are not funding the SDGs. Many of the policies listed in their VNRs are substantial, for example various national action plans and strategies, and most AMS indicated linkage between the SDGs and their national development plans, so presumably there was some funding from national budgets, but this was mostly not discussed in detail in the VNRs. Singapore mentioned financial support schemes for various sectors such as education, health, women, elderly, and small and medium enterprises (Government of Singapore 2018), while Viet Nam indicated that the majority of funding for medium-term public investment plans (2016-2020) is channelled towards SDG implementation (Viet Nam 2018). Most AMS may be using the VNRs as a way of attracting international financial support for SDG implementation. For example, the Philippines' VNR identified various potential funding sources (Government of the Philippines 2019).

Overall, analysis of AMS VNRs shows that the countries are clearly engaged in the SDG process, including the environmental dimensions. More research is needed to assess the implementation and effectiveness of ASEAN's environment-related SDG policies.

11.3 Using SDGs to promote integrated approaches to the environment, economy, and society

SDGs provide a framework to encourage integrated approaches to the environment, economy, and society. This is not always easy to visualize since SDGs are quite complex. Nevertheless, most SDGs include targets relating to all three dimensions of sustainable development – environment, economy, and society. A key insight is that some SDGs are means to achieve other SDGs (Elder, Bengtsson, and Akenji 2016). For example, the key measures to address climate change are not in SDG 13 itself, but rather in other SDGs such as SDG 7 (energy efficiency, and renewable energy). A holistic view of the environment in the SDGs also facilitates a broader view of the benefits of stronger environmental action on economic prosperity and social welfare. This can help generate greater understanding and support for stronger environmental policy measures, since one of the major obstacles to them is fears about how such measures might affect the economy and jobs. An SDG perspective can highlight how environmental protection measures can generate social and economic benefits such as job creation and ecosystem services (like flood mitigation) as well as lower health costs and better health.

This section examines four cases in detail: pollution control, ecosystems and biodiversity, sustainable consumption and production, and chemicals and waste. The centre of each case indicates the SDGs which address the status of the environmental issue; generally, there is more than one per issue. The left side of each diagram shows which SDGs can help achieve the environmental SDGs while the right side shows which SDGs can benefit from achieving the environmental SDGs. In this analysis, it becomes apparent that basically all of the SDGs are interrelated with each other.

The first example is pollution control illustrated in Figure 11.1. It shows that four SDGs have pollution-related targets. There is no SDG specifically for air pollution, although SDG 11 has an air pollution target. Six SDGs include measures that will help address pollution, including environmental education (SDG 4), SCP (SDG 12), renewable energy and energy efficiency (SDG 7), better governance (SDG 16), resource efficiency and "decoupling" economic growth from environmental damage (SDG 8), and sustainable industrialization and sustainable upgrading of industry (SDG 9). Six other SDGs will benefit from reduced pollution including reduced poverty, agriculture (e.g., improved crop yields), better health, better climate, and reduced inequality. Women also are disproportionately harmed by pollution, so reducing pollution will help gender equality. The diagrams also indicate that there are other measures to address these environmental issues which are not included in any specific SDG targets.

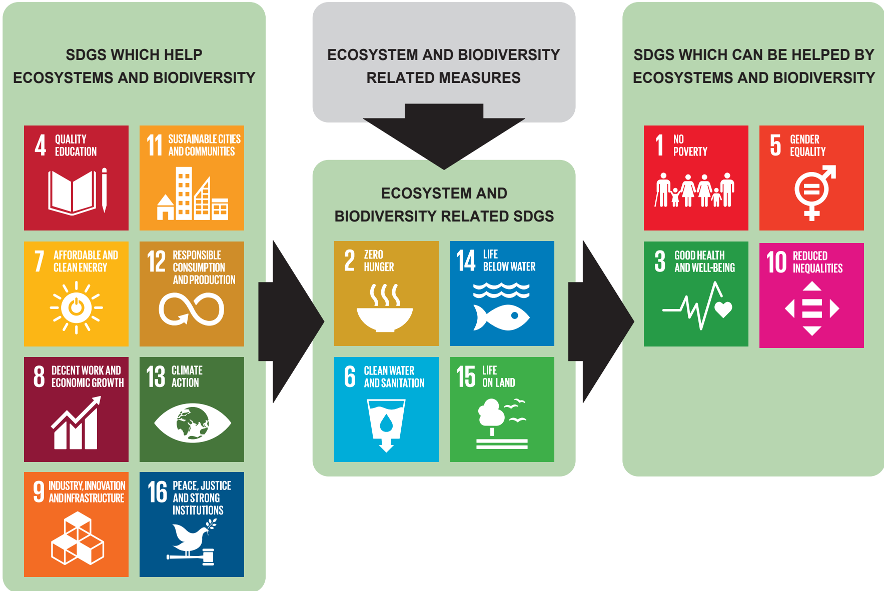
Figure 11.1 SDGs related to pollution control

Source: (Akenji et al. 2018)

Controlling pollution will also help SDGs 4, 8, and 9, although this is not indicated in the diagram because it does not repeat SDGs. Pollution obstructs learning, especially in low-income areas, so reducing pollution improves education in general (SDG 4). Likewise, pollution control measures will create jobs which will address SDG 8 (decent work) as well as contribute to industrial upgrading (SDG 9).

The second example relates to ecosystems and biodiversity (see Figure 11.2). Four SDGs address ecosystem health and biodiversity, not only SDGs 14 and 15 (oceans and land) but also SDG 6 (water ecosystems) and SDG 2 (Target 2.5 is on genetic diversity of seeds). However, the means to address ecosystem health and biodiversity issues are mainly in other SDGs, especially ones related to the economy, like SDGs 7, 8, 9, and 12, as well as environmental education (SDG 4) and better governance (SDG 16). Reducing air pollution – which is not a separate SDG – will also improve ecosystem services and biodiversity. Addressing climate (SDG 13) will also help ecosystems and biodiversity. Moreover, improving ecosystem services and biodiversity also improves health, reduces poverty, reduces inequality, and promotes gender equality. Overall resilience, which is not a separate SDG, will also be improved.

Figure 11.2 SDGs related to ecosystems and biodiversity



Source: (Akenji et al. 2018)

Similar to the case of pollution control, improved preservation of ecosystems and biodiversity also benefits some of the SDGs on the left side – and the centre – of the diagram, which were not repeated on the right side. Of course, these measures will create jobs and decent work (SDG 8). Also, ecosystem and biodiversity loss are very economically costly, so reducing these losses would help economic growth and industry (SDGs 8 and 9). Ecosystem and biodiversity preservation also will help targets on water availability (SDG 6) and food security (SDG 2), not just their targets on water ecosystems and genetic diversity of seeds. Finally, ecosystem and biodiversity preservation will also help with mitigation and adaptation of climate change (SDG 13).

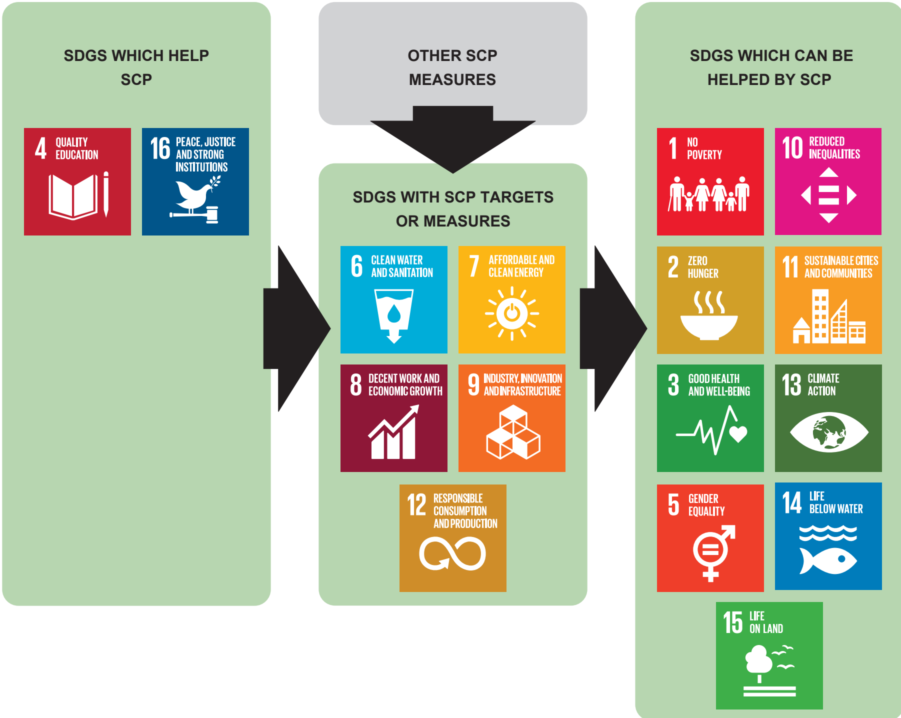
The third example relates to chemicals and waste (see Figure 11.3). There are three SDGs with targets relating to chemicals and waste: SDGs 6, 11, and 12. The economic SDGs play an important role in reducing waste, including not only energy (SDG 7) and resource efficiency (SDGs 8, 9, 12), but also the broader targets of decoupling economic growth from environmental degradation and sustainability upgrading of industry. Environmental education and improved governance will also make positive contributions. Better management of chemicals and waste benefits six other SDGs, especially those related to health, ecosystems and biodiversity, food security, and climate, as well as inequality and gender issues, as well as reduced air pollution (which is not a separate SDG). Environmental and health damage from improper management of chemicals and waste disproportionately affects low-income people and women. It is also overlooked that measures to address chemicals and waste issues will also create jobs (decent work as in SDG 8.2) as well as contribute to industrial upgrading. Pollution from improper management of chemicals and waste also worsens learning outcomes, especially in low-income people, so controlling this pollution will improve educational outcomes in general.

Figure 11.3 SDGs related to chemicals and waste

Source: (Akenji et al. 2018)

The fourth example is sustainable consumption and production. SCP is not only about SDG 12; SCP measures are also included in SDG 6 (integrated water management, water use efficiency), SDG 7 (energy efficiency), and SDGs 8 and 9 (resource efficiency, decoupling, sustainable upgrading of industry). SCP is not only one of the key means to achieve environmental targets relating to climate (SDG 13), pollution (especially in cities, SDG 11), ecosystem and biodiversity preservation (SDGs 14, 15), and related inequalities and gender disparities (SDGs 5 and 10). Moreover, by reducing pollution, SCP promotes food security by avoiding crop loss (SDG 2) and improves health (SDG 3). It reduces poverty by creating decent jobs (SDG 8) and improving health (SDG 3). It also improves overall resilience of societies (which is not a separate SDG).

Figure 11.4 SDGs related to sustainable consumption and production



Source: (Akenji et al. 2018)

A similar exercise could be conducted with other broad environmental issues like decarbonization, or even with more specific issues like air pollution. The results would be similar.

The integrated perspective on SDGs provides a way to show the broader social and economic benefits of environmental action more clearly. It also encourages environmental authorities to consider how environmental measures can contribute more directly to social and economic objectives, particularly creating decent jobs and eradicating poverty. This would help to generate greater support and understanding for environmental measures among the public and a broader range of policymakers.

11.4 Linkages between SDGs and ASEAN environment-related Working Groups

Each ASEAN Working Group is closely related to one primary SDG, and some WGs are additionally to other SDGs as shown in Table 11.4. For example, environmental issues addressed by cities in ASEAN are not only related to issues in SDG 11 but also to air pollution issues in SDG 3 and SCP related issues in SDG 12. Likewise, the focus of the Coastal and Marine Working Group combines land and water issues, and so it is related to both SDGs 14 and 15.

Table 11.4 Suggested priority SDGs for the Working Groups

Working Group	Highlighted Priority SDG	Related Priority SDGs
Cities	11	3, 12
Climate	13	7
Coastal and Marine	14	15
Water	6	
Nature Conservation and Biodiversity	15	
Environmental Education	4	
Chemicals and Waste	12	11

Going forward, SDGs could be used to inform and enhance the activities of the Working Groups, especially regarding their primary related SDG.

The WGs could also contribute to ASEAN's international cooperation on the environmental dimensions of the SDGs.

11.5 Way forward

Responses to environment-related SDG targets should be accelerated. SDGs encourage countries to develop synergies between the environment and the social and economic dimensions of sustainable development.

AMS have extensively engaged with the SDG process, developing data and indicators, and preparing VNRs to report on their progress to the HLPF. Assessments of SDG progress for East Asia have shown that not much progress has been made on environment-related SDGs in the Asia-Pacific region. AMS have adopted a range of policies to address environment-related SDGs according to their VNRs. The VNRs also seem to under report relevant environmental policies. Businesses, NGOs, youths, and other stakeholders have engaged in SDG implementation in ASEAN. SDGs can show how stronger environmental measures can help promote the economic and social dimensions of sustainable development. This could help gain more support for environmental measure by the public as well as a broader range of policymakers. SDGs could be an effective way to help guide the activities of the ASEAN Working Groups, since the SDG topics are similar to the WG focus areas.

ASEAN Working Groups could share information and coordinate efforts on SDG-related environmental data and indicators with lead agencies in AMS. Capacity to gather SDG-related environmental data should be strengthened.

Chapter 12
ASEAN Environmental Cooperation Framework

Main Messages

- In ASEAN's organizational structure, environmental cooperation is under the ASCC.
- Environmental cooperation within ASEAN is overseen by AMME, managed by ASOEN, and implemented through seven Working Groups under the ASOEN, supported by the ASEAN Secretariat.
- ASEAN conducts international cooperation on the environment at all levels, from the global to the regional to local levels, in a wide variety of formats, with a wide range of partners, and covering a wide range of topics.
- The extensive range of ASEAN's international cooperation on the environment indicates the commitment of AMS to address these issues. These cooperation frameworks also play an important role in enhancing the capacity of AMS to address environmental issues.
- The cumulative reporting burdens for MEAs and other cooperation frameworks with many overlapping requirements can be challenging. A streamlined data collection, storage, and analysis system should make these reporting requirements less burdensome.
- Some activities of the ASEAN Economic Community and Political and Security Community are also related to the environment, especially related to energy. How to strengthen their involvement with international environmental cooperation should be considered.
- Strengthen coordination among environmental cooperation frameworks at all levels and sectors and among key stakeholders.
- Better coordination, as well as strengthening the substance of projects and programmes, will require enhanced human resource capacity in the ASEAN Sectoral Bodies, especially Centres, the ASEAN Secretariat, and national ministries of AMS.

12.1 Introduction

The ASEAN Community has been built on many years of cooperation between AMS, regional partners, and the international community. Nowhere is that cooperation more important than in addressing the region's environmental issues. The following chapter outlines (i) the environmental cooperation framework within ASEAN; (ii) ASEAN strategies and plans that promote environmental cooperation; (iii) international environmental cooperation through multilateral agreements; (iv) environmental cooperation with ASEAN's external partners; and (v) the constraints and opportunities for future environmental cooperation. ASEAN countries participate in a wide range of types of international environmental cooperation frameworks including multilateral environment agreements, intergovernmental programmes, and multistakeholder partnerships (Elder 2018). It is not easy to get a comprehensive view of ASEAN's international environmental cooperation, which is not all compiled in one place. This chapter aims to survey the main elements, although it is not comprehensive.

The ASEAN Community is divided into three main pillars: the ASEAN Political and Security Community (APSC), the ASEAN Economic Community (AEC), and the ASEAN Socio-Cultural

Community (ASCC). In ASEAN's organizational structure, the environmental cooperation framework is part of the ASCC pillar. Some activities of the AEC and APSC are also related to the environment, especially in the area of energy, forestry and agriculture, among others. How to strengthen the involvement of the AEC and APSC with international environmental cooperation should be considered. However, this chapter will address only AMS cooperation on the environment under the ASCC and not under the other two Communities.

12.2 ASEAN institutional framework on the environment

ASEAN has two sectoral ministerial bodies related to the environment. First, the ASEAN Ministerial Meeting on Environment (AMME) is a sectoral ministerial body listed under Annex 1 of the ASEAN Charter which provides policy and strategic guidance related to ASEAN cooperation on environment. The AMME now meets every two years (ASEAN Secretariat 2017c). Second (also listed under Annex 1 of the ASEAN Charter) is the Conference of Parties to the ASEAN Agreement on Transboundary Haze Pollution (COP-AATHP), consisting of the ASEAN Ministers responsible for environment. (For details of COP-AATHP, see 12.3.4. below.) The two sectoral ministerial bodies, e.g. AMME and COP-AATHP, operate under their respective mandates. However, the cross-cutting nature of their work mutually reinforces each other in implementing environment-related aspects of the ASCC Blueprint 2025.

AMME is assisted by the ASEAN Senior Officials on Environment (ASOEN), who meet annually, and provide strategic guidance in advancing ASEAN cooperation on environment. The chairpersonship of ASOEN is rotated among ASEAN Member States alphabetically every three years.

Under the ASOEN, subsidiary thematic Working Groups lead the technical and operational implementation of their respective Working Group Action Plans. There are seven (7) working groups set up to oversee the priority areas of ASEAN environmental cooperation (see section 12.3.2 for more details). The Working Groups are chaired by an ASEAN Member State based on expression of interest, with a tenure of three years. The seven working groups are as follows:

- ASEAN Working Group on Nature Conservation and Biodiversity (AWGNCB)
- ASEAN Working Group on Coastal and Marine Environment (AWGCME)
- ASEAN Working Group on Water Resources Management (AWGWRM)
- ASEAN Working Group on Environmentally Sustainable Cities (AWGESC)
- ASEAN Working Group on Climate Change (AWGCC)
- ASEAN Working Group on Chemicals and Waste (AWGCW)
- ASEAN Working Group on Environmental Education (AWGEE)

ASOEN, together with the Secretary-General of

ASEAN, also serves as the Governing Board of the ASEAN Centre for Biodiversity (ACB), based in Los Baños, Philippines, which supports the AWGNCB in facilitating cooperation and coordination of the conservation and sustainable use of biological diversity in the region.

ASOEN and its working groups also provide support to relevant cross-sectoral issues beyond the environment sector such as the issues of climate resilience, forestry, agriculture, single-use plastics, etc.

ASEAN cooperation on environment is supported and coordinated by the Environment Division of the ASEAN Secretariat. The ASEAN Secretariat provides support for the various institutional bodies, “acting as a resource base, providing advice and information and coordinates the implementation of regional activities and programmes.” It also “ensures proper coordination on related activities of various other sectoral bodies so as to promote synergy and avoid duplication.” “Another important role played by the ASEAN Secretariat is the coordination between ASEAN bodies and its programmes with those of ASEAN Dialogue Partners and other international organisations” (ASEAN Secretariat 2017c).

The ASEAN Sectoral Bodies related to the environment are supported by or coordinated closely with relevant ASEAN entities, which include but are not limited to the ASEAN Centre for Biodiversity (ACB), ASEAN Centre for Climate Change (ACCC) (to be established), ASEAN Centre for Sustainable Development Studies and Dialogue (ACSDSD), ASEAN Centre for Energy (ACE), ASEAN Specialised Meteorological Centre (ASMC), and the ASEAN Institute for Green Economy.

ASEAN Centre for Biodiversity (ACB)

Established in 2005 and located in Los Baños, Philippines, ACB is responsible for “cooperation and coordination of matters related to the conservation and sustainable use of biological diversity and fair and equitable sharing of any benefits arising from the use of biodiversity in the ASEAN region”. ACB is managed by a Governing Board, drawn from ASOEN and the Secretary-General of ASEAN. The ASEAN Working Group on Nature Conservation and Biodiversity provides technical guidance to ACB and recommends issues to focus on. ACB serves as the Secretariat of the AHP programme as described in Chapter 4.

ASEAN Centre for Climate Change (ACCC)

At the 16th AMME in 2021, AMS endorsed in principle Brunei Darussalam’s initiative to establish the ASEAN Centre for Climate Change as part of its Chairmanship Initiative (ASEAN 2021a).

ASEAN Centre for Sustainable Development Studies and Dialogue (ACSDSD)

In 2019, the ASEAN Centre for Sustainable Development Studies and Dialogue (ACSDSD) was launched in Bangkok, Thailand, to “promote cooperation on sustainable development in the region, encourage research and capacity-building in AMS, implement cooperation projects on sustainable development, and enhance the complementarities between the ASEAN Community Vision 2050 and the UN 2030 Agenda for Sustainable Development” (ASEAN 2019b).

ASEAN Centre for Energy (ACE)

Although technically not affiliated with ASOEN, the ASEAN Centre for Energy (ACE) is a specialized organization established in 1999 aiming to “accelerate the integration of energy strategies within ASEAN” (ASEAN Centre for Energy n.d.), located in Jakarta, Indonesia. The ACE serves three critical roles (as a catalyst, knowledge hub, and think tank), helping to implement the ASEAN Plan of Action for Energy Cooperation along with the Sub-sector Networks, Specialized Energy Bodies, and the ASEAN Secretariat (ASEAN Centre for Energy n.d.).

ASEAN Specialised Meteorological Centre (ASMC)

The ASEAN Specialised Meteorological Centre (ASMC) was established as an ASEAN Centre under the Committee on Science and Technology (COST) in 1993. In 1997, the ASMC was "appointed to monitor and assess land and forest fires and the occurrence of transboundary smoke haze affecting the southern ASEAN region" under the ASEAN Regional Haze Action Plan (RHAP) (ASEAN Secretariat 2021l, 27). Its role further expanded in 2003 under the ASEAN Agreement on Transboundary Haze Pollution to cover the entire ASEAN region (ASEAN Secretariat 2021l). Its remit further includes undertaking "research and development to improve scientific understanding and prediction of weather and climate systems of significance to the region" and conducting "regional capability-building programmes to enable ASEAN National Meteorological Services to leverage advances in science and technology to support important economic sectors" (ASMC 2022). The ASMC is hosted by the Meteorological Service Singapore (ASMC 2022).

ASEAN Institute for Green Economy (AIGE)

The ASEAN Institute for Green Economy (AIGE) was launched on 12 November 2014 at the 25th ASEAN Summit in Nay Pyi Taw under Myanmar's chairmanship (Sein 2014). The Institute serves as a centre of excellence to "promote policies and practices to address green economy and green growth opportunities", with an aim to increase and improve sustainable development, conservation and efficient use of natural resources, particularly energy, water and biodiversity, and transition to low carbon technologies to address climate change. The Institute's mandate includes enhancing awareness of programmes on green technologies and management practices, and assisting interested AMS in research and knowledge-sharing of green technologies and management practices including through joint research, education, and training.

12.3 ASEAN policy framework on environment

12.3.1 ASEAN Socio-Cultural Community Blueprint 2025

The ASCC Blueprint 2025 is concerned with the quality of life in ASEAN, aiming to realize a "people-oriented, people-centred, environmentally friendly" region through sustainable development (ASEAN Secretariat 2016b). The ASCC Blueprint 2025 envisions "an ASEAN Community that engages and benefits the peoples and is inclusive, sustainable, resilient, and dynamic" (ASEAN Secretariat 2016b). The current blueprint follows its predecessor, which was implemented from 2009 to 2015 and made progress on poverty reduction, public health, gender parity, and other social goals (ASEAN Secretariat 2016b).

Environment-related key result areas are outlined in the ASCC Blueprint's components "Sustainable" and "Resilient", with each key result area accompanied by strategic measures focusing on regional cooperation. "Sustainable" key result areas relevant to the environment include (i) conservation and sustainable management of biodiversity and natural resources; (ii) environmentally sustainable cities; (iii) sustainable climate; and (iv) sustainable consumption and production. "Resilient" key result areas relevant to the environment include (i) a disaster resilient ASEAN; (ii) a safer ASEAN able to respond to all health-related hazards; (iii) a climate adaptive ASEAN; (iv) strengthened social protection for vulnerable groups; and (iv) financing systems, food, water, energy, and other social safety nets in times of crises (ASEAN Secretariat 2016b).

The Mid-term Review of the ASEAN Socio-Cultural Community Blueprint 2025 was published in 2021 (ASEAN 2021g). It reviewed 964 activities of 15 sectoral bodies according to the Blueprint's five characteristics and objectives: (A) engages and benefits the people, (B) inclusive, (C) sustainable, (D) resilient, and (E) dynamic. The Review's Executive Summary highlighted ASOEN's contributions to three of these Characteristics. Under Characteristic C (sustainable), 362 activities were implemented by 10 sectoral bodies, and 63.3 % were either completed or ongoing. The most common activites were policy formulation and capacity building. The Review noted that the two sectoral bodies related to environmental issues, ASOEN and COP-AATHP, dominated this group of activities, accounting for 68.2 and 13.54 % of the activities, respectively (p. 57). ASOEN also implemented the largest number of activities classified under Characteristics D (resilient) and E (dynamic), 44.17 % of 559 activities. Research and publication and capacity building were the most common activities under Characteristic D, while activities under Characteristic E were dominated by public outreach and capacity building in addition to research and publication, policy forumulation, and groundwork.

Overall, the Mid-term Review concluded that the AMS made "satisfactory progress in achieving the Blueprint's objectives since 2016". The review observed that almost every Sectoral Body "has secured funding internally", commended SOCA and ASEC "for facilitating and providing support to SBs in implementing the blueprint, especially in coordination between Sectors and Pillars", and noted progress on "engaging ASEAN's Dialogue Partners and relevant stakeholders to obtain technical and funding support". The Review also observed that areas with activities coordinated by centres (such as the ASEAN Centre for Biodiversity) tended to have stronger coordination and implementation. Challenges included the COVID-19 pandemic and "insufficient financial and human resources to implement the Blueprint at the national level", for example "responsible desks are overloaded with multiple tasks dealing with various international and bilateral cooperation issues", and the "rotation of ASEAN desk officers at SBs" which "has adversely affected institutional memory and expertise".

The Mid-term Review's strategic recommendations focused on data and indicators. Main recommendations included improved monitoring tools and more regular updating; collecting more data on public perceptions and awareness of ASEAN issues and using that information to improve awareness by ASEAN's stakeholders and the general public; developing indicators for quality outcomes (not just the number of projects); and ensuring more consistent efforts towards the end of the Blueprint's term. Some operational recommendations included cleaning data and entering them in a standard uniform format; greater coordination to mainstream the Blueprint into national plans; emphasizing the quality and impact of activities rather than their quantity; close monitoring and evaluation of activities; strengthening cross-sectoral and cross-pillar collaboration; encouraging more contributions from multinational companies and the private sector; and increasnig capacity building and online training platforms.

Other ASEAN sectoral bodies beyond the ASOEN have their own sectoral work plans that are relevant and contribute to efforts to address environmental issues, such as related to disaster risk reduction, adaptation to drought, and social welfare and development. These include the ASEAN Declaration on the Strengthening of Adaptation to Drought, ASEAN Regional Plan of Action for Adaptation to Drought, and the ASEAN Committee on Women (ACW) Work Plan 2021 – 2025 (Vision 3: Gender responsive climate and disaster resilience), among others.

12.3.2 ASEAN Strategic Plan on Environment (ASPEN)

ASPEN was developed by ASOEN to "serve as a comprehensive guide for ASEAN cooperation on the environment" from 2016-2025 (ASEAN Secretariat 2016c). ASPEN established seven strategic priorities which are each coordinated by an ASOEN Working Group. The seven strategic priorities and related Working Groups are listed in Table 12.1.The 26th Meeting of ASOEN in September 2015 endorsed the development of working group action plans and ASEAN strategic plan of action on environmental cooperation in line with the ASEAN Vision 2025 and the ASCC Blueprint. The 28th ASOEN Meeting held in 2017, however, endorsed in principle the remaining text of the draft ASPEN, which includes the Action Plans of ASOEN Working Groups, and tasked respective ASOEN Working Groups to continue to complete their work plans with details of implementation such as indicators, lead countries, budget and timeline, for their respective working group action plans. ASOEN is still deliberating on the draft ASEAN Strategic Plan on Environment (ASPEN).

12.3.3 Sectoral Workplans under ASOEN

The ASOEN Working Groups have each established Action Plans to implement the seven strategic priorities under ASPEN. ASOEN Working Group Action Plans are intended to guide ASEAN cooperation on the environment from 2016 to 2025, prioritizing nature conservation and biodiversity, coastal and marine environment, water resources management, environmentally sustainable cities, climate change, chemicals and waste, and environmental education (ASEAN Secretariat 2017c). The Working Groups and the priority programmes included in their Action Plans are listed in Table 12.1.

Table 12.1 Priority Programmes of the ASOEN Working Groups

ASOEN Working Group	Strategic Priority	Priority Programmes
AWGNCB (as of 9 July 2019)	Nature Conservation and Biodiversity	• Key Terrestrial Biodiversity Area Conservation Including Protected Areas • Urban Biodiversity • Agricultural Biodiversity • Access and Benefit Sharing • Communication, Education and Public Awareness • ASEAN Centre for Biodiversity
AWGCME (as of 12 May 2016)	Coastal and Marine Environment	• Key Coastal and Marine Area Conservation • Endangered Coastal and Marine Species Conservation • Tanker De-sludging and Oil Spill Reduction • Coastal and Marine Pollution Mitigation • Coastal and Marine Invasive Alien Species • Climate Change Issues and Impacts in Coastal Areas • Integrated Coastal Management and Marine Spatial Planning

AWGWRM (as of 27 June 2019)	Water Resources Management	• IWRM Country Strategy Guideline and Indicator Framework Implementation • Public Awareness and Cross-Sectoral Coordination • Water Conservation • Improving Water Quality and Sanitation • Water-related Disasters
AWGESC (as of)	Environmentally Sustainable Cities	• Sustainable Urban Planning, Development, and Implementation • Climate Resilient and Low Carbon Cities
AWGCC (as of 25 November 2020)	Climate Change	• Climate Change Adaptation • Long Term Planning and ASsesment of NDCs • Climate Change Mitigation • Climate Modelling and Assesment • Measurement, Reporting and Verification (MRV) and Stocktack of GHG Emissions • Climate Financing and Market • Cross-Sectoral Coordination • Technology Transfer
AWGCW (as of 4 September 2019)	Chemicals and Waste	• Hazardous Waste Management and other Waste Defined Under the Basel Convention • Transboundary Movements of [Hazardous] Chemicals and Hazardous Waste • Sound Chemicals Management • Environmentally Sound Management Technologies (EST) towards Green Industries • ASEAN Presence in the Global Community • Chemicals and Hazardous Wastes Accident Prevention, Preparedness and Emergency Responses • Remediation of Contaminated Sites from Chemicals and Hazardous Wastes
AWGEE	Environmental Education (and Sustainable Consumption and Production)	• ASEAN Eco-Schools Programme • ASEAN Green Higher Education Programme • Regional Communication, Education, and Public Awareness • Sustainable Consumption and Production (SCP)

Source: (ASEAN Secretariat 2016c)

The progress of implementation of the ASOEN Working Groups' Action Plans is well underway. Various cooperation programmes and projects with dialogue and development partners continue to be developed and implemented, including on priority environmental issues such as air pollution as well as emerging environmental issues such as nature-based solutions and advancement of SCP implementation in relation to transition to circular economy. Cross-sectoral coordination in addressing interdisciplinary nature of environmental issues continues to be deliberated across the relevant pillars of ASEAN.

12.3.4 ASEAN Agreement on Transboundary Haze Pollution (2002)

The ASEAN Agreement on Transboundary Haze Pollution (AATHP) is intended "to prevent and monitor transboundary haze pollution as a result of land and/or forest fires which should be mitigated, through concerted national efforts and intensified regional and international co-operation" (ASEAN Secretariat 2002a). AMS are expected to: "(i) cooperate in developing and implementing measures to prevent and monitor transboundary haze pollution as a result of land and/or forest fires which should be mitigated, and to control sources of fires, including by the identification of fires, development of monitoring, assessment and early warning systems, exchange of information and technology, and the provision of mutual assistance; (ii) when the transboundary haze pollution originates from within their territories, respond promptly to a request for relevant information or consultations sought by a State or States that are or may be affected by such transboundary haze pollution, with a view to minimizing the consequences of the transboundary haze pollution; and (iii) take legislative, administrative and/or other measures to implement their obligations under this Agreement" (ASEAN Secretariat 2002a).

The Conference of Partices (COP-AATHP) was established in 2003, consisting of the ASEAN Ministers responsible for the environment or agriculture. In view of the different periods of traditional dry season in the northern (Mekong) and southern ASEAN region, two sub-regional steering committees were established to address specific subregional issues. The Sub-regional Ministerial Steering Committee on Transboundary Haze Pollution (MSC) includes Brunei Darussalam, Indonesia, Malaysia, Singapore, and Thailand, while the Sub-regional Ministerial Steering Committee on Transboundary Haze Pollution in the Meking Sub-region (MSC Mekong) includes Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam. Each Subregional Steering Committee is supported by a technical working group (TWG and TWG Mekong) (ASEAN Secretariat 2017).

The Agreement also called for establishment of the ASEAN Coordinating Centre for Transboundary Haze Pollution Control (ACC) to facilitate the cooperation and coordination of regional countries in managing the impact of land and/or forest fires in particular haze pollution arising from such fires.

Roadmap on ASEAN Cooperation towards Transboundary Haze Pollution Control with Means of Implementation

Adopted in 2016, the Roadmap on ASEAN Cooperation towards Transboundary Haze Pollution Control with Means of Implementation (2016-2020) (Haze Free Roadmap) aims to ultimately achieve the vision of a "Transboundary Haze-free ASEAN" by 2020 through eight key strategies, as follows (ASEAN Secretariat 2022c; 2022b):

- Implementation of AATHP;
- Sustainable Management of Peatlands for Peatland Fire Prevention;
- Sustainable Management of Agricultural Land and Forest for Large Scale Forest and/or Land Fires Prevention;
- Strengthening of Policies, Laws, Regulations, and their Implementation;
- Enhancement of Cooperation, Information and Technology Exchange, Capacity Building;
- Enhancement of Public Awareness and Cross-Sectoral and Stakeholder Participation;
- Resource Procurement from Multiple Stakeholders; and
- Reduction of Health and Environmental Risks and Protection of the Global Environment

According to the final review of the implementation of the Haze Free Roadmap, the level of implementation of actions under each strategy was mixed, with most actions completed at a "moderate" rate. While fires in non-peat forests and peatlands are effectively and moderately managed, respectively due to national efforts, there were barriers to the establishment of the ACC, which has hindered implementation of AATHP. Regarding the development of the new roadmap, the final review report recommends incorporating economic instruments to complement regulations, considering subnational needs, implementing more innovative, multi-stakeholder and inclusive approaches, and aligning the new roadmap with the SDGs and ASCC Blueprint (ASEAN Secretariat 2022b).

ASEAN Peatland Management Strategy (2006-2020)

Related to the ASEAN Agreement on Transboundary Haze Pollution, the ASEAN Peatland Management Strategy (APMS) was endorsed in 2006 to guide actions to support the management of peatlands in the region in the period of 2006 – 2020. The goal of the APMS is to "promote sustainable management of peatlands in the ASEAN region through collective actions and enhanced cooperation, support and sustain local livelihoods, reduce risk of fire and associated haze and contribute to global environmental management" (ASEAN Secretariat 2006). To enhance the implementation of this strategy, the ASEAN programme on Sustainable Management of Peatland Ecosystems 2014-2020, was established in 2013 (ASEAN Secretariat 2013). The 2006-2020 report for APMS reported that "good progress" has been made on the objectives of the strategy, which are "enhancing awareness and capacity on peatlands", "addressing transboundary haze pollution and environmental degradation", "promoting sustainable management of peatlands", and "promoting regional cooperation" (ASEAN Secretariat 2013). The next phase of this strategy (2022-2030) is currently being developed and aims to be endorsed by the 18th Conference of the Parties to the ASEAN Agreement on Transboundary Haze Pollution (COP-18).

12.4 Other related key ASEAN policy frameworks

There are several ASEAN-wide, overarching strategies covering all three Communities that are relevant to environmental issues, including, but not limited to the ASEAN Comprehensive Recovery Framework (ACRF), the ASEAN Comprehensive Framework on Care Economy, and the Master Plan on ASEAN Connectivity 2025 (see section 8.2.4 for more details).

The ACRF is recommended as a holistic and inclusive policy framework to help integrate the sectoral workplans of the Blueprint by the Mid-term Review (Mid-term review 2020). The ACRF provides a consolidated exit strategy for ASEAN to emerge resilient and strong from the COVID-19 crisis. It promotes sustainable development in all dimensions, and it has many environmental elements including facilitating the transition to clean energy, green and sustainable infrastructure, sustainable transport, sustainable and responsible investment, sustainable and climate-smart agriculture, measures to combat wildlife trafficking, managing disaster risks and strengthening disaster management, and sustainable finance (ASEAN Secretariat 2020a). This is a good opportunity to help to mainstream environmental considerations into other policy areas.

Other sectoral bodies beyond ASCC have their own sectoral work plans that are relevant and contribute to efforts to address environmental issues in the areas of energy, transport, food and agriculture, health, education, and many others. These include the ASEAN Taxonomy for Sustainable Finance (ASEAN Taxonomy Board 2021), the ASEAN Declaration on Blue Economy, the ASEAN Green Hotel Standard, the ASEAN Smart Cities Network (see section 8.3.3, for example), and the ASEAN

Multi-sectoral Framework on Climate Change, Agriculture, Fisheries and Forestry towards Food Security (AFCC), ASEAN Plan of Action for Energy Cooperation (2021-2025) Phase 2, ASEAN Regional Strategy on Sustainable Land Transport, among others.

Ultimately, since many drivers of environmental issues fall outside of 'environmental' sectors (see Chapter 2), the many initiatives undertaken by "non-environmental" sectors have important implications for ASEAN's progress toward greater environmental sustainability.

12.5 AMS participation in MEAs

AMS membership selected major MEAs is shown in Table 12.2. The table demonstrates that AMS participation in MEAs is very extensive.

Table 12.2 Participation by AMS in Selected MEAs

MEAs	BRN	KHM	IDN	LAO	MYS	MMR	PHL	SNG	THA	VNM
Basel[9]	X	X	X	X	X	X	X	X	X	X
CBD[10]	X	X	X	X	X	X	X	X	X	X
CITES[11]	X	X	X	X	X	X	X	X	X	X
COBSEA[12]		X	X		X		X	X	X	X
Minamata[13]		X	X	X			X	X	X	X
Montreal[14]	X	X	X	X	X	X	X	X	X	X
Rotterdam[15]		X	X	X	X		X	X	X	X
Stockholm[16]	X	X	X	X	X	X	X	X	X	X
UNFCCC	X	X	X	X	X	X	X	X	X	X

Source: authors

The cumulative reporting requirements of these MEAs are significant. Cooperation at the regional level is useful to facilitate implementation, for example, by sharing experiences on successes and challenges.

[9] Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Information is available at the Basel Convention's website: http://www.basel.int/.
[10] Information is available at the Convention on Biodiversity's website: https://www.cbd.int/.
[11] Information is available at the website of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): https://cites.org/eng/disc/what.php.
[12] Information is available at the website of The Coordinating Body on the Seas of East Asia (COBSEA): https://www.unep.org/cobsea/.
[13] Information is available at the Minamata Convention on Mercury's website: https://www.mercuryconvention.org/en.
[14] Information is available at the website of the Montreal Protocol on Substances that Deplete the Ozone Layer: https://www.unep.org/ozonaction/who-we-are/about-montreal-protocol
[15] Information is available at the Rotterdam Convention's website: http://www.pic.int/.
[16] Information is available at the website of the Stockholm Convention on Persistent Organic Pollutants: http://www.pops.int/.

12.6 Bilateral cooperation with ASEAN Dialogue Partners, Sectoral Dialogue Partners and Development Partners

There are many bilateral cooperation mechanisms between ASEAN and various national partners as well as international organizations. Some of these mechanisms are highlighted in this section.

12.6.1 ASEAN and China

ASEAN and the People's Republic of China established dialogue relations in 1991, after which their Strategic Partnership has continued to be advanced, guided by documents such as the ASEAN-China Strategic Partnership Vision 2030 (ASEAN and People's Republic of China 2021b). The ASEAN-China Strategic Partnership Vision 2030 illustrates their commitment to issues such as water resources management, sustainable development, and climate change in alignment with the ASEAN-China Strategy on Environmental Cooperation and the ASCC Blueprint 2025 (ASEAN and People's Republic of China 2018). The action plan for the ongoing ASEAN-China Strategic Partnership for Peace and Prosperity (2021-2025) includes environmental initiatives for issues including but not limited to climate change, forestry conservation, marine plastics, clean water and air, and environmental technologies under "Social and Cultural Cooperation" and "Sustainable Development Cooperation" (ASEAN Secretariat, n.d.).

Based on the adoption of the ASEAN-China Strategy on Environmental Cooperation 2009-2015 in 2009, the China-ASEAN Environmental Cooperation Centre was launched in 2011 to strengthen cooperation on (i) public awareness and environmental education, (ii) environmentally sound technologies, (iii) environmental labelling and cleaner production; and in new areas such as (i) biodiversity conservation, (ii) environmental management capacity building, (iii) environmental goods and services, and (iv) global environmental issues (ASEAN Secretariat 2011).

Most recently, in 2021, which was designated as the ASEAN-China Year for Sustainable Development Cooperation commemorating 30 years of dialogue relations, the ASEAN-China Joint Statement on Enhancing Green and Sustainable Development Cooperation signified the adoption of the Framework of ASEAN-China Environmental Cooperation Strategy and Action Plan (2021-2025) (ASEAN and People's Republic of China 2021a).

12.6.2 ASEAN and the European Union (EU)

ASEAN and the EU established dialogue relations in 1977, which were elevated to a Strategic Partnership in 2020 (EU-ASEAN Strategic Partnership 2021). This partnership is comprehensive, covering all three ASEAN Communities (EU-ASEAN Strategic Partnership 2021). The EU has been supporting ASEAN on various environmental and sustainable development initiatives. For example, through E-READI, ASEAN and EU engaged in dialogues such as the annual ASEAN-EU High Level Dialogue on Environment and Climate Change (started in 2019) (ASEAN Secretariat 2021c), and on IUU fishing in 2019, paving the way for the adoption of a cooperation framework for the ASEAN Network for Combatting IUU Fishing (AN-IUU) in 2020 (EU-ASEAN Strategic Partnership 2021). The E-READI has also been used to support climate change efforts (e.g., a scoping study to support the formulation of national long-term strategies in AMS that have yet to submit to UNFCCC), circular economy initiatives (e.g. an analysis identifying gaps for circular economy and plastics in ASEAN), and natural capital initiatives (e.g., natural capital report) (EU-ASEAN Strategic Partnership 2021).

The EU also supports, among others, the Sustainable Use of Peatland and Haze Mitigation in ASEAN (SUPA) programme, Biodiversity Conservation and Management of Protected Areas in ASEAN (BCAMP) programme, ASEAN Circular Economy (CE) Stakeholder Platform[17], and the new Smart Green ASEAN Cities programme launched in 2021 (ASEAN Secretariat 2021m; ASEAN Centre for Biodiversity 2022b; European Commission 2021b).

12.6.3 ASEAN and Germany

Germany became a Development Partner of ASEAN in 2014 and has been cooperating broadly on various issues ever since (ASEAN Secretariat 2018c). Apart from supporting the SUPA programme along with the EU, Germany has been engaged in ASEAN through such projects as the "Reduce, Reuse, Recycle to Protect the Marine environment and Coral Reefs" (3RproMar) project and the Cooperation for Resilience in Urban Centres project. The 3RproMar project, implemented from 2020 to 2024, aims to promote regional cooperation and knowledge management among ASEAN working groups dealing with marine plastics, support the development of national measures to reduce waste leakage, promote the private sector engagement, and implement relevant pilot projects (GIZ 2021). The Cooperation for Resilience in Urban Centres project, scheduled to continue until the end of 2022, aims to build environmentally sustainable ASEAN cities by focusing on the conceptual development of 'urban resilience' for ASEAN, the development of approaches to increase urban resilience, and support for dialogue at different levels of governance (adelphi 2022). The project allows for an exchange of best practices and ideas on urban resilience between ASEAN and Germany (adelphi 2022).

12.6.4 ASEAN and Japan

In 2008, ASEAN and Japan concluded the Agreement on Comprehensive Economic Partnership among Japan and Member States of the Association of Southeast Asian Nations, which explicitly states that "the Parties, on the basis of mutual benefit, shall explore and undertake economic cooperation activities in [...] [the] environment" (ASEAN and Japan 2008).

ASEAN and Japan will celebrate 50 years of friendship and cooperation in 2023 (ASEAN 2021d). In 2007, the Japan-ASEAN Dialogue on Environmental Cooperation, a bilateral consultative mechanism for environmental issues, was launched, which has been a venue to not only discuss issues, but also report on programmes and explore potential environmental projects in which ASEAN-Japan cooperation would be beneficial (Ministry of the Environment Japan n.d.). The ASEAN-Japan Environment Cooperation Initiative was then launched in 2017 (Ministry of the Environment Japan 2021b). For climate

[17] For more information, see the link on ASEAN's website: https://asean.org/from-linear-to-circular-eu-asean-inaugurate-stakeholder-platform-secretariat-to-boost-regions-circular-economy/.

change, the Japanese government proposed the ASEAN-Japan Climate Change Action Agenda in 2018 and subsequently unveiled the ASEAN-Japan Climate Change Action Agenda 2.0 in 2021 (Ministry of the Environment Japan 2021b), which includes activities (development of assessments, implementation of projects, capacity-building workshops, development of reports, etc.) under the main areas of transparency, mitigation, and adaptation (Ministry of the Environment Japan, n.d.).

The JAIF, originally established in 2006, has offered financial support for various projects in ASEAN on issues such as “health, counterterrorism, the environment, outreach, disaster management, and economic integration” (JAIF Management Team n.d.). The fund was updated in 2013, with a commitment of US$ 100 million toward projects in priority areas such as maritime cooperation, disaster management, counterterrorism and transnational crime, and ASEAN Connectivity, as well as projects that contribute to the Vision Statement on ASEAN-Japan Friendship and Cooperation and/or its Implementation Plan (JAIF Management Team n.d.). Under the JAIF, various environment related projects and programmes have been undertaken. These include the development of the ASEAN State of Climate Change Report, ASEAN State of Environment Reports, ASEAN SGDs Frountrunner Cities Programmes, PaSTI Project - Development and implementation of facility/company level Monitoring, Reporting and Verification (MRV) systems for Greenhouse Gas (GHG) emissions in AMS, and Capacity Development for ASEAN Member States on Identification and Differentiation of Spilled Oil and Tarballs, among others.

In May 2021, the Japanese Ministry of Economy Trade and Industry (METI) also agreed to establish a US$ 10 billion investment and loan programme to aid ASEAN’s efforts toward decarbonization (Arai and Nikkei staff writers 2021).

Japan was the fourth-largest trading partner and third-largest source of foreign direct investment for ASEAN in 2020, remaining an important partner for ASEAN’s economic development (ASEAN 2021d).

12.6.5 ASEAN and the Republic of Korea

Having started sectoral dialogue relations in 1989, ASEAN and the Republic of Korea (ROK) further strengthened their relations with the establishment of the ASEAN-ROK Cooperation Fund (AKCF) a year later, a fund that has supported over 400 development projects (AKCF, n.d.). The New Framework for AKCF 2017-2020 aimed to “contribute to the realization of ASEAN Vision 2025” by focusing on education, the environment, and culture. Environmental objectives under this Framework included enhancing ecosystem management (forestry and biodiversity conservation) and cooperation on climate change adaptation (ASEAN-wide renewable energy) (AKCF 2019). In addition to this fund, ROK engages with ASEAN through the Mekong-ROK Cooperation Fund, the ASEAN-ROK Economic Cooperation Fund, other official development assistance, and projects by the ASEAN-Korea Centre (AKCF 2019).

In 2020, ASEAN and ROK strengthened their engagement by agreeing to the establishment of the “ASEAN-ROK Dialogue on Environment and Climate Change”, which is ASEAN’s third bilateral consultative mechanism following Japan and the EU (Ministry of Foreign Affairs of the Republic of Korea 2020). The purpose of the dialogue is to explore issues such as pollution, forestry, circular economy, Partnering for Growth (P4G), and climate change (Ministry of Foreign Affairs of the Republic of Korea 2020). The first ASEAN-ROK Dialogue on Environment and Climate Change was convened in September 2021 attended by senior officials from the AMS, ROK, and the ASEAN Secretariat. Within ASEAN, in 2021, ROK also established the Brunei Darussalam-Indonesia-Malaysia-Philippines East ASEAN Growth Area (BIMP-EAGA)-ROK Cooperation Fund for projects related to the environment, tourism, and connectivity (Ministry of Foreign Affairs of the Republic of Korea 2021). ROK was the fourth-largest trading partner and fifth-largest source of foreign direct investment among ASEAN Dialogue Partners in 2020 (ASEAN 2021c).

12.6.6 ASEAN and Norway

Norway has been a Sectoral Dialogue Partner of ASEAN since 2015, fostering a partnership on issues related to all three ASEAN Communities (ASEAN Secretariat 2022a). On environmental priorities such as ocean sustainability, biodiversity, and climate change, Norway and ASEAN agreed to work together on the implementation of the Bangkok Declaration on Combating Marine Debris and the ASEAN Framework of Action on Marine Debris through capacity building and knowledge exchange, support for green shipping, promotion of preventing, mitigating and managing fires, among others (ASEAN and Norway 2021). Notably, Norway supports ASEAN in implementing the ASEAN-Norwegian Cooperation on Local Capacity Building for Reducing Plastic Pollution in the ASEAN Region (Project ASEANO). Project ASEANO aims to build capacity to tackle plastic pollution in the region through building knowledge on the source to the final fate of plastics, focusing locally on the Imus River in the Philippines and Citarum River in Indonesia (PEMSEA 2022).

12.6.7 ASEAN and the United States

ASEAN and the U.S. began dialogue relations in 1977, building up to bilateral cooperation on development focused on issues such as “trade and investment, technology transfer, and education” (U.S. Mission to ASEAN n.d.). The U.S.-ASEAN Connect (“Connect”), the U.S.’ strategic framework for ASEAN and AMS engagement, was announced at the U.S.-ASEAN Leaders’ Summit in February 2016 (U.S. Mission to ASEAN n.d.). Connect serves to strengthen ties between ASEAN and the U.S. government and businesses. Through Connect, the U.S. is also supporting the five broad strategies of the ASEAN Comprehensive Recovery Framework to recover better from the COVID-19 pandemic. Notably, for “advancing sustainable recovery”, the U.S. is increasing energy access and clean energy development by strengthening partnerships with Lao PDR, the Philippines, and Viet Nam through the Asia Enhancing Development and Growth through Energy (Asia EDGE) initiative (U.S. Mission to ASEAN n.d.). In August 2021, a set of new programmes for the U.S.-ASEAN partnership were unveiled, including the U.S.-ASEAN Connect Green Economy Series, which aims to build the capacity of ASEAN policymakers and other stakeholders on issues such as circular economy, low-carbon technologies, renewable energy, and marine plastic debris (U.S. Mission to ASEAN n.d.). At the subnational level, the U.S.-ASEAN Smart Cities Partnership also engages 26 ASEAN Smart Cities Network participating cities, investing in US$ 10 million across 20 projects related to basic services, such as water, transport, energy, and health (U.S. Department of State 2021).

In October 2021, President Biden further expanded the U.S.-ASEAN Strategic Partnership, announcing a commitment of up to US$ 102 million, on health, climate and the economy (The White House 2021).

The U.S. pledged that up to US$ 20.5 million will be available for the U.S.-ASEAN Climate Futures Initiative, which includes activities including but not limited to launching the U.S.-ASEAN Climate Action Program to enhance the implementation of Nationally Determined Contributions, enhancing climate adaptation through the USAID SERVIR Mekong initiative, investing in USAID's Sustainable Fish Asia project, launching the Smart Transport Asia program, and establishing a Smart Cities Business Innovation Fund (The White House 2021).

12.6.8 Other partners

ASEAN has also developed partnerships with other Dialogue Partners and Sectoral Dialogue Partners, and Development Partners in addressing environmental issues. Other ASEAN Dialogue Partners include Australia, Canada, India, New Zealand, and Russia. ASEAN's Sectoral Dialogue Partners include Pakistan, Switzerland and Turkey, while the ASEAN Development Partners include Chile, France, and Italy.

ASEAN has also been working together with relevant international organizations and other partners on various environmental issues, including the World Bank, UN agencies (e.g. UN Framework Convention for Climate Change (UNFCCC) Regional Collaboration Centres (RCC), UN Environment Programme (UNEP), UN Economic and Social Commission for Asia and the Pacific (UNESCAP), UN Women, UN Capital Development Fund (UNCDF), UN Office for Project Services (UNOPS)), the Asian Development Bank (ADB), the Economic Research Institute for ASEAN and East Asia (ERIA), the Institute for Global Environmental Strategies (IGES), German Agency for International Cooperation (GIZ), Hanns Seidel Foundation, and the Mekong River Commission (MRC).

12.7 Multilateral environmental cooperation with ASEAN external partners

12.7.1 ASEAN Plus Three

Established over 20 years ago, ASEAN Plus 3 (APT) comprises ASEAN and three other nations (Japan, the People's Republic of China, and the Republic of Korea). The APT is currently implementing the ASEAN Plus Three Cooperation Work Plan 2018-2022, which has set forth a range of actions in realms including political and security cooperation, economic and financial cooperation, socio-cultural cooperation, and connectivity cooperation (ASEAN Secretariat et al. 2018). Actions under sections II and III, "Economic and Financial Cooperation" and "Socio-Cultural Cooperation" respectively, address environmental concerns such as sustainable resource use, pollution, nature conservation, climate change, and other topics directly or indirectly relevant to sustainable development (ASEAN Secretariat et al. 2018).

12.7.2 East Asia Summit

The East Asia Summit (sometimes informally referred to as ASEAN Plus Six) comprises ASEAN and six other nations (the People's Republic of China, Japan, the Republic of Korea, Australia, New Zealand and India), and take part in the East Asia Summit process, which was initiated in 2005 (ASEAN Secretariat n.d.). Since 2011, the East Asia Summit also includes the Russian Federation and the United States of America (ASEAN Secretariat n.d.). The members of the Summit cooperate on a range of issues: the environment and energy, education, finance, global health issues and pandemic diseases, natural disaster management, ASEAN connectivity, economic cooperation and trade, food security, and maritime issues (ASEAN Secretariat n.d.).

12.7.3 Other regional environmental cooperation mechanisms joined by AMS

The following are some non-ASEAN mechanisms for cooperation on the environment that each include some AMS. Each mechanism focuses on specific geographic areas and a range of environmental issues. AMS membership is shown in Table 12.3.

Table 12.3 Participation by AMS in other regional environmental cooperation mechanisms

Mechanism	BRN	KHM	IDN	LAO	MYS	MMR	PHL	SNG	THA	VNM
BIMSTEC						X			X	
GMS		X		X		X			X	X
MRC		X		X					X	X
CTI-CFF			X		X		X			
IMT-GT			X		X				X	
LMC		X		X	X				X	X
PEMSEA		X	X	X			X	X		X

Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC)

First established in 1997, BIMSTEC is a regional mechanism comprising Thailand, Myanmar, Bangladesh, Bhutan, Nepal, India, and Sri Lanka (BIMSTEC n.d.). At the most recent Fourth BIMSTEC Summit in 2018, the Parties expressed their "serious concerns over environmental degradation" and the impacts of climate change, agreed to work collaboratively toward a "comprehensive plan for energy cooperation", and "emphasized the importance of blue economy" (BIMSTEC n.d.).

Greater Mekong Subregion Environment Operations Centre

The GMS Environmental Operations Centre of the Asian Development Bank supports the GMS Working Group on the Environment to implement the Core Environment Programme (GMS Environment Operations Center n.d.). The GMS Core Environment Programme aims to build capacity and equip member countries with tools for better environmental management, focusing on four key areas: “assessing environmental challenges and opportunities”, “promoting environmentally sustainable planning”, “piloting innovation”, and “environmental monitoring” (GMS Environment Operations Center n.d.). It supports the improvement of environmental monitoring methods, improvement in biodiversity conservation in transboundary landscapes, development of climate strategies, and financing for sustainable management (GMS Environment Operations Center n.d.). The GMS Working Group on Environment, composed of two government officials from each of the six Member States (five AMS (Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam) and the People’s Republic of China), oversees the GMS Core Environment Programme and facilitates cross-sectoral collaboration (GMS Environment Operations Center n.d.).

Mekong River Commission (MRC)

The MRC was established as a regional mechanism for four AMS in the Lower Mekong River Basin (Cambodia, Lao PDR, Thailand and Viet Nam) in 1995, based on the Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (Mekong River Commission 1995). The MRC has also established a dialogue partnership with upstream countries (the People’s Republic of China and Myanmar) for technical matters such as exchanging information and jointly conducting studies (Mekong River Commission n.d.). The ongoing Basin Development Strategy 2021-2030 employs a whole-of-basin strategy, considering a broader range of opportunities for sustainable development than in previous editions (Mekong River Commission 2021). The accompanying MRC Strategic Plan 2021-2025 to implement the Basin Development Strategy includes measures to increase water security, improve food security, increase resilience of communities, including vulnerable populations, and further enhance regional cooperation (Mekong River Commission 2021).

Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security (CTI-CFF)

Formed in 2009, CTI-CFF is a regional partnership comprising three AMS (Indonesia, Malaysia, the Philippines), the Solomon Islands, Timor Leste and Papua New Guinea (CTI-CFF Secretariat 2021). The CTI-CFF focuses on food security and marine and coastal resource management, emphasizing “people-centred biodiversity conservation” (CTI-CFF Secretariat 2021). The activities of CTI-CFF are guided by its Regional Plan of Action, which promotes ecosystem-based approaches to fisheries, effective management of marine protected areas, climate adaptation, and safeguarding marine biodiversity (CTI-CFF Secretariat 2022b).

Indonesia-Malaysia-Thailand Growth Triangle

The Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT) is a partnership between the three AMS to realize “a seamless, progressive, prosperous and peaceful subregion with improved quality of life” (IMT-GT n.d.). Among its seven working groups, the Environment Working Group fosters cooperation on the environment between the partners, pursuing emission reductions (through initiatives on “sustainable urban development, renewable energy, energy efficiency and green mobility”), and sustainable resource use and biodiversity conservation (through upscaling the Green City Initiative, coordinated efforts on sustainable management of forests, water, wildlife, etc., and enhancing collaboration in managing and restoring adjacent ecosystems) (IMT-GT n.d.).

Lancang-Mekong Cooperation

The Lancang-Mekong Cooperation (LMC) is a regional partnership between the Republic of China, Myanmar, Lao PDR, Thailand, Cambodia, and Viet Nam for the management of the Lancang/Mekong River[18] (Lancang-Mekong Cooperation China Secretariat n.d.). The LMC’s 3+5 Cooperation Framework consists of three

[18] Note that Lancang and Mekong refer to the same river.

cooperation pillars (“political and security issues”, “economic and sustainable development”, and “social, cultural and people-to-people exchanges”) and five key priority areas (connectivity, production capacity, cross-border economic cooperation, water resources, agriculture and poverty reduction) (Lancang-Mekong Cooperation China Secretariat 2017).

Partnerships in Environmental Management for the Seas of East Asia (PEMSEA)

PEMSEA was established over two decades ago with the aim of “foster[ing] and sustain[ing] healthy and resilient coasts and oceans, communities, and economies across the Seas of East Asia” (PEMSEA n.d.). In addition to its 11 member countries (Cambodia, Indonesia, Lao PDR, the Philippines, Singapore, Viet Nam, Timor Leste, Japan, Republic of Korea, the Democratic Republic of Korea, and the People’s Republic of China), PEMSEA’s extended network includes local governments, integrated coastal management learning centres, and regional centres of excellence (PEMSEA n.d.). PEMSEA coordinates the Sustainable Development Strategy for Seas of East Asia (SDS-SEA), a non-binding strategy for marine sustainability first adopted in 2003 by Brunei Darussalam, Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, Viet Nam, the People’s Republic of China, Democratic People’s Republic of Korea, the Republic of Korea, and Japan, followed by Lao PDR and Timor Leste in 2006 (PEMSEA n.d.). SDS-SEA was updated in 2015 to take into account various developments in international processes, such as the Paris Agreement, Sendai Framework for Disaster Risk Reduction, and the SDGs (PEMSEA n.d.). The ongoing SDS-SEA Implementation Plan 2018-2022 contains three priority management programmes: biodiversity conservation, climate change and disaster risk reduction, and pollution reduction and waste management (PEMSEA 2018a).

12.8 Sector-specific regional environmental cooperation mechanisms

AMS also participate in a variety of sector-specific regional non-ASEAN environmental cooperation mechanisms and initiatives, in contrast to the broader mechanisms in the previous section. Some of these are not treaties or agreements but voluntary initiatives which often focus on information sharing and capacity building. Many of these are supervised by intergovernmental committees and funded by one or more member countries and international organizations and are coordinated by small secretariats. Many operate through multistakeholder participation with research institutes, civil society organizations. Some are discussed in earlier chapters, and selected ones are listed in Table 12.4. This is not a complete list, but it highlights a few examples in a range of sectors.

Table 12.4 Selected sector-specific regional environmental cooperation frameworks

Sector	Cooperation framework
Air Pollution	• EANET • ACP • APCAP • Clean Air Asia (CAA)
Biodiversity	• Satoyama Development Initiative (SDI) • Asia-Pacific Biodiversity Observation Network (APBON) • East and Southeast Asia Biodiversity Information Initiative (ESABII)
Climate	• LoCARNet
Climate Adaptation	• Asia-Pacific Adaptation Network (APAN)
Circular Economy	• ASEAN Circular Economy Stakeholder Platform
Compliance and Enforcement	• Asian Environmental Compliance and Enforcement Network (AECEN)
Environment and Health	• Regional Forum on Environment and Health
Global Change Research	• Asia-Pacific Network for Global Change Research (APN)
Marine Debris	• Regional Knowledge Centre for Marine Plastic Debris (RKC-MPD) • Regional Capacity Centre for Clean Seas (RC3S)
Natural Resources	• ASEAN Resources Panel
SCP	• Regional 3R Forum in Asia
Water	• WEPA

Source: authors

12.9 Conclusion

There are extensive intra-ASEAN institutional arrangements for environmental cooperation. This includes several centres, which the Mid-term Review noted helped to improve coordination and implementation. Thus, the ongoing-development of the ASEAN Centre for Climate Change may be very important in this regard. The Mid-term review also recommended greater efforts to promote coordination between sectoral bodies. This is especially important for environmental issues, since many of them require cooperation not only within the ASCC, but also between the ASCC and the AEC and APCC. For example, energy is closely linked to climate change as well as other environmental issues such as air pollution. The ACRF provides a good opportunity to promote a more holistic approach to the environment and improve the coordination of the environment with other sectors. Greater alignment between the ASCC Blueprint and the national plans of the AMS was also recommended by the Mid-term Review.

Going forward, it will be important to strengthen coordination among environmental cooperation frameworks at all levels and sectors and among key stakeholders. This will facilitate greater harmonization and synergies among projects and programmes.

Bettter coordination – as well as strengthening the substance of projects and programmes and ensuring full implementation of the Blueprint - will require enhanced human resource capacity in the ASEAN Sectoral Bodies, especially Centres, the ASEAN Secretariat, and national ministries of AMS, which sometimes have only one or two staff working on all international cooperation issues. Staff training and capacity building will also be necessary (Mid-term Review 2020, p. 16).

AMS participate in an extensive range of international cooperation frameworks and activities, at both the regional and global levels, including many MEAs. This indicates the AMS commitment to cooperate in addressing environmental issues. These cooperation frameworks also play an important role in enhancing the capacity of AMS to address environmental issues.

However, the cumulative reporting burdens for MEAs and other cooperation frameworks with many overlapping requirements can be challenging. A streamlined data collection, storage and analysis system should make these reporting requirements less burdensome.

Another crucial issue is how to enhance the benefits of the bilateral and multilateral cooperation frameworks for ASEAN. A coherent voice at the ASEAN level would help promote a greater focus on the region’s priorities in these cooperation frameworks.

Chapter 13
Outlook and Response Options

Main Messages

- Since its inception, ASEAN has had a vision of an integrated, sustainable, harmonious, peaceful, and productive region, with its “One Vision, One Identity, One Community”.
- The three complementary communities, APSC, AEC, and ASCC, all include aspects of the future environmental conditions and quality of life desired for all ASEAN people, aligned with ASEAN Community Vision 2025.
- Beyond 2025 and looking back from 2050, two possible scenarios were examined (i) business as usual, which continues current trends; and (ii) accelerated transformation towards a sustainable future, which would be in line with the respective ASEAN community “blueprints”.
- Overall, the business-as-usual scenario is unsustainable and likely to reduce overall human well-being including increased environmental and health damage, food insecurity, and deteriorating infrastructure, resulting in high economic costs and lost jobs.
- In contrast, the accelerated transformation scenario will put ASEAN much closer to realizing its vision. Well-being will be significantly higher with much better health, greater food security, inclusive and sustainable development, and overall economic prosperity with the substantial expansion of green jobs.
- The most likely outcome is that the trajectory of most or all AMS will be somewhere between the “business-as-usual” and “accelerated transformation” scenarios. AMS are likely to strengthen their policies and measures, but probably not enough to achieve accelerated transformation.
- Therefore, the measures featured in the “accelerated transformation” scenario are intended to illustrate the scale of the effort needed to achieve transformation. So the scenario is not a prediction of what will actually happen but rather an explanation of how to achieve accelerated transformation.
- Each of the ASOEN Working Groups may wish to conduct a similar scenario planning exercise.

13.1 Introduction

Since its inception, ASEAN has had a vision of an integrated, sustainable, harmonious, peaceful, and productive region, with its “One Vision, One Identity, One Community”. The most recent expression of that vision, the ASEAN Community Vision 2025, was adopted at the 27th ASEAN Summit in Kuala Lumpur, Malaysia, in 2015, which also celebrated the formal establishment of the ASEAN Community 2015 (ASEAN Secretariat 2015b).

Vision 2025 was built on the Treaty of Amity and Cooperation in Southeast Asia, ASEAN Vision 2020, Declaration of ASEAN Concord II, the ASEAN Charter, Roadmap for an ASEAN Community (2009-2015) and the Bali Declaration on ASEAN Community in a Global Community of Nations. Vision 2025 is also complementary to the 2030 UN Agenda for Sustainable Development.

The three complementary communities, APSC, AEC, and ASCC, all include aspects of the future environmental conditions and quality of life desired for all ASEAN people. The ASEAN

Political-Security Community states that “our peoples shall live in a safe, harmonious and secure environment” and that ASEAN should be “a united, inclusive and resilient community”. The vision for the ASEAN Economic Community also refers to “a more resilient, inclusive, and people-oriented, people-centred community, integrated with the global economy”. Notably, reference is made to “supportive policies towards innovation, science-based approach to green technology and development”.

The ASCC vision also refers to an “inclusive, sustainable, resilient and dynamic” community. The vision embraces a “high quality of life”, “environmental protection”, and resilience to “social and economic vulnerabilities, disasters, climate change” and emerging threats. The ASCC Blueprint 2025 notes the continuing challenges of pollution, resource degradation and climate change (ASEAN Secretariat 2016b). While final evaluation of the ASCC Blueprint 2025 will be conducted at the end of the term, there is currently no guidance on the post-2025 framework. Comparison of possible alternative post-2025 pathways, building on the ASCC Blueprint 2025, will help to guide AMS decision-makers on the changes needed to achieve the ASCC vision. A scenario approach is often used in environmental outlooks such as the Global Environment Outlook (GEO) and other similar assessments.

As 2025 is a mere three years from now, this chapter looks at what needs to be done for ASEAN to achieve its vision for 2050 and beyond and what additional responses may be needed to build on the level of progress likely to be reached by 2025. As projections about the future, especially for the longer-term, are notoriously prone to underestimation and overestimation, the chapter presents two “fictional” scenarios (1) continuing “business-as-usual” or (2) “accelerated transformation”. It should be noted that these scenarios were developed by the authors of this report, based on expert judgement, and should not be viewed as representing a consensus of the AMS or ASEAN Secretariat.

Scenarios or storylines, however, are useful devices to examine the future consequences of decisions taken, or not taken, today. Outlook scenarios are commonly used in environmental assessments such as UNEP’s Global Environment Outlook (UNEP 2019c), including the most recent regional one, GEO6 Regional Assessment for Asia and the Pacific (UNEP 2016).

These scenarios are explained by using a narrative of a hypothetical observer looking back to 2025 from 2050. The scenarios also incorporate the SDGs. While 2030 is a little further in the future than the ASEAN Community Vision 2025, the question remains “what else can be done to accelerate implementation of the SDGs in ASEAN” and what lies beyond 2030 towards 2050? An important point to note is that these two scenarios are at possible extreme ends of a spectrum of future pathways and not all AMS will follow the same pathways, regardless of where they fall along this spectrum. It is also important to stress that the scenarios are meant to incorporate social, economic, and environmental dimensions and not environment alone.

Between now and 2050, many changes will take place globally, regionally, and nationally, so the extent of the gap between the two scenarios by 2050 is impossible to predict, although it is almost certain that some gap will remain. The proposed response options that follow are intended to illustrate how AMS could bridge the expected gap between business as usual and accelerated transformation, especially in the post-2030 context. The reader should imagine that he/she is looking back from 2050 and can reflect on how and why ASEAN has changed over the 2030-2050 period.

To further clarify, the most likely outcome is that the trajectory of most or all AMS will be somewhere between the “business-as-usual” and "accelerated transformation" scenarios. AMS are likely to strengthen their policies and measures, but probably not enough to achieve accelerated transformation. Therefore, the measures featured in the "accelerated transformation" scenario are intended to illustrate the scale of the effort needed to achieve transformation. So the scenario is not intended to be a prediction of what will actually happen but rather an explanation of how to achieve accelerated transformation. The scenario also aims to show the benefits of accelerated transformation in comparison to the costs of business as usual.

13.2 Sustainable development outlook scenarios and response options

13.2.1 Business as usual scenario

Chapter 11 examines in detail the synergies and trade-offs regarding the environmental, social, and economic dimensions of development, integrated approaches, and relation of ASEAN environmental programmes to the SDGs. The evidence in 2021 suggested, however, that no AMS was on track for all 17 goals and in some cases may have been going backwards (UNESCAP 2022). This timely warning, however, was not heeded and by 2030 less than five of the SDGs had been achieved in each AMS. Of particular concern is that every AMS had regressed on SDG 12 (SCP), which is in many ways the "heart" of the SDGs. Sustainable consumption and production should have been at the core of the AMS sustainable development plans. After 2030, each AMS made their own sustainable development plans, with considerable variation across the region, as they all had differing starting points. The long-term effects of the COVID-19 pandemic and supply chain disruptions of the Russia-Ukraine war were unevenly addressed in these plans. As for the 2030 Agenda, however, the excellent aspirations were not matched with adequate financing and a regional mid-term assessment in 2040 found that even these national plans were unlikely to be fully achieved by 2050. The implications of this failure to achieve the SDGs are long-lasting as several of the planetary boundaries have been exceeded by 2050, some of which are essentially irreversible in the human time frame (Steffen et al. 2015).This means that advances made in socio-economic sectors such as food, education, poverty reduction, and infrastructure are at risk of regression due to negative impacts from transgressed planetary boundaries such as floods, droughts, wildfires, pandemics, and pervasive supply chain shortages within the region and beyond.

13.2.2 Accelerated transformation scenario

This scenario builds on the results of the ASEAN Comprehensive Recovery Framework (ASEAN 2020a), the Mid-Term Review of the ASEAN Socio-Cultural Community Blueprint 2025 (ASEAN 2021), the ASEAN Development Outlook (ASEAN Secretariat 2021b), and the preceding chapters of this State of Environment Report. It must be stressed, however, that both scenarios are entirely fictional, based on plausible outcomes only, and should not be viewed as representing a consensus of all AMS. The accelerated transformation scenario does, however, offer some insight into a potential pathway to accelerate the positive developments highlighted in the reports cited above.

By 2030, most of the AMS had achieved a significant proportion of the 17 SDGs but had also realized that much more needed to be done to achieve long-term sustainable development. Nevertheless, the ASEAN framework for recovery from the COVID-19 pandemic had already shown what was needed to be done (ASEAN Secretariat 2020a). In 2025, the ASEAN region embarked on preparation of an ambitious post-2030 regional sustainable development agenda. The top 10 renewed goals for the period 2030-2050 included (i) redistribution of wealth to go well beyond eliminating poverty; (ii) promotion of organic agriculture and farmer credits for soil carbon sequestration; (iii) a regional, affordable health insurance scheme; (iv) free education from kindergarten to undergraduate level; (v) mandatory gender and disability equality for all government employment, including at parliamentary level; (vi) piped sanitation systems and wastewater treatment for all communities, regardless of location; (vii) completion of the phase-out of fossil fuel energy by 2035; (viii) guaranteed employment for all, through creation of a green jobs programme; (ix) banning private vehicles (except delivery at night) from the central precincts of all cities; and (x) mandating extended producer responsibility for waste management, including industry -funded collection centres. Funding for implementation of the SDGs quadrupled from the 2025 baseline, as the “green new deal” increased economic growth, employment opportunities, and enabled a significant increase in taxes and fees. Sustainable development “champions” were recognized, awarded, and promoted through the media, providing incentives for young people to follow their lead. ASEAN presidencies became renowned across the world for their bold and decisive leadership in facilitating this transition. By 2050, most of these additional post-2030 goals were achieved in at least one AMS, with some (e.g., extended producer responsibility) adopted by all AMS. A regional assessment in 2050 identified additional actions, necessary investments, and the costs of inaction to spur accelerated transformation across the ASEAN region.

13.2.3 Response options

The following response options could be considered by potential “frontrunner” AMS to bridge the gap between the two scenarios, by improving sustainable solutions/pactices, adopting nature-based solutions, and improving harmonization and coordination, thus successfully achieving an accelerated sustainable transformation, recognizing that not all AMS will be in a position to adopt these changes in the short term:

a) Regionally harmonized “sin taxes” on unhealthy, environmentally damaging lifestyles and consumption patterns;

b) Incentives for farmers to engaged in soil carbon sequestration, organic agriculture, sustainable crop residue management (both bans on open burning and complementary incentives for alternative uses of residues), agroforestry, and land set aside for forest plots;

c) Universal healthcare insurance, with annual rebates for healthy lifestyle and consumption choices, to encourage environmentally sound lifestyles;

d) Universal, free education for all, at all school levels, with sustainable development as a compulsory curriculum item at all levels together with compulsory courses in home economics, repair, and food crop growth (e.g., urban gardening);

e) Completion of all remaining MDGs and targets, including access for all to safe drinking water and improved sanitation, as well as the 17 SDGs;

f) Just transition to full electrification of all sectors, by phasing out fossil fuel subsidies and converting that investment into renewable energy and energy efficiency measures;

g) Large scale expansion of public transportation, creating walkable cities, neighbourhood public parks, and separated bicycle paths from roadways; incentives to work from home whilst maintaining a healthy work-life balance in sectors where it is possible;

h) Employer incentives for creation of thousands of new green jobs, including government-provided retraining packages;

i) Promotion of the circular economy and 3Rs, with expansion of the extended producer responsibility system to all manufacturers, wholesalers, and retailers;

j) Facilitation of sustainability financing, using green and blue bonds, corporate social responsibility, sovereign wealth funds, and philanthropic trust funds, among others;

k) Expansion of protected areas for land and marine ecosystems, including forests; and

l) Negotiation of bilateral trade deals with trading partners based on green and just supply chains so that SMEs in the region can offer equitable and green jobs to the population and so that the transregional environmental footprint is gradually eliminated from production and trade.

13.3 Climate change outlook and response options

Looking back from 2050, is ASEAN on track for a net-zero emissions, low-carbon, resilient climate change outlook as expressed in AMS ambitions and nationally determined contributions in the 2020s and what additional policy and capacity enhancement is needed to accelerate the region's continued transformation to a net-zero future?

13.3.1 Business as usual

Following COP 26 in Glasgow, UK in 2021, which failed to reach consensus on a number of topics, ASEAN leaders returned home to a looming energy crunch as the region's economic growth bounced back much quicker than anticipated from the COVID-19 global pandemic. Deferred consumer demand led to a surge in manufacturing, tourism, hotel construction, new car purchases, and retail sales, all of which required increased energy supply. While there was some evidence that renewable energy would be the cheaper option, most power suppliers were more comfortable with their existing experience with fossil-fuel power plants, and they were able to convince their respective governments that the electricity grid could not stand a massive increase in renewable energy. These policy choices locked in fossil fuels and their associated infrastructure for the next 30 years. In addition, government policy in several AMS to increase the percentage of biofuels in the gasoline mix and airline companies using biofuels to bolster their "green" image, inadvertently led to increased deforestation and hence reduced carbon sequestration. COP 27 in Sharm El-Sheikh, Egypt achieved a breakthrough in creating a financial mechanism for loss and damage (albeit without significant confirmed financing) but did little to advance the ambition of major GHG emitters to drastically reduce fossil fuel use.

Increasing temperatures through the 2030's to the 2040's dried up former rainforests and devastating wildfires destroyed thousands of hectares of forest and many homes every year, while contaminating the atmosphere with particulate pollution and transboundary haze. Crop yields declined and the aging farmer population struggled with mounting debts. Food costs soared and hunger increased. In the peak summer months, outside temperatures were so hot that most people relied on air conditioning to keep cool, which merely added to the surging energy demand. Schools were closed for weeks at a time as the classrooms were too hot and students could not play outside. Outdoor work, including farming and construction, also saw losses in productivity due to extreme heat. Rich landowners relocated their assets to higher ground, while poor, vulnerable communities regularly lost all their meagre assets in storm surges, river flooding, and extreme wind and rainfall events, often surrounded by polluted water and air. Rising sea levels and stronger typhoons combined with degraded coastal ecosystems caused major structural damage to coastal cities. More extreme weather caused costly damage to infrastructure. Infrastructure damage was compounded by insufficient climate adaptation planning. These conditions created many climate refugees, but there were few safe places for them to escape to.

13.3.2 Accelerated transformation

The 2021 ASCCR underpinned and supported ASEAN's accelerated efforts towards achieving a 2050 net-zero transition target (ASEAN Secretariat 2021g). To achieve this ambitious target, however, required massive changes. The power, industry, transport, and buildings sectors set 5-yearly targets for, and rapidly implemented, clean energy and just transitions. The agriculture, forestry and fisheries sectors made significant contributions to increased carbon sequestration through organic, sustainable agriculture, reforestation, degraded land restoration, and blue carbon.

In the ASCCR, AMS governments have discussed a harmonized carbon pricing scheme reflecting the social cost of carbon and contributed to the successful adoption of Article 6 of the Paris Agreement on carbon market rules at COP 26, which was co-facilitated by Singapore and Norway. The rapid expansion of renewable energy throughout ASEAN was facilitated by upgrading the ASEAN regional power grid and a regional agreement on the terms of renewable energy trading among AMS. Adoption of new technologies was promoted with new "innovation funding", including advanced solar, wind, hydropower, and geothermal renewable energy with storage batteries and enhanced grid systems, high energy efficiency appliances, bioenergy (waste and primary resources), decarbonizing technologies for industry, electric or hydrogen-related mobility (for land, aviation, and shipping), materials with lower lifecycle GHG emissions, carbon capture, utilization and storage, and green hydrogen as indicated in the ASCCR (ASEAN Secretariat 2021g). Ultimately, when there was additional scientific evidence in the 2040's that ASEAN needed to do more to remain on track to net-zero, there was massive investment in direct air capture, storage and usage (ASEAN Secretariat 2021g).

By 2050, all AMS had invested heavily in mass transit systems and made public transportation much more affordable than owning a car. As an interim measure, electric vehicles were available for those who could afford the certificate of entitlement to own a private vehicle and were prepared to pay the city congestion and parking fees that were prohibitively expensive.

Starting from the 2030s, all construction materials were required to have the least practicably feasible embedded carbon content, facilitating widespread capture and recycling of materials like steel and concrete. Workers in fossil fuel related industries successfully transitioned to safer and higher paying green jobs in the new industries.

As there was a considerable time lag in the impacts of these measures on the global temperature increases, AMS also invested heavily in climate change adaptation and ensured that all infrastructure development was climate-proofed. The private sector was also enabled to protect their assets from climate-related impacts through generous tax concessions and other incentives.

13.3.3 Response options

To avoid the unwanted consequences of the business-as-usual scenario, the following policy options could be considered:

a) Phasing out of fossil fuel subsidies and other environmentally harmful subsidies, with accompanying measures to offset potential negative effects on low income people where applicable;

b) Creation of a regional stranded-asset fund that would allow operators of obsolete fossil-fuel related industries to seek creditor support as they transition to new, sustainable business opportunities, and for owners of coal, oil and gas deposits to abandon further development of those resources;

c) Job guarantees and/or reskilling for displaced fossil fuel workers, funded by the regional stranded-asset fund;

d) A 20-year regional plan to relocate vulnerable communities away from areas subject to coastal and river flooding and to create "green" jobs for the displaced families, such as turning floodplains into recreational parks;

e) Regional weather-index insurance schemes for agriculture, aquaculture, forestry, and fisheries producers;

f) Massive expansion of renewable energy and upgrading of the ASEAN power grid to accommodate substantially increased intra- and inter-regional trading of electricity;

g) Promotion of green hydrogen for heavy trucking, buses, shipping, and aviation and retrofitting industry to utilize hydrogen for industrial processes;

h) Use of “frontrunner” approaches, such as zero-emission houses, to encourage the private sector to match the best available practice on energy efficiency and GHG emissions reduction;

i) Major expansion of public transportation and the creation of 15-minute (i.e., walkable and bikeable) city;

j) Greater effort to combat urban air pollution and transboundary haze through increased collaboration and sharing of best practices by AMS;

k) Stronger efforts to reduce deforestation such as expanded protected areas, create green jobs for forest protection;

l) Use of climate smart agriculture, especially in rice production to reduce methane emissions and save scarce water supplies;

m) Nature-based solutions for climate change adaptation such as massive campaigns to reforest or revegetate riparian and floodplain areas; and

n) Capacity enhancement in all sectors to adjust lifestyles and business practices to become climate smart and adaptive to emerging climate threats.

13.4 Biodiversity outlook and response options

ASEAN is well known for its substantial biodiversity resources, but these are under severe stress. ASEAN also suffers from extensive deforestation and destruction of coastal and marine habitats. Looking back from 2050, has ASEAN re-asserted its global position as a repository of species conservation, habitat protection, and enhanced supplier of ecosystem services?

13.4.1 Business as usual

The last Sumatran rhinoceros in Malaysia died in November 2019, but few people took notice, and nobody cried. Although Southeast Asia covers a mere 3% of the Earth’s surface, prior to 2020, it contained about 20% of the world’s plant, animal, and marine species. Sadly, in 2050, that is no longer the case. Allan et al. (2019) reported around that time that ASEAN had a high number of species facing imminent extinction, but that warning was largely ignored. From 2020 to 2050, the historic trends in deforestation continued unabated, with the total forest cover in ASEAN shrinking from about 200 million ha to 150 million ha, partly due to increasing global demand for palm oil and toilet paper. Mangrove forests were cleared along all coastlines to construct vast areas of fishponds, as overfishing had forced AMS to increasingly rely on aquaculture production of seafood. The loss of habitat combined with a wildlife trade valued at US$ 107 billion in 2019 saw 140 out of 221 critically endangered species in ASEAN gradually diminish in number until they were functionally extinct by 2050 (ASEAN Centre for Biodiversity 2021). The global mass extinction event was mirrored in the ASEAN region, with innumerable species lost even before they could be identified and named. The 55 ASEAN Heritage Parks that were supposed to protect this precious biodiversity suffered greatly from a lack of financial support and illegal logging and the wildlife smuggling which nibbled away at the margins of the 2,000 protected areas in the region. While extinction of the larger fauna attracted most media attention, the silent loss of thousands of insect species had an even greater impact on the region's prosperity, as important agricultural crops were no longer effectively pollinated. Vector-borne and zoonotic diseases emerged in some parts of ASEAN, putting a massive burden on the region's healthcare system, with periodic repeats of pandemics similar to COVID-19. Expected ecotourism never materialized, and many forest dwellers and small farmers lost their livelihoods as forests disappeared and agricultural land degraded. Marginal agricultural lands became barren, and many subsistence farmers became economic refugees in their own countries.

13.4.2 Accelerated transformation

Energy was not the only sector in which massive transformation took place in the 2021-2050 period. Following the 15th meeting of the Conference of the Parties to the United Nations Convention on Biological Diversity (CBD COP-15) held in Kunming, China (Part 1) and Montreal, Canada (2022) (Part 2), each AMS took immediate action to implement the Kunming-Montreal Global Biodiversity Framework and this became the turning point for increasing the protected area coverage, committing to the 30% coverage of protected areas by 2030, and creating intact biodiversity corridors from previously scattered forest areas. These measures created thousands of new green jobs and expanded recreation areas across ASEAN, substantially contributing to the region's economic growth. Whale watching, forest bathing, and other nature-based recreation were strongly promoted through global tourism campaigns and created additional thousands of green jobs. Celebrations and intense media coverage were held every time one of the endangered species was removed from the list of 221 critically endangered species in ASEAN, with the number falling to less than 100 by 2050. ASEAN presidencies became famous across the world for their decisive leadership in facilitating this transition.

Important ecosystem services like filtration of water supplies, crop pollination, flood protection, urban cooling and many more were allocated real economic value and included in the gross national wealth and gross national well-being indexes adopted by AMS governments to supplement the obsolete and less emphasized GDP measurement. Landholders who were able to provide these ecosystem services were paid by the downstream users, such as farmers being paid for retaining riparian vegetation that filtered stream water before it reached the water bottling plant or apiarists paying farmers who allowed native vegetation to regrow on a portion of their land. Carbon farming, involving soil sequestration of carbon, became a lucrative source of income for thousands of organic farmers. These payments for ecosystem services provided multiple new remuneration avenues for landholders who were intent on protecting national biodiversity.

13.4.3 Response options

For the accelerated transformation scenario to be realised, the following response options may be considered by AMS.

a) Adoption of alternative measures of national progress, such as gross national wealth, gross national happiness, or gross national well-being;

b) Legislation creating a national payment for ecosystem services system, backed by additional regulations, guidance and capacity building for landholders;

c) Expansion of the protection area system so that all threatened species have adequate habitat protection, occupying at least 30% of the national land and coastal areas;

d) Investing in nature-based solutions and natural capital for biodiversity protection, preventing future risks, and creating a more resilient society;

e) Creation of biodiversity corridors for fauna with large range area requirements by connecting isolated fragments of forest cover;

f) Mandating that all infrastructure development must make adequate provision for wildlife, such as vegetated wildlife passes over roads;

g) Increasing the number of green jobs devoted to wildlife protection, including doubling the number of trained (and employed) taxonomists, protected area rangers, and illegal wildlife trafficking enforcement agencies;

h) Promoting nature-based recreation activities, such as whale watching, trekking, forest bathing, and citizen-science activities; and

i) Increasing attention to biodiversity in the school curricula at all levels and creating an environmental scout movement for after-school nature-related activities.

13.5 Regional coastal and marine outlook and response options

With the exception of land-linked Lao PDR, AMS are surrounded by vast oceans, long coastlines and numerous islands. This view from 2050 looks at what lies in store over the next few decades for this important natural heritage.

13.5.1 Business as usual

Professional fisherman, Supat, looks back on the many times he has had to change the fishing gear on his boats, as the large pelagic fish were no longer easy to catch by the 2030’s, demersal fish also were no longer a viable source, and the sardines that replaced them had also dried up. Now his boats are rigged for catching octopi, which had swarmed as their natural predators gradually disappeared. Vast oxygen-depleted dead zones seem to have no living fauna at all, and the coastline is regularly coated with toxic red algae and dead seaweed. Even the most remote fishing zones are littered with plastic waste, dead turtles and other animals are found full of ingested plastic, and captured fish have worrying levels of microplastics. Virtually all except the hardiest coral reefs are now dead and colourless, with the once thriving trade in live, tropical fish just a distant memory. Ocean acidification has devastated marine species with carbonate exoskeletons, including the formerly viable shrimp, prawn, and lobster industries. With increased manufacturing in ASEAN and its increasing role in global trade, the commercial shipping fleet has doubled in 30 years and discharge of bilge water and invasive alien species are now polluting hundreds of port areas, with little or no environmental enforcement. Sea level rise and storm surges regularly flood thousands of kilometres of coastline, causing billions of dollars of damage to properties and other coastal assets that can no longer be insured. Coastal properties, once highly priced, can no longer be sold, as no one wants to take the risk of the damage portrayed on television every night. Oil and gas extraction continued until the 2040's, but now there is huge controversy over who should pay to clean up the oil spill damage and the cost of removing the thousands of old, rusting drilling rigs and leaking pipelines.

13.5.2 Accelerated transformation

Recognizing the potential damage from land-based pollution, climate change, coral reef destruction, and coastal and marine pollution, ASEAN used the ASEAN Framework of Action on Marine Debris (2021-2025) as a pilot programme to show what could be achieved through regional cooperation in managing the coastal and marine areas (ASEAN Secretariat 2019a). The ASEAN Regional Action Plan for Combating Marine Debris (2021-2025) was subsequently adopted. Important guidance also was provided by the ASEAN Leaders' Declaration on the Blue Economy (ASEAN 2021f) and the Circular Economy framework for the ASEAN Economic Community (ASEAN Secretariat 2021j). In 2030, AMS agreed on a more ambitious regional action plan (2030-2050) to address all the important issues affecting coastal and marine ecosystems. The action plan included setting aside 30% of the exclusive economic zones as protected areas, with fishing controlled under strict quota based on scientific evidence of fish stocks and sustainable fishing limits. The licence fees for access to these quotas are sufficient to cover the cost of managing the protected areas and to employ hundreds of marine protected area rangers. Illegal fishing in ASEAN waters is strictly controlled by a new regional Maritime Police Agency, armed with the latest satellite imagery technology, and significantly expanded national coastguard services. Clearing mangrove forests has been prohibited in all AMS since 2025 and many of the abandoned fishponds that had replaced the mangroves had became too saline, so they were demolished and mangroves replanted. Coral reefs still suffer occasional bleaching, especially in El Niño years, but careful research and long-term implementation of the Coral Triangle Initiative have minimized the damage and there is still a viable reef fish trade, albeit diminished since the 2020's.

A voluntary coastal relocation programme, starting in 2030, allowed thousands of landowners concerned about the increasing incidence of seawater inundation and coastal erosion to offer their properties at significantly reduced prices to the local governments which had opened new, fully serviced housing estates on higher ground to accommodate the expected thousands of households which need to relocate. The land returned to public uses through this programme has increasingly been used for nature-based solutions, such as managed wetlands and constructed sand dunes, and other forms of ecosystem-based adaptation. Integrated coastal zone management plans are required for all local government areas with more than 100,000 population, as well as tertiary wastewater treatment systems. Oil and gas extraction was finally phased out by the 2030’s and the oil and gas companies were held legally responsible for removing the associated infrastructure. Some of the old offshore drilling platforms have been converted to wind farms, while others await future dismantling and recycling of the associated materials. The global shipping industry was slow to adjust to the climate change mitigation requirements but over a 20-year period most commercial shipping in ASEAN waters has been converted to electric or hydrogen power. All ports have bilgewater collection and treatment facilities and there are substantially fines and jail sentences for any deliberate discharges in ASEAN seas.

13.5.3 Response options

To avoid the undesirable future pathway of the business-as-usual scenario, the following responses may be considered by AMS.

a) Complete implementation of SDG 14 “conserve and sustainably use the oceans, seas and marine resources for sustainable development” targets in AMS by 2030 by implementing a range of priority actions (many of which are already documented in previous strategies and plans);

b) Regulate destructive fishing practices and end overfishing, illegal, unreported, and unregulated fishing in ASEAN waters by issuing legally binding fishing licences and allocated quotas, combined with increased monitoring and supervision of fishing fleets;

c) Effectively control all seabed activities in ASEAN exclusive economic zones, such as sand dredging, seabed mining, cable and pipeline laying, shipping and begin phasing down offshore oil and gas extraction by 2030;

d) Expand the capacity of the ASEAN Centre for Biodiversity to create a spatial database of all marine flora and fauna in ASEAN waters and design and implement an effective regional species monitoring, evaluation and reporting system;

e) Based on scientific assessment of key biodiversity hotspots, expand the cumulative ASEAN coastal and marine protected area to 30% (along the lines of the Kunming-Montreal Global Biodiversity Framework’s Target 3) of each national exclusive economic zone, increase management funding, and double the employment of protected area rangers;

f) Require all coastal local government areas with more than 100,000 population to install and operate tertiary wastewater treatment systems by 2030 (since larger cities have larger pollutant loads discharged to the ocean, so they need tertiary wastewater treatment that would remove the nitrogen, phosphate nutrients and the organic load);

g) Identify all coastal properties at risk of sea level rise, storm surges and/or coastal erosion and commence a medium-term programme of relocation away from the coast by no later than 2030 (Kirezci et al. 2023);

h) Prepare and adopt an ASEAN regional coastal and marine environmental action plan for the period 2025-2050, encompassing integrated coastal zone management plans, coastal and marine protected area management plans, and land-based pollution control plans; and

i) Strengthen policy coherence, advanced practices, and participatory approaches for sustainable coastal, marine and ocean environment management.

13.6 Pollution control and waste management outlook and responses

The draft ASPEN (2016-2025) states that the region is facing "massive environmental degradation" (ASEAN Secretariat 2016c). From the 2050 perspective, between 2016 and 2050, did the ASEAN region turn this situation around, or did the current trends continue? Are the ASEAN megacities clean or polluted?

13.6.1 Business as usual

Ali is 36 years old and suffers from chronic asthma. Every year in the "burning season", he spends at least one month in hospital, barely able to breathe and in continual need of oxygen. He is one of several million ASEAN residents expecting a shortened life due to worsening air quality in 2050. Anna Maria suffered the tragic death of her 2-year-old child who drank contaminated water while playing in the open drain in front of her house. Riccardo has suffered multiple health issues and diminished brain function all his short life from consuming mercury contaminated water supplies from an area subject to illegal gold mining. By 2050, the mounting death toll from ASEAN's poor environmental quality is constantly raised by the region's politicians, once again promising major change but delivering little improvement on the ground. New laws, regulations, and standards have been imposed over the past decades, but compliance and enforcement are ad hoc and often subject to corruption. Due to minimal investment in management of plastic waste, formerly pristine recreational beaches are now covered in plastic litter, significantly reducing the number of international tourists. Air, water, noise, litter, and chemicals pollution are taking their toll on the region's wildlife too, with whales often found on the region's beaches with a belly full of plastic waste. Toxic discharges into the region's rivers often cause major fish kills, including in areas being used for aquaculture. The Irrawaddy dolphin that was barely clinging to survival in the Mekong River in the 2020's was finally announced extinct in 2040. ASEAN's deteriorating environmental quality does not impact humans and wildlife alone, but also causes massive damage to infrastructure and buildings, causing losses extending into the billions of dollars every year. AMS megacities have been in the top 10 most polluted cities in the world for the past decade and there is little sign of future improvement.

13.6.2 Accelerated transformation

While it took AMS some time to effectively respond to the ASPEN priorities, by 2025 some significant improvement, especially in relation to water pollution, was noted. The remaining population without access to safe water and improved sanitation diminished to less than a few percent by 2025 and continued improvement since then has made this historic inequality disappear. The ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021-2025) was fully implemented by 2030 and sustainable alternative packaging is now mandatory in all AMS retail outlets (Hermawan and Astuti 2021; ASEAN Secretariat 2019a). Between 2020 and 2040 a concerted campaign of remediation for contaminated sites using a regional fund contributed to by chemical companies has resulted in almost no chemically contaminated sites in AMS by 2050. Uncontrolled open air burning was banned in all AMS in the 2030s, with very limited exceptions for unavoidable circumstances, and the fines have been progressively increased along with jail sentences for deliberate burning of forest areas. Gradually, wastewater treatment plants have been upgraded to the latest technological tertiary treatment processes and nutrients from liquid wastes have been extracted and recycled. Treatment plant sludge is being turned into compost and used to fertilize urban parks and gardens. Solid waste has been effectively controlled using a combination of waste separation at source, the 3Rs, circular economy, and extended producer responsibility. E-waste deposit and recycling centres have been established in all AMS cities and technology college students have been trained in reuse and repurposing of the deposited electronic equipment. The remaining issue of recycling building waste from demolitions was resolved by 2040. The rapid uptake of electric vehicles, ban on sales of new petrol driven private cars by 2035, and increasing “green” hydrogen use in heavy vehicles, buses, aviation, shipping, and industry have cleaned up the ambient air quality in all AMS cities. With the rapid expansion in electric vehicles and home battery systems, mandatory recycling, and reuse of the embedded chemicals in batteries was achieved by 2040 (Harper et al. 2019). Many green jobs were created monitoring and cleaning up pollution.

13.6.3 Response options

The cleaner air, water, and living environments will only be possible with ambitious policy responses and effective compliance and enforcement. AMS governments may consider the following response options.

a) Progressive phasing out of fossil fuel-driven private vehicles, promotion of electric vehicles, and accelerated investment in mass transit systems;

b) ASEAN regional standards for the density and security of publicly available electric charging stations and company incentives to transition petrol stations to electricity charging and battery replacement facilities;

c) Strengthening capacities for inspection and maintenance for in-use vehicles and government oversight of centres performing inspection and maintenance;

d) High priority campaign for implementation of waste separation at source, the 3Rs, circular economy, and extended producer responsibility in all AMS cities;

e) Banning open burning and increased fines and jail sentences for deliberate acts of arson, especially in forest areas;

f) Upgrading wastewater treatment plants to tertiary treatment standards and recovery of nutrients from wastewater;

g) Mandatory recycling of all batteries and recovery and reuse of the embedded chemicals;

h) Implementation of the “right to repair” policy for manufactured goods and support for community-run repair centres;

i) Payment for fishermen to collect plastic waste from the sea and avoid loss of fishing gear that endangers marine mammals;

j) Promotion of the circular economy and recycling, including a new recycling industry for used solar panels and associated equipment, matched with training of a new workforce for this industry from manufacturing to recycling;

k) Promotion of cleaner production methods and design for environment;

l) Establish scientifically sound monitoring systems for air, water, noise, and other environmental pollution across the ASEAN region; and

m) Strengthening of pollution standards and creating green jobs by strengthening compliance and enforcement.

13.7 Sustainable cities outlook and response options

As most future citizens of ASEAN will reside and work in cities by 2050, AMS governments face a formidable challenge in ensuring that the region's cities are functional, liveable, sustainable, and the environmental quality continues to improve. Some cities have already become increasingly unmanageable so AMS governments are actively considering relocating the capital city functions to new, better planned locations (Erkens et al. 2015). What does the future hold for ASEAN's cities and what is the pathway that should be followed towards a long-term, sustainable trajectory (Vu and Truong 2021; Urban Redevelopment Authority 2012; S. B. Lim et al. 2021)?

13.7.1 Business as usual

By 2050, more than 5 million ASEAN citizens have been relocated to "new" cities including Naypyitaw in Myanmar, New Clark City in the Philippines, Cyberjaya in Malaysia, Binh Duong New City in Viet Nam, and Nusantara in Indonesia, to escape the congestion, pollution, and deteriorating infrastructure of the cities they left. Mostly these were families of public servants, politicians, embassy officials, and other well-connected business families with a heavy reliance on government services. Meanwhile, the urban population in ASEAN has grown from 320 million in 2020 to 525 million in 2050. Arguably, the billions of dollars invested in development of the new cities has starved the existing megacities of urgently needed infrastructure investment, which is rapidly crumbling due to decades of neglect. The populations left behind in these deteriorating, partially abandoned cities are poor and suffer from chronic air and water pollution which put them in unsafe and unhealthy conditions.

In the region's coastal cities, extreme rainfall events combined with storm surges due to climate change and high tides result in low-lying, densely populated areas suffering not only flooding but also contamination with untreated sewage (World Bank 2010). As these areas are mainly home to the poorest parts of the community, the inability to access jobs, increased health costs, and frequent damage to property and other assets, have set back the ASEAN region's previously good performance in poverty reduction to 1970 levels. Children from low-income households are missing vital education opportunities because they cannot wade through the polluted flood water to reach school, while children from high-income households are able to take part in distance learning on such days. Industrial estates are also flooded regularly, disrupting global supply chains, and limiting national economic growth.

Flooding is not the only problem in ASEAN's cities, however, as vast informal settlements have continued to grow, often in the most vulnerable locations. These informal settlements, cobbled together with waste building materials, no electricity, no water supply, and no sanitation are hotbeds of health problems, social problems, community conflict, and environmental degradation. It is difficult for many people to travel to work due to inadequate public transportation. People who can afford cars spend hours each day in traffic jams causing health-destroying air pollution in urban areas. Wealthy suburbs are surrounded by walls, with armed guards controlling entry through the imposing gates. Green space and public parks per capita have shrunk and due to poor law enforcement are often too dangerous to visit, especially at night. These cities also suffer from high levels of air pollution to the extent that outside activities at school are too dangerous.

13.7.2 Accelerated transformation

The steady whir of massive solar-powered pumps behind the constructed sand dune systems ensures that coastal cities are no longer affected by sea level rise and storm surges. The vulnerable communities that once lived in shanty towns in the fluvial floodplains are now enjoying high rise living in public housing, overlooking the public parkland and playing fields on land that they vacated, and which occasionally absorbs the overbank flows from naturally controlled rivers. Cities have generally become more compact, with domestic skyscrapers connected to workplaces via cool, green corridors, skywalks, and bicycle paths. Sponge cities absorb the annual rainfall into groundwater or underground storage, from where it is recirculated to water the garden city vegetation and public parks. Safe drinking water, modern sanitation systems, solid waste collection and recycling, community gardens, and improved air circulation combine to improve the health of all urban citizens and extend life expectancy to beyond 80 years on average across ASEAN.

The only vehicles allowed into the central city are electric delivery and public utility vehicles. Congestion charges, which lasted until the 2040's, have been abandoned as mass transit systems provide transport services within 10 minutes walking distance of most housing. Massive investment in subways, trams, monorail, and autonomous electric buses have ensured that there is no need to own a private vehicle, but "share vehicles" are available for some inter-city and recreational trips. Increased investment in information and communication equipment has made working from home a preferred modality for former office work, banking, and other services that no longer need a physical presence. Avatars and holograms, plus 6G communication systems, ensure that individuals and families are not isolated from their communities. Most retail is also conducted online, delivered in simple packaging by electric tricycles, and personal details like accurate body measurements for clothing sales saved online. Housing is mostly high rise with nearly all essential services included in the same housing complex, reducing the need for private vehicles.

13.7.3 Response options

To set ASEAN cities on a more sustainable trajectory, recognizing that urban reform is not a quick and easy process, AMS governments could consider the following response options.

a) Creation of a fund that would assist families living in vulnerable locations such as flood plains or on steep hills to relocate to safer areas and into public housing, fully serviced by the local government;

b) Congestion charges or other disincentives to prevent private vehicles from entering central city precincts, until mass transit is the most convenient form of transport;

c) Development of urban water management plans including sponge city approaches, underground water storage, and recirculation of stormwater;

d) Increased investment in urban green spaces, public parks, rooftop vegetation, and roadside tree planting to combat the urban heat island effect, sequester GHGs, and encourage wildlife such as birds;

e) Increased investment in making cities walkable, with green corridors, skywalks, widened footpaths, and bikeable, with bicycle paths separated from vehicular traffic;

f) Increased investment in mass transit systems such as subways, monorail, and autonomous bus rapid transit systems;

g) Revised urban plans to move from urban sprawl to compact cities;

h) Strengthen system planning and adaptive management of mega-cities, medium and small size cities;

i) Strengthen environmentally sustainable city (ESC) award programmes and support ESC award cities for further improvement of their clean land, air, water and green space;

j) Adopt nature-based solutions such as sponge cities, rainwater retention, and expanded green spaces, to address urban climate stresses; and

k) Review of the environmental, social, and economic costs and benefits of city relocation plans to date, to determine if such approaches are better than fixing the existing urban problems.

13.8 Way forward

ASEAN's vision of an integrated, sustainable, harmonious, peaceful, and productive region, with its "One Vision, One Identity, One Community" is not likely to be achieved under the business-as-usual scenario. Overall, the business-as-usual scenario is likely to reduce overall human well-being. Pollution, degraded ecosystems, declining biodiversity, and climate change will result in more extreme weather, increased health damage, food insecurity, and deteriorating infrastructure, resulting in high economic costs and lost jobs. In contrast, the accelerated transformation scenario will put ASEAN much closer to realizing its vision, building on the ASEAN Sustainable Urbanisation Strategy (ASEAN Secretariat 2018b) and the ASEAN Work Programme on Biodiversity. Well-being will be significantly higher with much better health, greater food security, and overall economic prosperity with the substantial expansion of green jobs. The goal of "leaving no one behind" will be within reach.

Each of the ASOEN Working Groups may wish to conduct a similar scenario planning exercise or perhaps take the scenario further using modelling to chart possible pathways towards a desirable future. While the business-as-usual scenarios may appear like a dystopian nightmare, there are lessons to be learned from each of them and they should serve as a cautionary tale of the consequences of inaction or benign neglect. The accelerated transformations may appear to be too idealistic, but again there may be useful insights about what could be possible in the future. Thirty years is not a long planning horizon, but much could be achieved in that timeframe. The ultimate outcomes will vary among the AMS, depending on their starting point and policy advances, but most AMS will probably fall somewhere between the two ends of the spectrum of possibilities. The suggested responses, if adopted fully or partly, would go a considerable way towards bridging the gap between the two scenarios.

Chapter 14 Conclusions and Recommendations

This report comprehensively reviewed the state and trends of the environment, the pressures on it and the drivers of those pressures, and the national and regional initiatives in place to address environmental concerns, using the DPSIR framework, and provided an overall outlook for the ASEAN environment. New elements, especially the SDGs, Paris Agreement, and the environmental implications of the COVID-19 pandemic were also discussed. This assessment also endeavoured to be more relevant to wider audiences by addressing the relation between environmental problems to human health, similar to GEO-6, as well as to the economy and jobs.

ASEAN's environmental cooperation was another main theme of this report. Recent global and regional environmental assessments (GEO5, GEO6-Global, GEO6-Asia-Pacific, IPCC, IPBES, etc.) have blurred the distinction between transboundary and domestic environmental issues. Transboundary aspects, basically flows across national boundaries of air and water pollution, greenhouse gases, and waste, begin as national issues and ultimately require domestic solutions, as well as international cooperation. Waste in the ocean, including marine plastic, originated from land-based activities. Therefore, solutions are needed at the national/domestic level, as indicated in this report, as well as international cooperation. Moreover, this report also shows that international cooperation increasingly focuses on building domestic capacity, including information sharing, to enable solutions to manage environmental problems at their domestic sources.

14.1 Climate change and air pollution

14.1.1 Key issues

The recently completed ASCCR observed that "the ASEAN region is already experiencing significant climate change impacts with the growing intensity and magnitude of extreme weather events and increasing economic, environmental and social damage" (ASEAN Secretariat 2021g).

While climate change may be more like a slow onset disaster, air pollution is an existing killer and has disproportionate impact on poor, less protected communities such as roadside vendors or "tuk tuk" and "jeepney" drivers. Air pollution is expected to kill more than 650,000 people annually in ASEAN by 2040 (IEA 2019).

14.1.2 Key recommendations

AMS have a variety of policies and responses to climate mitigation, adaptation, disaster risk reduction, and air pollution, including international and regional cooperation. These should be further strengthened, including with additional financing. There is an ASEAN-wide target of 23% renewable energy by 2025, and energy efficiency will also be improved. Greater attention also needs to be paid to urban development, industry, infrastructure construction, transport, agriculture, forestry, and fisheries. In all sectors, AMS need to avoid locking in technology choices that will increase

GHG emissions for several decades. Proactive planning is essential for long-term transitions such as public transport infrastructure, the uptake of electric vehicles, and transboundary energy trading, as governments have an important role in creating the necessary enabling conditions and private sector incentives. The current NDC targets will see GHG emissions continuing to increase in the ASEAN region, with an uncertain peak, while the net-zero emissions goal by or around mid-century will require increased ambition. While the NDCs contain some form of adaptation planning, AMS should accelerate the preparation of national adaptation plans and adaptation communications, emphasizing nature-based solutions.

Additional solutions for air pollution need to be found in all major polluting sectors, including fossil fuel energy, road transport, industry, construction, waste management, agricultural deforestation, open burning of crop residue and land use fires. These solutions include increased investment in mass transit systems, replacement of outdated industrial technologies, stiff penalties for open burning, diversion of wastes away from landfills into recycling, and improved on-site controls of urban construction. Ambient air quality standards need to be brought into alignment with WHO guidelines, as Myanmar did in 2020, but standards are only as good as compliance and enforcement. A good starting point would be more effective enforcement of the ASEAN Agreement on Transboundary Haze Pollution, as open burning continues unabated in many AMS. Other priority actions include (i) a systematic assessment of pollutant levels and sources; (ii) provision of reliable low-cost air monitoring sensors and training in their use (co-located in key locations with conventional air quality monitoring equipment); (iii) an air pollution inventory for key cities; (iv) based on robust air quality modelling, cost-effective policies and investments identified; and (v) achievable air quality targets in air quality management plans at all levels (World Bank Group 2019).

A variety of SDG targets are related to climate and air pollution and implementing them would substantially contribute to reducing GHG emissions and air pollution. These include especially SDGs 7 (on energy efficiency and renewable energy), and 13 (on climate), as well as the targets under SDG 11 on cities on sustainable transport (11.2) and buildings (11.c). Implementation of SDG target 2.4 on sustainable agriculture, target 8.4 on resource efficiency and decoupling economic growth from environmental degradation, targets under SDG 9 on sustainable infrastructure, industrialization, and sustainable upgrading of industry, and SDG 12 on sustainable consumption and production, would contribute more generally.

A co-benefit approach to climate change and air pollution is cost effective way to save money and lives while also addressing both problems. Climate change and air pollution share many drivers and solutions in common, so adopting them would deliver multiple benefits or co-benefits.

14.2 Biodiversity conservation

14.2.1 Key issues

The ASEAN region is one of the most biodiverse in the world on land, in freshwater and in the ocean. This global heritage, however, is under threat from habitat loss, over-exploitation, and climate change. In ASEAN, major drivers that underlie pressures on biodiversity include economic incentives leading to intensifying activity, demographic dynamics that lead to land use change, the misuse of certain innovations, and institutional challenges that threaten low-impact practices led by indigenous peoples and local communities. A recent assessment found that no significant progress has been made toward reducing pressures on vulnerable ecosystems in Southeast Asia and species richness is declining (IPBES 2018). IPBES experts estimated that some, but insufficient progress had been achieved towards global targets to prevent extinction (IPBES 2018). The region is on track, however, in adopting NBSAPs and all AMS are Party to the CBD (IPBES 2018).

14.2.2 Key recommendations

To ensure that the rich biodiversity in the region remains bountiful, resource use efficiency must continue to increase, and nature must be valued in a way similar to mineral resources, agricultural produce, or fisheries. The region should continue to make progress on conservation through designating protected areas, implementing other area-based conservation measures, and employing economic and financial incentives such as ecotourism and payment for ecosystem services, possibly in the context of responding to the Kunming-Montreal Global Framework on Biodiversity. Nature-based solutions and investing in natural capital also contribute to human well-being while conserving biodiversity resources. Implementation of SDGs 6, 14, and 15 on water, oceans, and land ecosystems, respectively, would significantly improve the conditions of these ecosystems.

14.3 Water resources

14.3.1 Key issues

Water security in the ASEAN region is now under pressure due to various factors such as human activities affecting water quality and quantity, climate change impacts, and water-related disasters, which will gradually contribute to increased vulnerability and risks in the region, especially for human health and well-being. Remarkable progress has been made to improve access to clean drinking water over the last 20 years. However, water degradation caused by poor sanitation and hygiene services, low water-use efficiency for agriculture, and lack of developing wastewater treatment systems are still common challenges observed in AMS. Pollution from industrial and agricultural activities is also a major threat to water quality. Climate change, which may exacerbate water-related disasters such as droughts and floods as well as degrade water quality, is worsening this situation. Other major challenges affecting regional water security are a lack of regular water quality monitoring, ineffective data management and reporting systems, a lack of practical technical guidelines at the city/provincial/local levels, ineffective inter-sectoral coordination mechanisms and institutional collaboration between water-related sectors and other stakeholders, as well as among national, subnational and basin levels (e.g., unsustainable development of hydropower plants in upstream regions).

14.3.2 Key recommendations

Improved water governance, including transboundary water management and enforcement capacity of institutions at both national and local levels, as well as enhanced cross-sector coordination and collaborative partnerships on vertical and horizontal dimensions, are critical for effective implementation of sustainable water resources management in the region. Water quality monitoring and reporting need to be strengthened. Access to clean water and sanitation for all is the key objective of SDG 6. Implementing the SDG 6 target on integrated water management would significantly improve water security and access for all by improving water quality and efficiency of its use.

14.4 Coastal and marine

14.4.1 Key issues

Except for land-linked Lao PDR, the remaining AMS are bordered by seas, which are under increasing direct and indirect pressure from human interference. Coastal and marine waters in the region are increasingly affected by shipping, offshore oil and gas, pipelines and cables, sand mining, wastewater disposal, tourism resort development, and potentially seabed mining, with accumulating impacts on marine biodiversity and water quality. Climate change will also have major impacts on ASEAN's extensive shorelines and coastal waters, as the projected sea level rise of about 1 meter by 2100 would affect 410 million people, with 59% in tropical Asia. Sea level rise will be exacerbated by land subsidence, which can exceed 25 mm/year in coastal cities like Jakarta. All of this will cause extensive and costly damage to a wide range of infrastructure. The estimated economic value of coastal and marine ecosystem services at risk from poor management in ASEAN ranges from US$ 62,400/km^2/yr for coastal protection and fisheries to US$ 23,100-US$ 270,000/km^2/yr for fisheries, coastal protection, tourism, and recreation (ASEAN Centre for Biodiversity 2017b).

14.4.2 Key recommendations

High priority should be given to integrated coastal zone planning and management, incorporating climate change adaptation. Offshore, marine protected areas only cover about 7% of coastal and marine waters, often without encompassing the most threatened species or ecosystems, so much greater attention needs to be paid to establishing and effectively managing much larger marine protected areas. The recently updated Strategic Plan of Action for ASEAN Cooperation on Fisheries (2021-2025) highlights the need to complete the outstanding activities from the previous plan (2015-2020). The Coral Triangle Initiative, which involves Indonesia, Malaysia, and the Philippines should continue to prioritize activities that address biodiversity loss and poverty reduction. Other ASEAN initiatives that should be further strengthened include the ASEAN Leaders' Declaration on Blue Economy, ACRF, and the ASEAN Mangrove Restoration Initiative. Implementation of SDGs 14 and 15 on land and ocean ecosystems, as well as SDG 12 on sustainable consumption and production, would especially contribute to the improvement of coastal and marine ecosystems.

14.5 Chemicals and waste

14.5.1 Key issues

As ASEAN increasingly transitions away from its agrarian traditions and becomes a core part of the global supply chain, improved environmental management of chemicals and waste is imperative, steering industry away from its current linear production-consumption-waste approach and "end-of-pipe" solutions for waste management. The manufacture of chemicals and chemical products across the 10 AMS involves more than 15,000 factories, many with outdated production processes and/or located too close to residential areas. As agriculture increasingly industrializes and depends on pesticides and herbicides, this is an additional source of chemical contamination of water and food, with highly harmful health consequences. Plastic waste generation keeps increasing with industrialization and the increasing adoption of high material consumption lifestyles. There are growing concerns in AMS on marine plastic litter and microplastic related pollution and their impacts.

14.5.2 Key recommendations

Chemicals and waste management need to be considered in a holistic and integrated manner because they are cross-cutting issues relevant to circular economy, extended producer responsibility (EPR), SCP, cities, climate change, biodiversity, water, and environmental education. Most AMS have ratified a range of multilateral agreements dealing with chemicals and waste, but more effort is needed to synergise and implement them. Regional cooperation should be expanded, and regional action plans should be developed on chemicals and waste, including plastic, using a lifecycle approach. Much greater efforts are needed to implement existing policies and regulations, including compliance and enforcement as well as source and ambient monitoring and promoting public awareness; these activities could be good sources of green jobs. Ultimately, the private sector must take the initiative and protect the public and the environment from unwanted chemical contamination. The international principles of green chemistry and green engineering can provide a useful guide for companies in the ASEAN region. Outdated, unsustainable smokestack industries and end-of-pipe pollution controls need to be replaced with cleaner, more efficient production technology. Implementation of SDG 12 on sustainable consumption and production would especially improve the management of chemicals and waste.

14.6 Sustainable cities

14.6.1 Key issues

ASEAN is becoming more urbanized, so cities play a key role in shaping the region's sustainable future and implanting integrated approaches to enhance human well-being while ensuring environmental sustainability. Cities are a laboratory of local and global challenges and solutions, and ASEAN cities are frequently frontrunners in developing sustainable (model) cities, with multiple good practices shared through the ASEAN sustainable cities programme. Cities in ASEAN are very diverse, including megacities of over 10 million people as well as small and medium-sized cities, but they face a range of common challenges. Moreover, the traditional distinction between rural and urban areas is being blurred, and cities' relationships with neighbouring peri-urban areas is becoming increasingly important for sustainability.

14.6.2 Key recommendations

Accelerated actions on climate change adaptation and mitigation, localizing and delivering the SDGs, reducing poverty and inequalities, and advancing a circular economy, will help the ASEAN region meet its sustainable development objectives. The opportunities to build back better and "greener" once the COVID-19 pandemic subsides should be enthusiastically adopted by ASEAN city administrations. Long term planning, complementary to cities' short-term plans, including in response to climate change, is critically needed to achieve more sustainable cities. The ASEAN Smart Cities Network has illustrated its worth during the COVID-19 pandemic when many people had to work from home and home delivery services soared, but the retrofitting of houses and commercial buildings with smart meters and other sensors is an ongoing business opportunity for the region's digital entrepreneurs. SDG 11 on cities includes several environment-related targets; implementing them would significantly contribute to reducing the environmental impact of cities. Cities would also greatly benefit from implementing the water management and sanitation targets under SDG 6.

14.7 Environmental education

14.7.1 Key issues

EE and Education for Sustainable Development (ESD) are key tools to promote sustainable development, as they are needed to develop individuals' and communities' capacities to build sustainable environments, economies, and societies through reconfiguring the relationship between people, the environment, the economy, and society. EE must be well rounded and multi-faceted as solutions to environmental problems are interconnected with other challenges such as poverty reduction, economic growth, social participation, gender equality, human rights, and cultural diversity. EE/ESD is especially important for youth, which can promote their engagement with environmental issues and also help to raise public awareness. AMS face various challenges when implementing EE/ESD programmes such as overloaded educational programmes, resource constraints, and insufficient implementation guidelines. EE/ESD in the ASEAN region is not universal nor harmonized.

The AWGEE has been mandated "to promote coordination and collaboration among various relevant ASEAN sectoral bodies and dialogue partners to ensure a well-coordinated and integrated approach to promoting environmental education". The AWGEE Action Plan has guided several region-wide programmes such as the ASEAN Eco-schools Programme and the ASEAN Green Higher Education Programme, among others. There is, therefore, a substantial body of good plans and initiatives to implement in future. The AWGEE Action Plan's thematic programmes are (i) ASEAN Eco-Schools Programme; (ii) ASEAN Green Higher Education Programme; (iii) Regional Communication, Education and Public Awareness; and (iv) SCP.

14.7.2 Key recommendations

A better framework or scheme for accelerating the understanding and sharing of the status of EE/ESD in the region is needed, including content of EE/ESD for each area and level; educational methods used; assistance from governments, businesses, NGOs, and international organizations; and challenges in planning and implementation. EE/ESD are enablers of the SDGs and should be mainstreamed in the planning, programming, budgeting and implementation across all SDG programmes and projects. Implementation of SDG target 4.7 on education for sustainable development would help to address all the environmental issues in the region.

14.8 Circular economy

14.8.1 Key issues

There is no question that ASEAN requires more materials to meet its consumption demand as its population, income, and trade increases, and as its rapidly growing industries come to play key roles in global supply chains, but the challenge is to manage this in an environmentally sustainable way using circular economy approaches. As disposable income increases in the ASEAN region, consumption will shift to material-intensive sectors such as housing, transport, energy, and other goods in addition to food and beverages. In addition, waste imported from other countries is becoming an increasing environmental concern in the ASEAN region. The current linear model of production-consumption-waste will lead to several negative environmental impacts including more pollution and waste, which will impact human health and GHG emissions.

14.8.2 Key recommendations

Circular economy approaches, such as 3R and EPR, emphasize reduction, reuse, and recycling of resources, and address these issues by promoting resource efficiency. AMS have adopted various policies, such as extended producer responsibility, the polluter pays principle, and eco-labels among others, as well as various strategies, plans and regulations. ASEAN has also established several regional initiatives such as the Framework for Circular Economy for the ASEAN Economic Community, the ASEAN Circular Economy Stakeholder Platform, and the ASEAN SCP Framework. Regional cooperation is needed to coordinate among upstream and downstream stakeholders to create a regional circular economy and related enabling mechanisms. For example developing an ASEAN-wide EPR framework or green public procurement with a single ASEAN-wide standard or several standards that could be harmonized would provide incentives for the private sector to embrace circular economy principles. The ASEAN Working Groups on Chemicals and Waste (AWGCW) and on Natural Resources and Biodiversity (AWGNCB) could jointly promote integrated circular economy approaches for ASEAN. Implementation of SDG 12 on SCP would greatly facilitate the development of a circular economy in the region, especially when combined with the targets on sustainable industrialization and infrastructure in SDG 9.

14.9 Sustainable Development Goals

14.9.1 Key issues

AMS have extensively engaged with the SDG process, along with businesses, NGOs, youths, and other stakeholders, AMS have also developed indicators and data and prepared Voluntary National Reviews (VNRs) presenting their progress. To address environment-related SDGs, AMS have adopted a range of policies according to their VNRs (Elder 2020). The VNRs also seem to underreport relevant environmental policies (Elder 2020). Nevertheless, progress on SDGs has been insufficient in the region, especially as related to the environment, and action to address them has been insufficient (UNESCAP 2019; 2020a). Data and indicators are also still major challenges for many countries, including AMS. Therefore, more efforts are still needed on SDGs, especially their environmental dimensions, including strengthening the implementation of existing policies and programmes and development of data and indicators.

14.9.2 Key recommendations

Responses to environment-related SDG targets should be accelerated. The SDGs encourage countries to develop synergies between the environment and the social and economic dimensions of sustainable development. SDGs can show how stronger environmental measures can help promote the economic and social dimensions of sustainable development. This could help gain more support for environmental measures from the general public as well as a broader range of policymakers. SDGs could be an effective way to help guide the activities of the ASEAN Working Groups, since the SDG topics are similar to the WG focus areas.

14.10 ASEAN cooperation

14.10.1 Institutional framework for ASEAN cooperation

In ASEAN's organizational structure, environmental cooperation is part of the ASCC. Environmental cooperation within ASEAN is overseen by AMME, managed by ASOEN, and supported by the thematic working groups and the ASEAN Secretariat. Sectoral bodies are becoming more important. In the ASCC, the ASEAN Centre for Biodiversity (ACB), ASEAN Specialised Meteorological Centre (ASMC), ASEAN Centre for Sustainable Development Studies and Dialogue (ACSDSD), and the ASEAN Institute for Green Economy will be joined by the ASEAN Centre for Climate Change (ACCC) (to be established) and the ASEAN Centre for Transboundary Haze Pollution (ACTHP) (to be established). Note that the ASEAN Centre for Energy (ACE) is part of the ASEAN Economic Community.

14.10.2 Key issues

ASEAN conducts international cooperation on the environment at all levels, from the global to the regional to local levels, with a wide range of partners and in a wide variety of formats. ASEAN's international environmental cooperation is very extensive covering a wide range of topics. ASEAN's environmental cooperation activities are implemented through seven Working Groups.

The extensive range of cooperation that AMS are participating in indicates the AMS commitment to cooperate in addressing environmental issues. These cooperation frameworks also play an important role in enhancing the capacity of AMS to address environmental issues. However, some AMS do not have sufficient capacity to fully address these issues.

14.10.3 Key recommendations

Stronger coordination among ASEAN's wide range of environmental cooperation frameworks is needed at all levels, in all sectors, and among key stakeholders and partners to enhance the exchange of best practices as well as strengthen the substance of projects and programmes to support the further advancement of environmental management in the region. Better coordination will require enhanced human resource capacity in the ASEAN Sectoral Bodies, especially the specialised Centres, the ASEAN Secretariat, and national ministries of AMS. Some activities of the AEC and APSC are also related to the environment, especially energy; so how to strengthen their involvement with international environmental cooperation should be considered. The cumulative reporting burdens for MEAs and other cooperation frameworks with many overlapping requirements can be challenging. A streamlined data collection, storage and analysis system should make these reporting requirements less burdensome.

14.11 Outlook

14.11.1 Key issues

Since its inception, ASEAN has had a vision of an integrated, sustainable, harmonious, peaceful, and productive region, with its "One Vision, One Identity, One Community". The three complementary communities, ASEAN Political-Security Community, AEC, and ASCC, all include aspects of the future environmental conditions and quality of life desired for all ASEAN people, aligned with ASEAN Community Vision 2025. Beyond 2025 and looking back from 2050, two possible scenarios were examined (i) business as usual, which continues current trends; and (ii) accelerated transformation towards a sustainable future. Overall, the business-as-usual scenario is likely to reduce overall human well-being including increased health damage, food insecurity, and deteriorating infrastructure, resulting in high economic costs and lost jobs. In contrast, the accelerated transformation scenario will put ASEAN much closer to realizing its vision. Well-being will be significantly higher with much better health, greater food security, and overall economic prosperity with the substantial expansion of green jobs. Each of the ASOEN Working Groups on Environment may wish to conduct a similar scenario planning exercise.

14.11.2 Key recommendations

While this report shows that AMS have taken many actions and made significant progress, the current trajectory will probably not be enough to achieve the accelerated transformation scenario. Strengthened implementation of existing plans and programmes would accelerate progress, but may still not be sufficient to achieve the ASEAN Community Vision 2025. The scenario analysis in this report illustrates further measures which could be adopted.

14.12 Scientific research, data, and monitoring

The importance of strengthened scientific research, monitoring, and data for improving environmental policies and making them more effective is a common theme throughout this report. It is also essential to understand and address emerging environmental risks. ASEAN has made progress in these areas, and this has been facilitated by the need to report on SDGs. However, data is still insufficient or unavailable for many issues, impeding scientific research and making it difficult to develop evidence-based policies. Basic scientific capacity is also insufficient. Moreover, the lack of harmonization of data among the countries in the region has made environmental research and environmental cooperation on solutions more difficult. More resources should be devoted to strengthening scientific research, monitoring, and data development for environmental issues, and greater international cooperation should focus on further developing the relevant capacity. The development of an ASEAN environmental monitoring and evaluation framework could be studied and considered to facilitate tracking the progress of ASEAN plans, programmes, and contributions to various cooperation frameworks, as well as ease the burden of related reporting. Improved data systems will also facilitate the creation of big data for future use of advanced analytical methods such as artificial intelligence to make environmental management more effective.

14.13 Emerging environmental risks

AMS are already aware of and have begun to address some new priority environmental issues which have gained global attention in recent years, including marine plastic pollution, ocean ecosystems, management of chemical wastes, and circular economy solutions. However, as mentioned earlier in this report, longstanding priority issues such as air, water, and soil pollution; climate change; biodiversity; and basic waste management are becoming ever more serious. For example, biodiversity loss now includes economically valuable insects while economically damaging insects such as malarial mosquitoes are spreading.

New emerging environmental risks continue to appear. These include potential negative environmental impacts from mining of critical minerals, deep sea mining, new materials made from nano particles, other new materials and chemicals, genetic modification, and artificial intelligence. Large amounts of energy will be required for new industries such as data centres and server farms needed to support the digital revolution, and blockchain-based applications such as crypto-currencies. The COVID-19 pandemic resulted in a large increase in medical waste as well as plastic and other kinds of waste. ASEAN should also prepare for the management of waste resulting from potential future earthquakes. How to manage nuclear waste and prepare for potential nuclear accidents should also be considered if commercial nuclear power plants are built in the region. Strengthened capacity for scientific research and data collection will be needed for the region to address these risks in a timely manner.

14.14 Conclusion and way forward

Overall, this report shows that environmental problems and challenges in the region are becoming increasingly serious, especially the risks to human health, agricultural production, and food security. Related direct and indirect economic costs of these environmental problems and challenges are also escalating, especially for climate change, extreme weather, and sea level rise, which risk substantial costly damage to infrastructure. Vulnerable populations often suffer disproportionately from environmental problems and challenges.

The ASEAN Community Vision 2025 and other ASEAN plans and programmes aim to address these environmental problems and challenges. AMS have steadily upgraded their policies and other responses. Many environmental cooperation frameworks and mechanisms have been established both within ASEAN and between ASEAN and other countries, international organizations, stakeholders, and others, encompassing a large number and wide range of various activities. However, the responses to date have not been sufficient, and the costs of environmental problems and challenges have been rising and are expected to continue to escalate in the future.

This report and others, have provided various suggestions for strengthening responses to environmental challenges. Many of these suggestions are not necessarily new, but the urgency of the problems and challenges is increasing. It is hoped that this report may encourage stronger responses, not only by highlighting the problems and challenges themselves, but also by examining their economic and human costs, as well as the economic and human benefits of the solutions, including the potential for job creation.

The importance of the cross-cutting nature of environmental issues and the need for greater coordination and more integrated solutions is a main theme of this report. The interlinkages between climate and air pollution and related solutions were especially highlighted, but they are related to other issues as well. Climate change and waste urbanization harm biodiversity, while waste contributes to climate change. Circular economy and improved waste management help address all types of pollution as well as climate change. The COVID-19 pandemic also highlighted the need for integrated approaches, especially the opportunity to promote a green economic recovery from the pandemic to “build back better” with more environmentally sustainable and climate friendly development, including nature-based solutions. The integrated nature of the SDGs helps to bring more attention to some of these interlinkages.

The SDGs promote a more holistic approach to sustainable development and making synergies between the environment, economy, and society more visible, including the social and economic benefits of environmental conservation and the social and economic costs of pollution and environmental degradation. Implementing the SDGs, especially environment-related targets, would significantly improve the environment as well as overall human well-being in the region.

In addition to SDGs, several other approaches seek to synergise economic and social sustainability with the environment. The circular economy shifts production methods to increase resource efficiency and reduce pollution. Nature-based solutions and investing in natural capital also contribute to human well-being while conserving biodiversity resources. The blue economy is a similar approach applied to oceans. These approaches also help to strengthen mainstreaming environmental/sustainability in sectoral development plans as well as in the private sector and local communities. Integrated planning and management should be strengthened, and more resources need to be mobilized in order to implement these measures.

References

2030 Water Resources Group. 2017. ‘Vietnam: Hydro-Economic Framework for Assessing Water Sector Challenges’. Washington, D.C.

ABC/wires. 2022. ‘Indonesia Reveals Name for Nation’s New Capital City, Passes Law on Funding and Development’. ABC News, January 2022.

Abd-Ebrah, N. A., and R. F. Peters. 2021. ‘Giant Clam Conservation in Sabah: A Need for the Appreciation of the Bajau People’s Traditional Ecological Knowledge’. IOP Conference Series: Earth and Environmental Science 736 (1). https://doi.org/10.1088/1755-1315/736/1/012001.

Abeynayaka, Amila. 2021. ‘Plastic Spills in Maritime Transportation and Consequences’. The Green Guardian, 2021.

Abeynayaka, Amila, and Norihiro Itsubo. 2019. ‘A Framework to Incorporate Aquatic Plastic into Life Cycle Assessment of Plastic Products’. In EcoDesing 2019 International Symposium, 261–65. Yokohama.

Abeynayaka, Amila, Induka Werellagama, Pham Ngoc-Bao, Matthew Hengesbaugh, Pradeep Gajanayake, Bhagya Nallaperuma, Selim Karkour, Bui Xuan-Thanh, and Norihiro Itsubo. 2022. ‘Microplastics in Wastewater Treatment Plants’. In Advances in Biological Wastewater Treatment Systems: Current Developments in Biotechnology and Bioengineering, edited by Xuan-Thanh Bui, Dinh Duc Nguyen, Phuoc Dan Nguyen, Huu Hao Ngo, and Ashok Pandey. Vol. 26. Elsevier.

Abraham, Martin A, and Nhan Nguyen. 2003. ‘“Green Engineering: Defining the Principles”— Resdts from the Sandestin Conference’. Environmental Progress 22 (4): 233–36. https://doi.org/10.1002/ep.670220410.

ACS. n.d. ‘12 Principles of Green Chemistry’. American Chemical Society. Accessed 14 January 2022. https://www.acs.org/content/acs/en/greenchemistry/principles/12-principles-of-green-chemistry.html.

ADB. 2002. ‘National Coastal Erosion Control Sector Project’. Manila, Philippines.

———. 2012. ‘Environmental Governance and the Courts in Asia: An Asian Judges Network on the Environment’.

———. 2016. ‘The Coral Triangle: An Ecosystem Under Threat’. 2016. https://www.adb.org/multimedia/coral-triangle/.

———. 2017a. ‘A Region at Risk: The Human Dimension of Climate Change in Asia and the Pacific’. https://doi.org/10.22617/TCS178839-2.

———. 2017b. ‘Meeting Asia’s Infrastructure Needs 2030’.

———. 2017c. ‘Meeting Asia’s Infrastructure Needs 2030’.

———. 2017d. ‘Population and Aging in Asia: The Growing Elderly Population’. ADB. 16 November 2017.

———. 2019. ‘ASEAN Infrastructure Fund’.

———. 2020a. ‘ASEAN Catalytic Green Finance Facility’.

———. 2020b. ‘Asian Water Development Outlook 2020’.

———. 2020c. ‘Managing Infectious Medical Waste during the COVID-19 Pandemic’.

———. 2022a. ‘ASEAN Catalytic Green Finance Facility 2021: Financing for a Green Recovery in Southeast Asia’.

———. 2022b. ‘What Southeast Asian Countries Need to Do to Shift to Sustainable Tourism’. Southeast

Asia Development Solutions (SEADS). 2022. https://seads.adb.org/solutions/what-southeast-asian-countries-need-do-shift-sustainable-tourism.

———. n.d. 'ADB's Work in Sustainable Transport'. Asian Development Bank.

adelphi. 2022. 'Cooperation for Resilience in Urban Centres'. 2022. https://asean-urban-resilience.net/.

Adhityatama, Shinatria, Rr Triwurjani, Suryataman, Priyatno Hadi Sulistyarto, and Bambang Budi Utomo. 2017. 'Underwater Archaeological Study on Prehistoric Material Culture in Matano Lake, South Sulawesi, Indonesia'. Journal of Southeast Asian Archaeology 37: 37–49.

AHA Centre. 2022. 'ASEAN Risk Monitor and Disaster Management Review'. 3rd ed. Jakarta, Indonesia.

Ahmed, Tofael, Saad Mekhilef, Rakibuzzaman Shah, N. Mithulananthan, Mehdi Seyedmahmoudian, and Ben Horan. 2017. 'ASEAN Power Grid: A Secure Transmission Infrastructure for Clean and Sustainable Energy for South-East Asia'. Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2016.09.055.

AIT, and UNEP. 2021. 'COVID-19 & Plastic Plight: A Reflection from One Year of the Pandemic'.

AKCF. 2019. 'New Framework for the ASEAN-ROK Cooperation Fund (AKCF) 2017-2020'.

———. n.d. 'ASEAN-Korea Cooperation Fund'.

Akenji, Lewis, Magnus Bengtsson, Mizuki Kato, Matthew Henegsbaugh, Yasuhiko Hotta, Chika Aoki-Suzuki, Premakumara Jagath Dickella Gamaralalage, and Chen Liu. 2019. Circular Economy and Plastics: A Gap-Analysis in ASEAN Member States. Brussels and Jakarta: European Commission and ASEAN.

Akenji, Lewis, Mark Elder, Magnus Bengtsson, Simon Høiberg Olsen, and Peter King. 2018. 'Transformative Policy Approaches to Implement the Sustainable Development Goals in the Asia-Pacific Region'. In Realising the Transformative Potential of the SDGs, 13–52. Hayama, Japan: Institute for Global Environmental Strategies.

Alam, Z. F., A. J. V. Riego, J. H. R. P. Samson, and S. A. V. Valdez. 2019. 'The Assessment of the Genotoxicity of E-Waste Leachates from e-Waste Dumpsites in Metro Manila, Philippines'. International Journal of Environmental Science and Technology 16 (2): 737–54. https://doi.org/10.1007/s13762-018-1719-6.

Alas, Honey Dawn, Thomas Müller, Wolfram Birmili, Simonas Kecorius, Maria Obiminda Cambaliza, James Bernard B. Simpas, Mylene Cayetano, et al. 2018. 'Spatial Characterization of Black Carbon Mass Concentration in the Atmosphere of a Southeast Asian Megacity: An Air Quality Case Study for Metro Manila, Philippines'. Aerosol and Air Quality Research 18 (9): 2301–17. https://doi.org/10.4209/aaqr.2017.08.0281.

Alegado, Joseph Edward, Jose Miguel Aliño, Stephen Cheuk Fai Chow, Ma. Brida Lea Diola, Premakumara Jagath Dickella Gamaralalage, Lea Gurrero, Matthew Hengesbaugh, et al. 2021. PLASTIC ATLAS - Facts and Figures about the World of Synthetic Polymers (Asia Edition). Edited by Kevin Li and Clemens Kunze. Heinrich Boll Stiftung.

Ali, Qaisar, Shazia Parveen, Hakimah Yaacob, Zaki Zaini, and Nur Anissa Sarbini. 2021. 'COVID-19 and Dynamics of Environmental Awareness, Sustainable Consumption and Social Responsibility in Malaysia'. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-021-14612-z.

Al-Qaim, Fouad Fadhil, Zainab Haider Mussa, Ali Yuzir, Nurfaizah Abu Tahrim, Norbaya Hashim, and Shamila Azman. 2018. ‘Transportation of Different Therapeutic Classes of Pharmaceuticals to the Surface Water, Sewage Treatment Plant, and Hospital Samples, Malaysia’. Water (Switzerland) 10 (7): 1–16. https://doi.org/10.3390/w10070916.

Amach, Omar H. 2021. ‘ASEAN Achieves a Milestone towards Regional Disaster Risk Reduction | UNDRR’. UNDRR. 2021. https://www.undrr.org/news/asean-achieves-milestone-towards-regional-disaster-risk-reduction.

Amanuma, Nobue, Eric Zusman, So-Young Lee, Dickella Gamaralalage Jagath Premakumara, Bijon Kumer Mitra, Ngoc-Bao Pham, Ryoko Nakano, et al. 2018. ‘Governance for Integrated Solutions to Sustainable Development and Climate Change: From Linking Issues to Aligning Interests’.

Aminrad, Z., S.Z.B.S. Zakariya, A.S. Hadi, and M Sakari. 2012. ‘Environmental Education in Malaysia, Progresses and Challenges Ahead (Review)’. Life Science Journal 9 (2): 1149–54.

Ancrenaz, M., M. Gumal, A.J. Marshall, E. Meijaard, S.A. Wich, and S. Husson. 2016. ‘Pongo Pygmaeus (Errata Version Published in 2018)’. The IUCN Red List of Threatened Species 2016.

Anh, Hoang Quoc, Thi Phuong Quynh Le, Nhu Da Le, Xi Xi Lu, Thi Thuy Duong, Josette Garnier, Emma Rochelle-Newall, et al. 2021a. ‘Antibiotics in Surface Water of East and Southeast Asian Countries: A Focused Review on Contamination Status, Pollution Sources, Potential Risks, and Future Perspectives’. Science of the Total Environment 764. https://doi.org/10.1016/j.scitotenv.2020.142865.

———. 2021b. ‘Antibiotics in Surface Water of East and Southeast Asian Countries: A Focused Review on Contamination Status, Pollution Sources, Potential Risks, and Future Perspectives’. Science of the Total Environment 764. https://doi.org/10.1016/j.scitotenv.2020.142865.

Anh, Pham Thi, Carolien Kroeze, Simon R. Bush, and Arthur P.J. Mol. 2010. ‘Water Pollution by Intensive Brackish Shrimp Farming in South-East Vietnam: Causes and Options for Control’. Agricultural Water Management 97 (6): 872–82. https://doi.org/10.1016/j.agwat.2010.01.018.

Antonio, Ella, Steve Bass, and Donna Gasgonia. 2012. Philippines Experience , Lessons and Challenges in Environmental Mainstreaming. International Institute for Environment and Development.

APRSCP, and SWITCH-Asia RPAC. 2021. ‘Inputs to the Development of the ASEAN SCP Framework’.

———. 2022. ‘ASEAN SCP Framework: Implementation Mechanism’.

Arai, Juntaro, and Nikkei staff writers. 2021. ‘ASEAN to Receive $10bn Decarbonization Support from Japan’. Nikkei Asia, May 2021.

Arias, P.A., N. Bellouin, E. Coppola, R.G. Jones, G. Krinner, J. Marotzke, V. Naik, et al. 2021. Technical Summary. Edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, et al. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

Arsac, Kate. 2020. ‘Deep Dive: Rising Sea Levels Force Relocation of Indonesian Capital’. Earth.Org. 2020. https://earth.org/deep-dive-rising-sea-levels-force-relocation-of-indonesian-capital/.

ASCOPE. n.d. ‘The Trans-ASEAN Gas Pipeline – Accelerating Gas Market Integration Within the ASEAN Region’, 1–12.

ASEAN. 2013. 'ASEAN+6 Population Forecast: Global Share, Aging and Dependency Ratio Population Forecast for ASEAN+6'.

———. 2019a. 'ASEAN Joint Statement on Climate Change to UNFCCC COP25'.

———. 2019b. 'Chairman's Press Statement on the Launch of the ASEAN Centre for Sustainable Development Studies and Dialogue (ACSDSD)'.

———. 2020. 'Old-Age Income Security in ASEAN Members States-Policy Trends, Challenges and Opportunities'.

———. 2021a. 'ASEAN Joint Statement on Climate Change to the 26th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC COP26)'.

———. 2021b. 'ASEAN Joint Statement to the Fifteenth Meeting of the Conference of the Parties to the Convention on Biological Diversity (CBD COP 15)'. ASEAN Secretariat.

———. 2021c. 'Chairman's Statement of the 22nd ASEAN-Republic of Korea (ROK) Summit'.

———. 2021d. 'Chairman's Statement of the 24th ASEAN-Japan Summit'.

———. 2021e. 'East Asia Summit Leaders Statement on Sustainable Recovery'.

———. 2021f. ASEAN Leaders' Declaration on the Blue Economy. https://asean.org/asean-leaders-declaration-on-the-blue-economy/.

———. 2021g. Mid-Term Review of the ASEAN Socio-Cultural Community Blueprint: Final Report. ASEAN Secretariat. https://asean.org/book/mid-term-review-of-the-asean-socio-cultural-community-blueprint-2025-final-report/.

ASEAN and UN Women. 2021. 'ASEAN Gender Outlook'.

ASEAN Centre for Biodiversity. 2016. 'Regional Action Plan for ASEAN Heritage Parks 2016-2020'.

———. 2017a. 'ASEAN Biodiversity Outlook 2'.

———. 2017b. 'Global Taxonomy Initiative: Regional Action Plan for Southeast Asia (2017-2025)'.

———. 2019. 'Progress of the AHP Regional Action Plan (2016–2020)'. In 6th AHP Conference. Pakse, Lao PDR.

———. 2020. 'ASEAN Initial Inputs to the Post-2020 Global Biodiversity Framework'.

———. 2021. 'Statement for Endangered Species Day, 21 May 2021'. 2021. https://www.aseanbiodiversity.org/2021/05/21/statement-for-endangered-species-day-21-may-2021/.

———. 2022a. 'About ACB'. ASEAN Centre for Biodiversity. 2022.

———. 2022b. 'Biodiversity Conservation and Management of Protected Areas in ASEAN (BCAMP)'. ASEAN Centre for Biodiversity. 2022. https://asean.chm-cbd.net/projects/biodiversity-conservation-and-management-protected-areas-asean-bcamp.

ASEAN Centre for Biodiversity, BirdLife International, Haribon Foundation, and Sabah Parks. 2008. 'Regional Action Plan for ASEAN Heritage Parks and Other Protected Areas'. Philippines.

ASEAN Centre for Energy. 2020a. 'ASEAN Energy Outlook 2017-2040'. 6th ed.

———. 2020b. 'ASEAN Plan of Action for Energy Cooperation (APAEC) Phase II: 2021 - 2025'.

———. 2020c. ‘Harmonisation of Energy Performance Standards for Lighting – A Regional Policy Roadmap’.

———. 2022. ‘Guidelines for Developing Indicators to Track Action on Energy-Related Climate Change Mitigation Policies’.

———. n.d. ‘Introductions’. Accessed 16 December 2021. https://aseanenergy.org/introductions/.

ASEAN Cooperation on Environment. 2013. ‘Joint Statement on the Implementation of Sustainable Consumption and Production in ASEAN by the ASEAN Ministers Responsible for Environment – ASEAN Cooperation on Environment’. Joint Statement on the Implementation of Sustainable Consumption and Production in ASEAN by the ASEAN Ministers Responsible for Environment. 2013.

ASEAN Free Trade Area Council. 1992. ‘ASEAN Free Trade Agreements’.

ASEAN International Conference on Energy and Environment. 2021. ‘ASEAN International Conference on Energy and Environment (AICEE) Proceeding Book’. ASEAN Climate Change and Energy Project (ACCEPT).

ASEAN, and Japan. 2008. ‘Agreement on Comprehensive Economic Partnership Among Japan and Member States of the Association of Southeast Asian Nations’.

ASEAN Ministers of Tourism. 2016. ‘Pakse Declaration on Asean Roadmap for Strategic Development of Ecotourism Clusters and Tourism Corridors’.

———. 2022. ‘The 25th Meeting of ASEAN Tourism Ministers’. Sihanoukville, Cambodia: ASEAN Secretariat.

ASEAN, and Norway. 2021. ‘ASEAN-Norway Sectoral Dialogue Partnership: Practical Cooperation Areas (2021-2025)’.

ASEAN Parliamentarians for Human Rights. 2021. ‘Building Back Better: Southeast Asia’s Transition to a Green Economy After COVID-19’.

ASEAN, and People’s Republic of China. 2018. ‘ASEAN-China Strategic Partnership Vision 2030’. Singapore.

———. 2021a. ‘ASEAN-China Joint Statement on Enhancing Green and Sustainable Development Cooperation’.

———. 2021b. ‘Joint Statement of the ASEAN-China Special Summit to Commemorate the 30th Anniversary of ASEAN-China Dialogue Relations: Comprehensive Strategic Partnership for Peace, Security, Prosperity and Sustainable Development’.

ASEAN SDGs-Frontrunner Cities Programme. n.d. ‘About’. ASEAN SDGs Frontrunner Cities. Accessed 31 December 2021a. https://www.aseansdgscities.org/about.

———. n.d. ‘ASEAN SDGs Frontrunner Cities’. Accessed 31 December 2021b. https://www.aseansdgscities.org/.

ASEAN Secretariat. 2002a. ‘ASEAN Agreement on Transboundary Haze Pollution’.

———. 2002b. ‘Framework Agreement on Comprehensive Economic Cooperation Between the Association of South East Asian Nations and the People’s Republic of China’.

———. 2005. ‘ASEAN Strategic Plan of Action on Water Resources Management’.

———. 2006. ‘ASEAN Peatland Management Strategy (2006-2020)’.

———. 2008. 'ASEAN Marine Water Quality Management Guidelines and Monitoring Manual'.

———. 2009. 'Agreement on Trade in Goods under the Framework Agreement on Comprehensive Economic Cooperation between the Association of Southeast Asian Nations and the Republic of India'.

———. 2011. 'ASEAN and China Officially Launch the Establishment of the China-ASEAN Environmental Cooperation Centre'. Association of Southeast Asian Nations. 2011. https://asean.org/asean-and-china-officially-launch-the-establishment-of-the-china-asean-environmental-cooperation-centre/.

———. 2013. 'Strategy and Action Plan For Sustainable Management of Peatlands in ASEAN Member States (2006-2020) - Updated'.

———. 2014. ASEAN Environmental Education Action Plan 2014-2018.

———. 2015a. APSC Blueprint 2025. Vol. 1.

———. 2015b. 'ASEAN Community Vision 2025'.

———. 2015c. 'ASEAN Community Vision 2025'.

———. 2015d. 'ASEAN Tourism Strategic Plan 2016-2025'. Jakarta, Indonesia.

———. 2015e. 'Strategic Plan of Action on ASEAN Cooperation on Fisheries 2016-2020'.

———. 2016a. 'ASEAN Agreement on Transboundary Haze Pollution'.

———. 2016b. 'ASEAN Socio-Cultural Community Blueprint 2025'.

———. 2016c. 'ASEAN Strategic Plan on Environment 2016-2025 [Draft]'.

———. 2016d. 'Master Plan on ASEAN Connectivity 2025'.

———. 2017a. 'ASEAN Joint Declaration on Hazardous Chemicals and Wastes Management'.

———. 2017b. 'ASEAN Plan of Action on Science, Technology and Innovation (APASTI) 2016-2025 – Implementation Plan'.

———. 2017c. 'Fifth ASEAN State of the Environment Report'. Jakarta: ASEAN Secretariat.

———. 2018a. 'ASEAN Smart Cities Framework'. Jakarta, Indonesia: ASEAN Secretariat.

———. 2018b. 'ASEAN Sustainable Urbanisation Strategy'. Jakarta: ASEAN Secretariat.

———. 2018c. 'ASEAN-Germany Development Partnership'. Jakarta, Indonesia.

———. 2018d. 'Concept Note: ASEAN Smart Cities Network'. ASEAN Secretariat.

———. 2019a. 'ASEAN Framework of Action on Marine Debris'.

———. 2019b. 'ASEAN Key Figures 2019'.

———. 2019c. 'Bangkok Declaration on Combating Marine Debris in ASEAN Region'.

———. 2019d. 'Integration Report 2019'.

———. 2020a. 'ASEAN Comprehensive Recovery Framework'.

———. 2020b. 'ASEAN Key Figures 2020'.

———. 2020c. 'ASEAN Statistical Yearbook 2020'.

———. 2020d. 'ASEAN Sustainable Development Goals Indicators Baseline Report 2020'.

———. 2021a. ‘16th ASEAN Ministerial Meeting on the Environment and the 16th Meeting of the Conference of the Parties to the ASEAN Agreement on Transboundary Haze Pollution’. 2021. https://asean.org/16th-asean-ministerial-meeting-on-the-environment-and-the-16th-meeting-of-the-conference-of-the-parties-to-the-asean-agreement-on-transboundary-haze-pollution/.

———. 2021b. ‘ASEAN Development Outlook: Inclusive and Sustainable Development’.

———. 2021c. ‘ASEAN, EU Hold High-Level Dialogue on Environment, Climate Change’. 2021. https://asean.org/asean-eu-hold-high-level-dialogue-on-environment-climate-change/.

———. 2021d. ‘ASEAN Leaders’ Declaration on the Reformulation and Production of Healthier Food and Beverage Options’.

———. 2021e. ‘ASEAN Regional Action Plan for Combating Marine Debris in the ASEAN Member States (2021-2025)’.

———. 2021f. ‘ASEAN Regional Plan of Action for Adaptation to Drought 2021-2025’.

———. 2021g. ‘ASEAN State of Climate Change Report: Current Status and Outlook of the ASEAN Region’. Jakarta: ASEAN Secretariat.

———. 2021h. ‘ASEAN Strategy on Sustainable Biomass Energy for Agriculture Communities and Rural Development in 2020-2030’. Jakarta, Indonesia: ASEAN Secretariat.

———. 2021i. ‘Consolidated Strategy on the Fourth Industrial Revolution for ASEAN’. Jakarta, Indonesia: ASEAN Secretariat.

———. 2021j. ‘Framework for Circular Economy for the ASEAN Economic Community’. Jakarta, Indonesia.

———. 2021k. ‘Phnom Penh Declaration on a More Sustainable, Inclusive and Resilient ASEAN Tourism’. ASEAN Secretariat.

———. 2021l. ‘Roadmap on ASEAN Cooperation Towards Transboundary Haze Pollution Control with Means of Implementation’. Jakarta, Indonesia.

———. 2021m. ‘Sustainable Use of Peatland and Haze Mitigation in ASEAN (SUPA) Fact Sheet’.

———. 2021n. ‘The Road to Sustainable Cities’. 2021. https://asean.org/wp-content/uploads/2021/08/The-ASEAN-Sustainable-Cities-June-July-2021.pdf.

———. 2022a. ‘ASEAN-Norway Sectoral Dialogue Relations’. Jakarta, Indonesia.

———. 2022b. ‘Executive Summary of the Final Review of the Roadmap on ASEAN Cooperation Towards Transboundary Haze Pollution Control with Means of Implementation’. Jakarta, Indonesia.

———. 2022c. ‘Roadmap on ASEAN Cooperation towards Transboundary Haze Pollution Control with Means of Implementation’. ASEAN Haze Portal. 2022.

———. n.d. ‘East Asia Summit’. Accessed 31 December 2021. https://eastasiasummit.asean.org/about-east-asia-summit.

———. n.d. ‘Plan of Action to Implement the ASEAN-China Strategic Partnership for Peace and Prosperity (2021 – 2025)’.

ASEAN Secretariat, Government of Japan, Government of the Republic of China, and Government of the

Republic of Korea. 2018. 'ASEAN Plus Three Cooperation Work Plan 2018 - 2022'. ASEAN Secretariat.

ASEAN Sectoral Working Group on Fisheries. 2021. 'Strategic Plan of Action on ASEAN Cooperation on Fisheries 2021-2025'.

ASEAN Taxonomy Board. 2021. 'ASEAN Taxonomy for Sustainable Finance'.

ASEAN Working Group on Water Resources Management (AWGWRM). 2022. 'ASEAN Water Data Management and Reporting System'. 2022. http://rhn.water.gov.my/awgwrm/.

ASEAN-Japan Centre. 2022. 'ASEAN Global Value Chain and Its Relationship with RCEP: Impacts of RCEP on ASEAN Integration'.

ASEAN-Thailand. 2018. 'Progress Report: Promoting Complementarities Between the ASEAN Community Vision 2025 and the UN 2030 Agenda for Sustainable Development'. Bangkok, Thailand: Ministry of Foreign Affairs, Thailand.

Asian Co-benefits Partnership Secretariat. n.d. 'Asian Co-Benefits Partnership'.

ASMC. 2022. 'About ASMC'. ASEAN Specialized Meteorological Centre. 2022.

AUN Secretariat. n.d. 'AUN Thematic Network on Ecological Education and Culture (AUN-EEC)'. ASEAN University Network.

Balanay, Raquel M, and Anthony Halog. n.d. 'Teaching Education for Sustainable Development at University Level : A Case Study from the Philippines'. In , 163–74. https://doi.org/10.1007/978-3-319-32928-4.

Bao, P N. 2021. 'Toward the Establishment of Sustainable Faecal Sludge Management - Lessons Learned from WEPA Partner Countries and Japan'. Policy Brief Series 8.

Bao, Pham Ngoc, Khoeurn Kimleang, Boeut Sophea, Nobue Amanuma, Binaya Raj Shivakoti, and Rajendra Khanal. 2022. 'Lake and Livelihoods: Threats to Their Sustainability'. In Water and Life in Tonle Sap Lake, 13–22. Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-16-6632-2_2.

Bao, P.N. 2021. 'Toward the Establishment of Sustainable Faecal Sludge Management - Lessons Learned from WEPA Partner Countries and Japan'. Policy Brief Series 8 2021 (3): 1–12.

Bao, P.N. and Canh, V.D. 2021. 'Addressing Acssociated Risks of COVID-19 Infections Accross Water and Wastewater Service Chain in Asia'. In Environmental Resilience and Transformation in Times of COVID-19. Elsevier. https://doi.org/10.1016/c2020-0-02703-9.

Bappenas. 2021. 'SANIMAS - Independent Evaluation of SANIMAS Model as an Approach for Providing Decentralised Sanitation'.

Baran, E., and C. Myschowoda. 2009. 'Dams and Fisheries in the Mekong Basin'. Aquatic Ecosystem Health and Management 12 (3): 227–34. https://doi.org/10.1080/14634980903149902.

Barg, U.C. 1992. 'Guidelines for the Promotion of Environmental Management of Coastal Aquaculture Development'.

Basel Convention Secretariat, Rotterdamn Convention Secretariat, Stockhom Convention Secretariat, and Minamata Convention on Mercury Secretariat. 2021. 'Chemicals, Wastes and Climate Change: Interlinkages and Potential for Coordinated Action'.

Baum, Gunilla, Indra Januar, Sebastian C.A. Ferse, Christian Wild, and Andreas Kunzmann. 2016. 'Abundance and Physiology of Dominant Soft Corals Linked to Water Quality in Jakarta Bay, Indonesia'.

PeerJ 2016 (11). https://doi.org/10.7717/PEERJ.2625/SUPP-2.

Bellard, Céline, Cleo Bertelsmeier, Paul Leadley, Wilfried Thuiller, and Franck Courchamp. 2012. ‘Impacts of Climate Change on the Future of Biodiversity’. Ecology Letters 15 (4): 365–77. https://doi.org/10.1111/j.1461-0248.2011.01736.x.

Bendixen, Mette, Jim Best, Chris Hackney, and Lars Lønsmann Iversen. 2019. ‘Time Is Running out for Sand’. Nature 571 (7763): 29–31. https://doi.org/10.1038/D41586-019-02042-4.

Bignoli, D. Juffe. 2011. ‘Terniopsis Ubonensis’. The IUCN Red List of Threatened Species 2011. 2011.

BIMSTEC. n.d. ‘About BIMSTEC’. Accessed 31 December 2021a. https://bimstec.org/?page_id=3917.

———. n.d. ‘Summit Declarations’. Accessed 31 December 2021b. https://bimstec.org/?page_id=3812%0A.

Binohlan, Crispina B., and Armi G. Torres. n.d. ‘Catlocarpio Siamensis’. FishBase.

Biodiversity.fi. 2015. ‘CICES’. 2015.

Bonnema, Matthew, Faisal Hossain, Bart Nijssen, and Gordon Holtgrieve. 2020. ‘Hydropower’s Hidden Transformation of Rivers in the Mekong’. Environmental Research Letters 15 (4). https://doi.org/10.1088/1748-9326/ab763d.

Borongan, Guilberto, and Shigefumi Okumura. 2010. ‘Municipal Waste Management Report: Status-Quo and Issues in Southeast and East Asian Countries’.

Borrelli, Pasquale, David A. Robinson, Emanuele Lugato, Jae E. Yang, Christine Alewell, David Wuepper, Luca Montanarella, Panos Panagos, and Cristiano Ballabio. 2020. ‘Land Use and Climate Change Impacts on Global Soil Erosion by Water (2015-2070)’. PNAS, 117 (36): 21994-22001–22001. https://doi.org/10.1073/pnas.2001403117.

Bott, Lisa Michéle, Tilo Schöne, Julia Illigner, Mahmud Haghshenas Haghighi, Konstantin Gisevius, and Boris Braun. 2021. ‘Land Subsidence in Jakarta and Semarang Bay – The Relationship between Physical Processes, Risk Perception, and Household Adaptation’. Ocean & Coastal Management 211 (October): 105775. https://doi.org/10.1016/J.OCECOAMAN.2021.105775.

Breu-Grobois, A, and P. Plotkin. 2008. ‘Lepidochelys Olivacea’. The IUCN Red List of Threatened Species 2008.

BRI. 2021. ‘Belt and Road Initiative’. 2021. https://www.beltroad-initiative.com/belt-and-road/.

Brown, K, and A Mijic. 2019. ‘Integrating Green and Blue Spaces into Our Cities: Making It Happen’. Imperial.Ac.Uk. London.

Bui, Huyen Anh. 2020. ‘Promoting Education for Sustainable Development (ESD) in Vietnam via Non-Formal Education Case Study : CHANGE ’ s Vietnam Climate Leadership Initiative’. Aalato University School of Business.

Byatnal, and Amruta. 2020. ‘USAID Begins New Round of Agent Orange Cleanup in Vietnam’. Devex, https://www.devex.com/news/usaid-begins-new-round-.

Cairns, Stephen. 2018. ‘Debilitating City-Centricity: Urbanization and Urban-Rural Hybridity in Southeast Asia’. In Routledge Handbook of Urbanization in Southeast Asia, edited by Rita Padawangi. London: Routledge.

Canadell, J.G., P.M.S. Monteiro, M.H. Costa, L. Cotrim da Cunha, P.M. Cox, A.V. Eliseev, S. Henson, et al. 2021. 'Global Carbon and Other Biogeochemical Cycles and Feedbacks'. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, et al. Cambridge University Press.

Carrara, S., P. Alves Dias, B. Plazzotta, C. Pavel, and European Commission. Joint Research Centre. 2020. 'Raw Materials Demand for Wind and Solar PV Technologies in the Transition towards a Decarbonised Energy System.'

Carrard, Naomi, Tim Foster, and Juliet Willetts. 2019. 'Groundwater as a Source of Drinking Water in Southeast Asia and the Pacific: A Multi-Country Review of Current Reliance and Resource Concerns'. Water (Switzerland) 11 (8). https://doi.org/10.3390/w11081605.

Casale, P., and A.D. Tucker. 2017. 'Caretta Caretta (Amended Version of 2015 Assessment)'. The IUCN Red List of Threatened Species 2017. 2017. https://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T3897A119333622.en.

Cassou, Emilie, Steven M. Jaffee, and Jiang Ru. 2017. The Challenge of Agricultural Pollution: Evidence from China, Vietnam, and the Philippines. The World Bank. https://doi.org/10.1596/978-1-4648-1201-9.

CBD Secretariat. 2010. 'Decision Adopted by the Conference of the Parties to the Convention on Biological Diversity at Its Tenth Meeting: X/2. The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets'.

———. 2018. 'Protected Areas and Other Effective Area-Based Conservation Measures (Decision 14/8)'.

———. 2020. Global Biodiversity Outlook 5. Montreal: Secretariat of the Convention on Biological Diversity.

———. 2021. 'First Draft of the Post-2020 Global Biodiversity Framework'.

———. 2022a. 'National Reports'. Convention on Biological Diversity. 2022. https://www.cbd.int/reports/.

———. 2022b. 'Parties to the Nagoya Protocol'. 2022. https://www.cbd.int/abs/nagoya-protocol/signatories/.

———. 2022c. 'Search NBSAPs and National Reports'. 2022. https://www.cbd.int/nbsap/search/.

CCAC. n.d. 'Climate & Clean Air Coalition'.

CCAC, UNEP, and APCAP. 2019. 'Air Pollution in Asia and the Pacific: Science-Based Solutions'. Paris.

Center for International Earth Science Information Network (CIESIN) / Columbia University. 2013. 'Urban Land Area (Sq. Km)'. Urban-Rural Population and Land Area Estimates Version 2. World Bank.

Centre for Liveable Cities. 2018. ASEAN Smart Cities Network. Singapore: Centre for Liveable Cities.

Centre for Research on the Epidemiology of Disasters. 2021. 'EM-DAT | The International Disasters Database'. EM-DAT | The International Disasters Database. 2021.

Chaijaroen, Pasita. 2019. 'Long-Lasting Income Shocks and Adaptations: Evidence from Coral Bleaching in Indonesia'. Journal of Development Economics 136 (January): 119–36. https://doi.org/10.1016/j.jdeveco.2018.10.002.

Chan, L., O. Hillel, P. Werner, N. Holman, I. Coetzee, R. Galt, and T. Elmqvist. 2021. Handbook on the Singapore Index on Cities' Biodiversity (Also Known as the City Biodiversity Index). Vol. 98. Secretariat of the Convention on Biological Diversity and National Parks Board, Singapore.

Chan, Tran, Dao, Sulser, Phillips, Batka, Wiebe, and Preston. 2017. 'Fish to 2050 in the ASEAN Region'.

Penang, Malaysia: WorldFish and Washington DC, USA: International Food Policy Research Institute.

Chandra, Alexander C. 2009. 'The Pursuit of Sustainable Development through Regional Economic Integration ASEAN and Its Potential as a Development-Oriented Organization'. Trade Knowledge Network.

Chatham House Circular Economy Trade Database. 2020. 'Trade | Circulareconomy.Earth | Chatham House'. 2020. circulareconomy.earth.

Chen, Hui Ling, Sivathass Bannir Selvam, Kang Nee Ting, and Christopher Neil Gibbins. 2021. 'Microplastic Pollution in Freshwater Systems in Southeast Asia: Contamination Levels, Sources, and Ecological Impacts'. Environmental Science and Pollution Research 2021 28:39 28 (39): 54222–37. https://doi.org/10.1007/S11356-021-15826-X.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, et al. 2015. 'Regional Climate Projections'. In Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, 11–15. Cambridge University Press. https://doi.org/10.1007/978-81-322-1967-5_4.

Chua, Daniel, and Eddie Lim. 2017. The ASEAN Charter. Asean 50. https://doi.org/10.1142/9789813221147_0005.

CITES. 2021. 'List of Contracting Parties'. 2021. https://cites.org/eng/disc/parties/chronolo.php.

Clark, James. 2020a. 'Forest City Malaysia – A New City on Man-Made Islands near Singapore'. Future Southeast Asia. 2020. https://futuresoutheastasia.com/forest-city/.

———. 2020b. 'The Thai Canal: The Proposed Canal across the Isthmus of Kra in Southern Thailand'. Future Southeast Asia.

CMS Secretariat. 2021. 'Parties and Range States'. 2021. https://www.cms.int/en/parties-range-states.

COBSEA. 2011. 'Spatial Planning in the Coastal Zone of the East Asian Seas Region: Integrating Emerging Issues and Modern Management Approaches'.

Colwill, J. A., E. I. Wright, S. Rahimifard, and A. J. Clegg. 2012. 'Bio-Plastics in the Context of Competing Demands on Agricultural Land in 2050'. Https://Doi.Org/10.1080/19397038.2011.602439 5 (1): 3–16. https://doi.org/10.1080/19397038.2011.602439.

Convention on Biological Diversity. 2022. 'Kunming-Montreal Global Biodiversity Framework'. Decision 15/4. https://www.cbd.int/doc/decisions/cop-15/cop-15-dec-04-en.pdf.

CRED/UC-Louvain. 2021. 'The International Disaster Database'.

Cronin, Richard, and Timothy Hamlin. 2012. Mekong Turning Point: Shared River for a Shared Future. Stimson Center, Washington DC, Viewed April. The Henry L. Stimson Center.

Cruz, Tess, and Armi G. Torres. n.d. 'Pangasianodon Gigas'. FishBase.

CTI-CFF Secretariat. 2019. 'Regional Plan of Action on IUU'. Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security.

———. 2021. 'About'. Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security. 2021. https://www.coraltriangleinitiative.org/about.

———. 2022a. 'About The Regional Secretariat'. Coral Triangle Initiative on Coral Reefs Fisheries and Food

Security (CTI-CFF). 2022. https://coraltriangleinitiative.org/about-regional-secretariat.

———. 2022b. ‘RPOA (CTI-CFF Regional Plan of Action)’.

Curren, Emily, Victor S. Kuwahara, Teruaki Yoshida, and Sandric Chee Yew Leong. 2021. ‘Marine Microplastics in the ASEAN Region: A Review of the Current State of Knowledge’. Environmental Pollution 288 (November): 117776. https://doi.org/10.1016/J.ENVPOL.2021.117776.

Daily, Gretchen C., ed. 1997. Nature’s Services: Societal Dependence on Natural Ecosystems. 1st ed.

Dang, Anh Nguyet, Bethanna Marie Jackson, Rubianca Benavidez, and Stephanie Anne Tomscha. 2021. ‘Review of Ecosystem Service Assessments: Pathways for Policy Integration in Southeast Asia’. Ecosystem Services 49: 101266. https://doi.org/10.1016/j.ecoser.2021.101266.

Davies, Grace I., Lachlan McIver, Yoonhee Kim, Masahiro Hashizume, Steven Iddings, and Vibol Chan. 2015. ‘Water-Borne Diseases and Extreme Weather Events in Cambodia: Review of Impacts and Implications of Climate Change’. International Journal of Environmental Research and Public Health 12 (1): 191–213. https://doi.org/10.3390/ijerph120100191.

Delegation of the European Union to ASEAN. n.d. ‘Adopting Circular Economy Practices Requires More Than Just Reducing the Use of Plastics’. Accessed 14 January 2022. https://euinasean.eu/adopting-circular-economy-practices-requires-more-than-just-reducing-the-use-ofplastics/.

Dempsey, Caitlin. 2021. ‘Terrestrial Ecoregions GIS Data’. GIS Lounge.

DENR-EMB. n.d. ‘Compendium of Philippine Environment Statistics (2008-2017)’.

Department of Environment and Natural Resources, The Government of the Philippines. 2017. The National Environmental Education Action Plan 2018-2040.

Department of Industry Science Energy and Resources. 2021. ‘Exporting Solar Energy under the Sea: A Potential World First for Australian Technology’.

Dhoj GC, Yubak, Bhakta R. Palikhe, Baogen Gu, and Grenier Beatrice. 2021. ‘Status of Highly Hazardous Pesticides and Their Mitigation Measures in Asia’. Advances in Entomology 10 (1): 14–33. https://doi.org/10.4236/AE.2022.101002.

Dinerstein, Eric, David Olson, Anup Joshi, Carly Vynne, Neil D. Burgess, Eric Wikramanayake, Nathan Hahn, et al. 2017. ‘An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm’. BioScience 67 (6): 534–45. https://doi.org/10.1093/biosci/bix014.

Ding, Yuanzhao. 2019. ‘Heavy Metal Pollution and Transboundary Issues in ASEAN Countries’. Water Policy 21 (5): 1096–1106. https://doi.org/10.2166/wp.2019.003.

Diss, Kathryn. 2019. ‘Recycled Electronics Are Turning Thailand into a “Dumping Ground for Hazardous Waste”’. ABC News.

Douville, H., K. Raghavan, J. Renwick, R.P. Allan, P.A. Arias, M. Barlow, R. Cerezo-Mota, et al. 2021. ‘Water Cycle Changes’. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, et al. Cambridge University Press.

Drzymała, J., and J. Kalka. 2020. ‘Ecotoxic Interactions between Pharmaceuticals in Mixtures:

Diclofenac and Sulfamethoxazole'. Chemosphere 259 (November): 127407. https://doi.org/10.1016/j.chemosphere.2020.127407.

Duke, N., K. Kathiresan, S.G. Salmo III, E.S. Fernando, J.R. Peras, S. Sukardjo, T Miyagi, et al. 2010. 'Bruguiera Hainesii'. The IUCN Red List of Threatened Species 2010.

EANET. 2019. 'Acid Deposition Monitoring Network in East Asia Fact Sheet'. Niigata.

———. n.d. 'Myanmar: Policies and Practices Concerning Acid Deposition'.

ECD, and MONREC. 2018. 'National Waste Management Strategy and Master Plan for Myanmar 2018-2030'. Government of Myanmar.

Eckstein, David, Vera Künzel, Laura Schäfer, and Maik Winges. 2020. GLOBAL CLIMATE RISK INDEX 2020 Who Suffers Most from Extreme Weather Events ? Weather-Related Loss Events in 2018 and 1999 to 2018.

Editors of Encyclopaedia Britannica. 2015. 'Tonle Sap'. In Encyclopaedia Britannica.

Elder, Mark. 2015a. 'Air Pollution and Regional Economic Integration in East Asia: Implications and Recommendations'. In Greening Integration in Asia: How Regional Integration Can Benefit People and the Environment, edited by IGES, 117–47. Hayama, Japan: Institute for Global Environmental Strategies.

———. 2015b. 'Air Pollution and Regional Economic Integration in East Asia: Implications and Recommendations'. In Greening Integration in Asia: How Regional Integration Can Benefit People and the Environment, edited by IGES, 117–47. Hayama, Japan: Institute for Global Environmental Strategies.

———. 2018. 'Regional Governance for Environmental Sustainability in Asia in the Context of Sustainable Development: A Survey of Regional Cooperation Frameworks'. In Routledge Handbook of Sustainable Development in Asia, edited by Sara Hsu, 468–94. London and New York: Routledge.

———. 2020. Assessment of ASEAN Countries' Concrete SDG Implementation Efforts: Policies and Budgets Reported in Their 2016-2020 Voluntary National Reviews (VNRs). Hayama, Japan: Institute for Global Environmental Strategies.

Elder, Mark, Magnus Bengtsson, and Lewis Akenji. 2016. 'An Optimistic Analysis of the Means of Implementation for Sustainable Development Goals: Thinking about Goals as Means'. Sustainability 8 (9): 962–86. https://doi.org/10.3390/su8090962.

Elder, Mark, and Gemma Ellis. 2022. 'ASEAN Countries' Environmental Policies for the Sustainable Development Goals (SDGs)'. Environment, Development and Sustainability. https://doi.org/10.1007/s10668-022-02514-0.

Elder, Mark, and Peter King. 2018. Realising the Transformative Potential of the SDGs. Hayama, Japan: IGES.

Elder, Mark, and Simon Høiberg Olsen. 2019. 'The Design of Environmental Priorities in the SDGs'. Global Policy 10 (S1): 70–82. https://doi.org/10.1111/1758-5899.12596.

Elder, Mark, and Eric Zusman. 2016. 'Strengthening The Linkages Between Air Pollution And The Sustainable Development Goals'. IGES Policy Brief, July 2016.

Ellis, S., and B. Talukdar. 2020a. 'Javan Rhinoceros'. The IUCN Red List of Threatened Species 2020.

———. 2020b. ‘Sumatran Rhinoceros’. The IUCN Red List of Threatened Species 2020.

Elmqvist, Thomas, Erik Andersson, Niki Frantzeskaki, Timon McPhearson, Per Olsson, Owen Gaffney, Kazuhiko Takeuchi, and Carl Folke. 2019. ‘Sustainability and Resilience for Transformation in the Urban Century’. Nature Sustainability 2 (4): 267–73. https://doi.org/10.1038/s41893-019-0250-1.

Enviliance Asia. n.d. ‘Thailand, Impacts of the Expandable Fire Accident at Polystyrene Factory’. Accessed 30 December 2021. https://enviliance.com/regions/southeast-asia/th/th-case-july2021.

———. n.d. ‘Thailand, Regulation Development Under Chemical Management Master Plan 2019 – 2037’.

Environment Division of the ASEAN Secretariat. n.d. ‘ASEAN Cooperation on Environmental Education’. Accessed 31 December 2021a. https://environment.asean.org/awgee/.

———. n.d. ‘ASEAN Cooperation on Water Resources Management’.

———. n.d. ‘ASEAN Eco-Schools Award Programme and ASEAN Youth Eco-Champions Award’. Accessed 31 December 2021b. https://environment.asean.org/asean-eco-schools-award-and-ayeca/.

ERIA. 2016. Towards a Circular Economy: Corporate Management and Policy Pathways. Edited by Venkatachalam Anbumozhi and Jootae Kim.

———. 2020. ‘COVID-19 and Southeast and East Asian Economic Integration: Understanding the Consequences for the Future’. Jakarta, Indonesia: Economic Research Institute for ASEAN and East Asia (ERIA).

Erkens, G., T. Bucx, R. Dam, G. De Lange, and J. Lambert. 2015. ‘Sinking Coastal Cities’. Proceedings of the International Association of Hydrological Sciences 372 (November): 189–98. https://doi.org/10.5194/PIAHS-372-189-2015.

Eslami, Sepehr, Piet Hoekstra, Nam Nguyen Trung, Sameh Ahmed Kantoush, Doan Van Binh, Do Duc Dung, Tho Tran Quang, and Maarten van der Vegt. 2019. ‘Tidal Amplification and Salt Intrusion in the Mekong Delta Driven by Anthropogenic Sediment Starvation’. Scientific Reports 9 (1): 1–10. https://doi.org/10.1038/s41598-019-55018-9.

Esteban, Miguel, Hiroshi Takagi, Laurice Jamero, Christopher Chadwick, John Erick Avelino, Takahito Mikami, Dyah Fatma, et al. 2020. ‘Adaptation to Sea Level Rise: Learning from Present Examples of Land Subsidence’. Ocean and Coastal Management 189 (May).

Estoque, Ronald C., Makoto Ooba, Valerio Avitabile, Yasuaki Hijioka, Rajarshi DasGupta, Takuya Togawa, and Yuji Murayama. 2019a. ‘The Future of Southeast Asia’s Forests’. Nature Communications 10 (1): 1–12. https://doi.org/10.1038/s41467-019-09646-4.

———. 2019b. ‘The Future of Southeast Asia’s Forests’. Nature Communications 2019 10:1 10 (1): 1–12. https://doi.org/10.1038/s41467-019-09646-4.

EU. 2022. ‘Promoting Sustainable Consumption and Production (SCP) in the Middle East, Asia and the Pacific’. Capacity4dev.

EU-ASEAN Strategic Partnership. 2021. EU ASEAN Strategic Partners Blue Book 2021. EU Mission to ASEAN.

European Commission. 2018. ‘EU-Vietnam Trade and Investment Agreements’. 2018.

———. 2021a. ‘Making Sustainable Products the Norm’.

———. 2021b. ‘Start of a New EU-Funded “Smart Green ASEAN Cities” Programme’. EURAXESS. 2021. https://euraxess.ec.europa.eu/worldwide/asean/start-new-eu-funded-“smart-green-asean-cities”-programme.

European Commission Copernicus Climate Change Service. 2022. ‘Land Cover Classification Gridded Maps from 1992 to Present Derived from Satellite Observations’. Copernicus.

Faghihinia, Maede, Yaoyang Xu, Dong Liu, and Naicheng Wu. 2021. ‘Freshwater Biodiversity at Different Habitats: Research Hotspots with Persistent and Emerging Themes’. Ecological Indicators 129 (October): 107926. https://doi.org/10.1016/j.ecolind.2021.107926.

FAO. 2011. ‘Global Food Losses and Food Waste: Extent, Causes and Prevention. FAO (Food and Agriculture Organization of the United Nations).’ Rome.

———. 2020a. ‘Global Forest Resources Assessment 2020’.

———. 2020b. The State of World Fisheries and Aquaculture 2020. FAO. https://doi.org/10.4060/ca9229en.

———. 2021. ‘Land Use Indicators’. FAO.

———. 2022. ‘Crops and Livestock Products’. FAOSTAT. 2022. https://www.fao.org/faostat/en/#data/QCL.

FAO, and UNEP. 2021. ‘Global Assessment of Soil Pollution: Report’. Global Assessment of Soil Pollution: Report, June. https://doi.org/10.4060/CB4894EN.

Fauna & Flora International Cambodia. 2020. ‘Investigating Solutions to Marine Plastic Pollution in Cambodia’.

Filho, Walter Leal, Ismaila Rimi Abubakar, Cintia Nunes, Johannes Platje, Pinar Gokcin Ozuyar, Markus Will, Gustavo J. Nagy, Abul Quasem Al-Amin, Julian David Hunt, and Chunlan Li. 2021. ‘Deep Seabed Mining: A Note on Some Potentials and Risks to the Sustainable Mineral Extraction from the Oceans’. Journal of Marine Science and Engineering 9, 521.

Forti, Vanessa, Cornelis P Balde, Ruediger Kuehr, and Garam Bel. 2020. ‘The Global E-Waste Monitor 2020: Quantities, Flows and the Circular Economy Potential’.

Frederick, William H., Thomas R. Leinbach, Adam Augustyn, Aakanksha Gaur, Amy McKenna, Veenu Setia, Amy Tikkanen, Grace Young, and The Editors of Encyclopaedia Britannica. 2020. ‘Drainage of Southeast Asia’. In Encyclopaedia Britannica.

Freire, Paulo. 1970. Pedagogy of the Oppressed. New York and London: Continuum.

Friess, Daniel A., Kerrylee Rogers, Catherine E. Lovelock, Ken W. Krauss, Stuart E. Hamilton, Shing Yip Lee, Richard Lucas, Jurgenne Primavera, Anusha Rajkaran, and Suhua Shi. 2019. ‘The State of the World’s Mangrove Forests: Past, Present, and Future’. Annual Review of Environment and Resources 44 (1): 89–115. https://doi.org/10.1146/annurev-environ-101718-033302.

Fu, Kaidao, and Daming He. 2007. ‘Analysis and Prediction of Sediment Trapping Efficiencies of the Reservoirs in the Mainstream of the Lancang River’. Chinese Science Bulletin 52 (SUPPL. 2): 134–40. https://doi.org/10.1007/s11434-007-7026-0.

GA Circular. 2020. ‘Safeguarding the Plastic Recycling Value Chain: Insights from COVID-19 Impact in South and Southeast Asia'. PEMSEA.

García-Gómez, José Carlos, Marta Garrigós, and Javier Garrigós. 2021. 'Plastic as a Vector of Dispersion for Marine Species With Invasive Potential. A Review'. Frontiers in Ecology and Evolution 9 (May): 208. https://doi.org/10.3389/FEVO.2021.629756/BIBTEX.

Garschagen, Matthias, Gusti Ayu Ketut Surtiari, and Mostapha Harb. 2018. 'Is Jakarta's New Flood Risk Reduction Strategy Transformational?' Sustainability (Switzerland) 10 (8). https://doi.org/10.3390/SU10082934.

Gavrilescu, Maria, Katerina Demnerova, Jens Aamand, Spiros Agathos, and Fabio Fava. 2015. 'Emerging Pollutants in the Environment : Present and Future Challenges in Biomonitoring , Ecological Risks and Bioremediation'. New Biotechnology 32 (1): 147–56. https://doi.org/10.1016/j.nbt.2014.01.001.

Ghazali, Nor Hisham M. 2007. 'Coastal Erosion and Reclamation in Malaysia'. New Pub: Michigan State University Press 9 (2): 237–47. https://doi.org/10.1080/14634980600721474.

Ghosh, Sadhan Kumar. 2020. Circular Economy: Global Perspective. Edited by Sadhan Kumar Ghosh. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-1052-6.

Giang, Pham Quy, Le Thi Giang, and Kosuke Toshiki. 2017. 'Spatial and Temporal Responses of Soil Erosion to Climate Change Impacts in a Transnational Watershed in Southeast Asia'. Climate, https://doi.org/10.3390/cli5010022-https://doi.org.

Gilfillan, Rob. 2020. 'Flexible Packaging Sees Demand Boost As Coronavirus Changes Consumer Patterns | Wood Mackenzie', 2020.

Gitz, Vincent., Alexandre. Meybeck, Leslie. Lipper, Cassandra. Young, and Susan. Braatz. 2015. 'Climate Change and Food Security: Risks and Responses'. Food and Agriculture Organization of the United Nations. Rome, Italy. https://doi.org/10.1080/14767058.2017.1347921.

GIZ. 2020. 'National Adaptation Plan : NAP Vision'. 2020. www.climate.onep.go.th.

———. 2021. 'Strengthening Reduce, Reuse, Recycle (3R) to Preserve Marine Biodiversity'. GIZ GmbH. 2021. https://www.giz.de/en/worldwide/105755.html.

Global Carbon Project. 2021. 'Global Carbon Project (GCP)'.

Global Cement. 2021. 'Global Cement Directory 2021'.

Global Invasive Species Database. 2022. 'Species Profile: Mimosa Pigra'. Global Invasive Species Database. 2022. http://iucngisd.org/gisd/species.php?sc=41 on 29-08-2022.

GMS Environment Operations Center. n.d. 'About the GMS Environment Operations Center'. Accessed 31 December 2021a. http://gms-eoc.org/GMS-eoc%0A.

———. n.d. 'The Core Environment Program'. Accessed 31 December 2021b. http://www.gms-eoc.org/the-program.

———. n.d. 'Working Group on Environment'. Accessed 31 December 2021c. http://www.gms-eoc.org/working-group-on-environment%0A.

Gomes, Inês B, Jean-Yves Maillard, Lucia C. Simões, and Manuel Simões. 2020. 'Emerging Contaminants

Affect the Microbiome of Water Systems — Strategies for Their Mitigation'. Npj Clean Water 3 (39). https://doi.org/10.1038/s41545-020-00086-y.

Gomollón-Bel, Fernando. 2021. 'IUPAC Top Ten Emerging Technologies in Chemistry 2021 Breakthroughs for a Circular, Climate-Neutral Future'.

Gough, Annette. 2013. 'Historical, Contextual and Theoretical Orientations That Have Shaped Environmental Education Research.' In International Handbook of Research on Environmental Education, edited by Robert B. Stevenson, Michael Brody, Justin Dillon, and Arjen E.J. Wals, 9–12. Routledge.

Government of Indonesia. 2021. 'Indonesia Third Biennial Update Report'.

Government of Singapore. 2018. Towards a Sustainable and Resilient Singapore: Singapore's Voluntary National Review Report to the 2018 UN High Level Political Forum on Sustainable Development. Singapore: Ministry of Foreign Affairs, Singapore.

———. 2019a. Resources Sustainability Act 2019. Singapore: Republic of Singapore.

———. 2019b. 'Yearbook of Statistics Singapore 2019'. Singapore.

———. 2021. 'Singapore Green Plan 2030'. 2021. https://www.greenplan.gov.sg/.

Government of Thailand. 2019. 'Thailand's Sixth National Report on the Implementation of the Convention on Biological Diversity'.

Government of the Philippines. 2019. 'The 2019 Voluntary National Review of the Philippines'.

Government of Viet Nam. 2020. 'Vietnam Third Biennial Update Report'.

———. 2022. 'Decree 08/2022/ND-CP Detailing a Number of Articles of the Law on Environmental Protection'.

Government of Viet Nam, and Online Newspaper of the Government of the Socialist Republic of Viet Nam. 2021. National Green Growth Strategy for 2021-2030, Vision towards 2050.

Grebmer, K von, J Bernstein, C Delgado, D Smith, M Wiemers, T Schiffer, A Hanano, et al. 2021. 'Global Hunger Index: Hunger and Food Systems in Conflict Settings'.

Greenpeace Southeast Asia. 2019. Policy Brief: Southeast Asia's Struggle against the Plastic Waste Trade.

Greenstone, Michael, and Qing (Claire) Fan. 2019. 'Indonesia's Worsening Air Quality and Its Impact on Life Expectancy'.

Greenview. 2021. 'Final Study Report for the Post-COVID-19 Recovery Plan for ASEAN Tourism'.

Grizzetti, B., D. Lanzanova, C. Liquete, A. Reynaud, and A. C. Cardoso. 2016. 'Assessing Water Ecosystem Services for Water Resource Management'. Environmental Science and Policy 61: 194–203. https://doi.org/10.1016/j.envsci.2016.04.008.

Güneralp, Burak, Meredith Reba, Billy U. Hales, Elizabeth A. Wentz, and Karen C. Seto. 2020. 'Trends in Urban Land Expansion, Density, and Land Transitions from 1970 to 2010: A Global Synthesis'. Environmental Research Letters 15 (4). https://doi.org/10.1088/1748-9326/ab6669.

Gutiérrez, J. M., R. G. Jones, G. T. Narisma, L. M. Alves, M. Amjad, I. V. Gorodetskaya, M. Grose, et al.

2021. 'Atlas'. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, et al. Cambridge University Press.

Ha, Hoang Thi, and Farah Nadine Seth. 2021. 'The Mekong River Ecosystem in Crisis: ASEAN Cannot Be a Bystander'. ISEAS Perspective.

Hackney, Christopher R, Stephen E Darby, Daniel R Parsons, and Julian Leyland. 2020. 'River Bank Instability Induced by Unsustainable Sand Mining in the Mekong River'. Nature Sustainability 3: 217–25. https://doi.org/10.1038/s41893-019-0455-3.

Han, E.S., Goleman, D., Boyatzis, R., Mckee, A. 2020. Review of Maritime Transport 2020. Journal of Chemical Information and Modeling. Vol. 53.

Hanaoka, Tatsuya, and Toshihiko Masui. 2018. 'Co-Benefit Reductions of Short-Lived Climate Pollutants and Air Pollutants by 2050 While Achieving the 2 Degree Target in Asia'. Journal of Sustainable Development of Energy, Water and Environment Systems 6 (3): 505–20. https://doi.org/10.13044/j.sdewes.d6.0218.

Harper, Gavin, Roberto Sommerville, Emma Kendrick, Laura Driscoll, Peter Slater, Rustam Stolkin, Allan Walton, et al. 2019. 'Recycling Lithium-Ion Batteries from Electric Vehicles'. Nature 2019 575:7781 575 (7781): 75–86. https://doi.org/10.1038/s41586-019-1682-5.

Harris, Ian, Timothy J Osborn, Phil Jones, and David Lister. 2020. 'Version 4 of the CRU TS Monthly High-Resolution Gridded Multivariate Climate Dataset'. Scientific Data 7 (1): 109. https://doi.org/10.1038/s41597-020-0453-3.

Hasnan, L. 2019. 'Sand Mining in Malaysia | The ASEAN Post'. The ASEAN Post. 2019. https://theaseanpost.com/article/sand-mining-malaysia.

Health Effects Institute. 2020a. 'State of Global Air 2020'. State of Global Air 2020.

———. 2020b. 'State of Global Air 2020'. State of Global Air 2020. 2020. https://www.stateofglobalair.org/data/#/air/plot.

Hegnsholt, Esben, Shalini Unnikrishnan, Matias Pollmann-Larsen, Björg Askelsdottir, and Marine Gerard. 2018. 'Tackling the 1.6-Billion-Ton Food Loss and Waste Crisis'.

Henlock, Magnus, Malin zu Castell-Rüdenhausen, Margareta Wahlström, Birgitte Kjær, Leonidas Milios, Eldbjørg Vea, David Watson, et al. 2014. Economic Policy Instruments for Plastic Waste.

Hermawan, Sapto, and Wida Astuti. 2021. 'Analysing Several ASEAN Countries' Policy for Combating Marine Plastic Litter'. Environmental Law Review 23 (1). https://doi.org/10.1177/1461452921991731.

Hernández, A. J., and J. Pastor. 2008. 'Relationship between Plant Biodiversity and Heavy Metal Bioavailability in Grasslands Overlying an Abandoned Mine'. Environmental Geochemistry and Health 30 (2): 127–33. https://doi.org/10.1007/s10653-008-9150-4.

Hicks, Robin. 2020. 'Covid-19 Has Hobbled Asia's Recycling Trade as Demand for Recycled Plastic Dips and Recyclers Face Ruin'. Eco-Business, 30 August 2020.

High-level Experts and Leaders Panel on Water and Disasters (HELP). 2017. 'ASEAN-ROK Project: Building Resilience for Sustainable ASEAN (from WaterRelated Disasters)'. Gyeongju, Republic of Korea.

Ho, Y.M., and M. Azizi. 2009. 'Assessment of Pre-Service Teachers' Environmental Citizenship Attributes:

Implications for EE Curriculum and Teaching'. In Proceedings 3rd International Conference on Science and Mathematics Education (COSMEd), 10-12 Nov 2009. Pulau-Pinang.

Hoang, P Long, Michelle T H.van Vliet, Matti Kummu, Hannu Lauri, Jorma Koponen, Iwan Supit, Rik Leemans, Pavel Kabata, and Fulco Ludwig. 2019. 'The Mekong's Future Flows under Multiple Drivers: How Climate Change, Hydropower Developments and Irrigation Expansions Drive Hydrological Changes'. Science of The Total Environment, 649: 601-609–609.

Hoffmann, Roman, and Raya Muttarak. 2020. 'Greening through Schooling : Understanding the Link between Education and pro-Environmental Behavior in the Philippines Greening through Schooling : Understanding the Link between Education and pro-Environmental Behavior in the Philippines'. Environment Research Letter 15.

Hogan, Z. 2011a. 'Giant Carp'. The IUCN Red List of Threatened Species 2011.

———. 2011b. 'Mekong Giant Catfish'. The IUCN Red List of Threatened Species 2011. 2011. https://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T15944A5324699.en.

Hondo, Derek, Linda Arthur, and Premakumara Jagath Dickella Gamaralalage. 2020. 'Solid Waste Management in Developing Asia: Prioritizing Waste Separation' 2020 (7).

Hooijer, A., and R. Vernimmen. 2021. 'Global LiDAR Land Elevation Data Reveal Greatest Sea-Level Rise Vulnerability in the Tropics'. Nature Communications 12 (1): 1–7. https://doi.org/10.1038/s41467-021-23810-9.

Hotta, Yasuhiko, Tomohiro Tasaki, and Ryu Koide. 2021. 'Expansion of Policy Domain of Sustainable Consumption and Production (SCP): Challenges and Opportunities for Policy Design'. Sustainability 2021, Vol. 13, Page 6763 13 (12): 6763. https://doi.org/10.3390/SU13126763.

Hughes, Alice C. 2017. 'Understanding the Drivers of Southeast Asian Biodiversity Loss'. Ecosphere 8 (1). https://doi.org/10.1002/ecs2.1624.

Hume, Therese, and John Barry. 2015. Environmental Education and Education for Sustainable Development. International Encyclopedia of the Social & Behavioral Sciences: Second Edition. Second Edi. Vol. 7. Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.91081-X.

Huy, Lai Nguyen, Ekbordin Winijkul, and Nguyen Thi Kim Oanh. 2021. 'Assessment of Emissions from Residential Combustion in Southeast Asia and Implications for Climate Forcing Potential'. Science of the Total Environment 785 (September). https://doi.org/10.1016/j.scitotenv.2021.147311.

IBRRI, and IUCN. 2020. 'Wetlands of Southeast Asia'. IUCN. 2020. https://digital.iucn.org/regions/asia/wetlands-of-southeast-asia/.

ICEM. 2010. 'MRC Strategic Environmental Assessment (SEA) of Hydropower on the Mekong Mainstream'.

IEA. 2019. 'Southeast Asia Energy Outlook 2019'.

———. 2020. 'Electricity Market Report'.

———. 2021a. 'ASEAN Roadmaps Towards Sustainable and Energy Efficient Buildings and Cooling in Southeast Asia'.

———. 2021b. 'Net Zero by 2050 – Analysis'. Net Zero by 2050.

———. 2021c. 'The Role of Critical World Energy Outlook Special Report Minerals in Clean Energy Transitions'.

IFRC. 2020. 'Viet Nam: Drought and Saltwater Intrusion'.

IGES. 2015. ‘Greening Integration in Asia How Regional Integration Can Benefit People and the Environment’.

———. 2018. ‘Outlook on Water Environmental Management in Asia 2018’. Hayama, Japan.

———. 2020. ‘Implications of COVID-19 for the Environment and Sustainability (Version 2): Perspectives from the Triple R (Response , Recovery , Redesign) Framework Purpose of the Position Paper (Version 2)’, no. December: 1–22.

IMF. 2018a. ASEAN Progress Towards Sustainable Development Goals and the Role of International Monetary Fund. Bali, Indonesia: International Monetary Fund.

———. 2018b. ASEAN Progress Towards Sustainable Development Goals and the Role of International Monetary Fund. Bali, Indonesia: International Monetary Fund. https://www.imf.org/en/Publications/Policy-Papers/Issues/2018/11/07/pp101118asean-progress-towards-sdgs.

IMT-GT. n.d. ‘About IMT-GT’. Indonesia-Malaysia-Thailand Growth Triangle. Accessed 31 December 2021a. https://imtgt.org/about-imt-gt/.

———. n.d. ‘Strategies to Spearhead Growth’. Indonesia-Malaysia-Thailand Growth Triangle. Accessed 31 December 2021b. https://imtgt.org/wge/.

Independent Group of Scientists. 2019. Global Sustainable Development Report 2019. New York: United Nations.

Indra Overland. 2017. ‘Impact of Climate Change on ASEAN International Affairs: Risk and Opportunity Multiplier’.

InforMEA. 2015. ‘Status of Ratification of the Basel, Rotterdam and Stockholm Conventions’. InforMEA. 2015. https://www.informea.org/en/status-ratification-basel-rotterdam-and-stockholm-conventions.

International Association of Universities. 2020. ‘Regional/National Perspectives on the Impact of COVID-19 on Higher Education’.

International Seabed Authority. n.d. ‘Exploration Contracts’. International Seabed Authority.

IPBES. 2018. ‘The Regional Assessment Report on Biodiversity and Ecosystem Services for Asia and the Pacific’. Edited by M. Karki, S. Senaratna Sellamuttu, S. Okayasu, and W. Suzuki. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany.

———. 2019. ‘Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services’. Debating Nature’s Value.

IPBES Secretariat. 2021. ‘Members and Observers’. 2021. https://ipbes.net/members-observers?field_ipbes_member_value=All&field_region_target_id=284&page=5.

IPCC. 2013. ‘Fifth Assessment Report (AR5)’.

———. 2018. ‘IPCC Special Report on Global Warming of 1.5°C’. Vol. 2.

———. 2020. ‘Climate Change and Land’. Climate Change and Land: Summary for Policymakers. https://doi.org/10.1002/9781118786352.wbieg0538.

———. 2021a. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the

Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Edited by S. I. Seneviratne, X. Zhang, M. Adnan, W. Badi, C. Dereczynski, A. Di Luca, S. Ghosh, et al. Cambridge, United Kingdom.

———. 2021b. 'Summary for Policymakers'. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, et al., 42. Cambridge University Press.

———. 2022. 'Summary for Policymakers'. In Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, et al. Cambridge, United Kingdom and New York, USA: Cambridge University Press.

IRENA. 2019. 'Renewable Power Generation Costs in 2018'. Abu Dhabi.

———. 2020. 'Global Renewables Outlook: Energy Transformation 2050'. Abu Dhabi.

IRP. 2017. 'Green Technology Choices: The Environmental and Resource Implications of Low-Carbon Technologies'. Nairobi, Kenya.

———. 2018. The Weight of Cities: Resource Requirements of Future Urbanization. Edited by M. Swilling, M. Hajer, T. Baynes, J. Bergesen, F. Labbé, J.K. Musango, A. Ramaswami, et al. Nairobi, Kenya.

———. 2020. 'Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future'. Edited by N. Hertwich, E., Lifset, R., Pauliuk, S., Heeren. Nairobi, Kenya.

———. 2021. 'Global Material Flows Database'. Global Material Flows Database. 2021.

Ismail, Maizura. 2018. 'Losing Our Water to Tourism'. The ASEAN Post, 2018.

IUCN. 2020. IUCN Global Ecosystem Typology 2.0: Descriptive Profiles for Biomes and Ecosystem Functional Groups. Edited by David A. Keith, Jose R. Ferrer-Paris, Emily Nicholson, and Richard T. Kingsford. IUCN, International Union for Conservation of Nature. https://doi.org/10.2305/IUCN.CH.2020.13.en.

———. 2021. Nature 2030: One Nature, One Future. International Union for Conservation of Nature. https://portals.iucn.org/library/sites/library/files/documents/WCC-7th-001-En.pdf.

———. 2022. 'Statistics'. IUCN Red List. 2022. https://www.iucnredlist.org/search/stats.

Ives, Mike. 2016. 'The Rising Environmental Toll of China's Offshore Island Grab'. Yale Environment 360.

Iwata, Masamitsu, Yoshitaka Yabumoto, Toshiro Saruwatari, Shinya Yamauchi, Kenichi Fujii, Rintaro Ishii, Toshiaki Mori, et al. 2019. 'Field Surveys on the Indonesian Coelacanth, Latimeria Menadoensis Using Remotely Operated Vehicles from 2005 to 2015'. Bulletin of the Kitakyushu Museum of Natural History and Human History, Series A (Natural History) 17: 49–56. https://doi.org/10.34522/kmnh.17.0_49.

Jacobs, T. 2021. 'Southeast Asian Producers Want To Tie Their Future to Region's Growing Energy Demand'. Journal of Petroleum Geology, April.

JAIF Management Team. 2020. 'ASEAN Strengthens the ASEAN Heritage Parks Programme through Capacity Building and Information Development'. 2020. https://jaif.asean.org/beneficiaries_voice/asean-strengthens-the-asean-heritage-parks-programme-through-capacity-building-and-information-development/.

———. n.d. 'JAIF 2.0'. Japan-ASEAN Integration Fund. Accessed 31 December 2021a. https://jaif.asean.org/jaif-component/jaif-2-0/%0A.

———. n.d. 'Original JAIF'. Japan-ASEAN Integration Fund. Accessed 31 December 2021b. https://jaif.asean.org/jaif-component/original-jaif/.

Jain, Amit. 2017. 'Waste Management in ASEAN Countries: Summary Report'. Bangkok, Thailand.

Jalal, Fasli. 2014. 'Education for Sustainable Development : The Case of Indonesia'.

Jambeck, Jenna R., Roland Geyer, Chris Wilcox, Theodore R. Siegler, Miriam Perryman, Anthony Andrady, Ramani Narayan, and Kara Lavender Law. 2015. 'Plastic Waste Inputs from Land into the Ocean'. Science 347 (6223): 768–71. https://doi.org/10.1126/science.1260352.

Jenkins, Tia, Bhaleka D. Persaud, Win Cowger, Kathy Szigeti, Dominique G. Roche, Erin Clary, Stephanie Slowinski, et al. 2022. 'Current State of Microplastic Pollution Research Data: Trends in Availability and Sources of Open Data'. Frontiers in Environmental Science 0 (June): 824. https://doi.org/10.3389/FENVS.2022.912107.

JICA. 2017. 'Thematic Guidelines on Urban and Regional Development'. Tokyo, Japan.

Jickling, Bob, and Arjen E.J. Wals. 2008. 'Globalization and Environmental Education: Looking beyond Sustainable Development'. Journal of Curriculum Studies 40 (1): 1–21. https://doi.org/10.1080/00220270701684667.

Jin, Yeoh Wee. 2021. 'ASEAN Steel Industry: Steel Market Developments'. ASEAN Steel Industry: Steel Market Developments. Steel Committee Meeting, OECD.

Johansson, C. Henrik, Lisa Janmar, and Thomas Backhaus. 2014. 'Toxicity of Ciprofloxacin and Sulfamethoxazole to Marine Periphytic Algae and Bacteria'. Aquatic Toxicology 156 (November): 248–58. https://doi.org/10.1016/j.aquatox.2014.08.015.

Jones, David Seth. 2006. 'ASEAN and Transboundary Haze Pollution in Southeast Asia'. Asia Europe Journal 4 (3): 431–46. https://doi.org/10.1007/s10308-006-0067-1.

Kadarudin, Ahsan Yunus, Andi Muhammad Aswin Anas, Andi Kurniawati, Mutiah Wenda Juniar, Andi Suci Wahyuni, and Arini Nur Annisa. 2020. 'Bangkok Declaration and Awareness of ASEAN Member Countries: The Regional Law of Cleaning Our Oceans'. Journal of Critical Reviews 7 (19). https://doi.org/10.31838/jcr.07.19.110.

Karki, Madhav, Rosemary Hill, Dayuan Xue, Wilfredo Alangui, Kaoru Ichikawa, and Peter Bridgewater. 2017. Knowing Our Lands and Resources: Indigenous and Local Knowledge and Practices Related to Biodiversity and Ecosystem Services in Asia. UNESCO.

Kaza, Silpa, Lisa C Yao, Perinaz Bhada-Tata, and Frank Van Woerden. 2018. 'What a Waste 2.0'. What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. https://doi.org/10.1596/978-1-4648-1329-0.

Kiddee, Peeranart, and Somsiri Decharat. 2018. 'Risk Assessment of Lead and Cadmium Exposure from Electronic Waste Recycling Facilities in Southern Thailand'. Environmental Earth Sciences 2018 77:12 77 (12): 1–7. https://doi.org/10.1007/S12665-018-7648-3.

Kieu, Thi Kinh, Singer Jane Tracey, and Jean Gannon. 2016. 'Education for Sustainable Development in Vietnam : Lessons Learned from Teacher Education'. International Journal of Sustainability in Higher Education 17 (6): 853–74. https://doi.org/10.1108/IJSHE-05-2015-0098.

Kim Oanh, Nguyen Thi, Didin Agustian Permadi, Philip K. Hopke, Kirk R. Smith, Nguyen Phan Dong, and Anh Nguyet Dang. 2018. 'Annual Emissions of Air Toxics Emitted from Crop Residue Open Burning in Southeast Asia over the Period of 2010–2015'. Atmospheric Environment 187 (August): 163–73. https://doi.org/10.1016/j.atmosenv.2018.05.061.

Kirezci, Ebru, Ian R. Young, Roshanka Ranasinghe, Daniel Lincke, and Jochen Hinkel. 2023. 'Global-Scale Analysis of Socioeconomic Impacts of Coastal Flooding over the 21st Century'. Frontiers in Marine Science 9 (January): 2808. https://doi.org/10.3389/FMARS.2022.1024111.

Kollmuss, Anja, and Julian Agyeman. 2002. 'Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to pro-Environmental Behavior?' Environmental Education Research 8 (3): 239–60.

Korea Environment Institute (KEI). 2018. Environmental Sustainability in Asia: Progress, Challenges and Opportunities in the Implementation of the Sustainable Development Goals, Series 2 - Cambodia. Edited by Hyun Woo Lee and Jun Hyun Park. Vol. Series 2-CAMBODIA. KEI.

Koto, J, and Ridho Bela Negara. 2018. 'Study on Rivers Pollution in DKI Jakarta'. Journal of Ocean, Mechanical and Aerospace 52 (52): 6–13.

Kumar, Manish, WLE Greater Mekong, M. O. Rodrigues, A. M.M. Gonçalves, F. J.M. Gonçalves, H. Nogueira, J. C. Marques, et al. 2021. 'The Urgency of Maintaining Safe and Clean Water Availability in Indonesia'. Marine Pollution Bulletin 12 (1): 245–51. https://doi.org/10.1038/d41586-021-01143-3.

Kunzmann, Andreas, Zainal Arifin, and Gunilla Baum. 2018. 'Pollution of Coastal Areas of Jakarta Bay: Water Quality and Biological Responses'. Marine Research in Indonesia 43 (1): 37.

Kyburz-Gruber, H. 2013. 'Socioecological Approaches to Environmental Education and Research'. In International Handbook of Research on Environmental Education, edited by Robert B Stevenson, Michael Brody, Justin Dillon, and Arjen E.J. Wals, 23–32. Routledge.

Ladou, Joseph, and Sandra Lovegrove. 2013. 'Export of Electronics Equipment Waste'. Http://Dx.Doi.Org/10.1179/Oeh.2008.14.1.1 14 (1): 1–10. https://doi.org/10.1179/OEH.2008.14.1.1.

LakePedia. 2021. 'Lake Matano'. Lakepedia.Com. 2021. https://www.lakepedia.com/lake/matano.html.

Lancang-Mekong Cooperation China Secretariat. 2017. '3+5 Cooperation Framework'. Lancang-Mekong Cooperation. 2017. http://www.lmcchina.org/eng/2017-12/14/content_41449855.html%0A.

———. n.d. 'About LMC'. Lancang-Mekong Cooperation. Accessed 31 December 2021. http://www.lmcchina.org/eng/node_1009536.html.

Le, Nhu Da, Anh Quoc Hoang, Thi Thu Ha Hoang, Thi Anh Huong Nguyen, Thi Thuy Duong, Thi Mai Huong Pham, Tien Dat Nguyen, et al. 2021. 'Antibiotic and Antiparasitic Residues in Surface Water of Urban Rivers in the Red River Delta (Hanoi, Vietnam): Concentrations, Profiles, Source Estimation, and Risk Assessment'. Environmental Science and Pollution Research 28 (9): 10622–32. https://doi.org/10.1007/s11356-020-11329-3.

Lebreton, Laurent C M, Joost Van Der Zwet, Jan Willem Damsteeg, Boyan Slat, Anthony Andrady, and Julia Reisser. 2017. 'River Plastic Emissions to the World's Oceans'. Nature Communications 2017 8:1 8 (1): 1–10. https://doi.org/10.1038/ncomms15611.

Lee, Benjamin P.Y.H., Zoe G. Davies, and Matthew J. Struebig. 2017. ‘Smoke Pollution Disrupted Biodiversity during the 2015 El Niño Fires in Southeast Asia’. Environmental Research Letters 12 (9). https://doi.org/10.1088/1748-9326/aa87ed.

Lee, Eunhee, Ramasamy Jayakumar, Sangam Shrestha, and Zaisheng Han. 2018. ‘Assessment of Transboundary Aquifer Resources in Asia: Status and Progress towards Sustainable Groundwater Management’. Journal of Hydrology: Regional Studies 20 (November 2017): 103–15. https://doi.org/10.1016/j.ejrh.2018.01.004.

Lee Goi, Chai. 2020. ‘The River Water Quality before and during the Movement Control Order (MCO) in Malaysia’. Case Studies in Chemical and Environmental Engineering 2 (May): 100027. https://doi.org/10.1016/j.cscee.2020.100027.

Lee, Hsiang He, Oussama Iraqui, Yefu Gu, Steve Hung Lam Yim, Apisada Chulakadabba, Adam Yiu Ming Tonks, Zhengyu Yang, and Chien Wang. 2018. ‘Impacts of Air Pollutants from Fire and Non-Fire Emissions on the Regional Air Quality in Southeast Asia’. Atmospheric Chemistry and Physics 18 (9): 6141–56. https://doi.org/10.5194/ACP-18-6141-2018.

Lele, Sharachchandra. 2020. ‘Environment and Well-Being’. New Left Review, May/June.

Li, Ying, and Douglas J. Crawford-Brown. 2011. ‘Assessing the Co-Benefits of Greenhouse Gas Reduction: Health Benefits of Particulate Matter Related Inspection and Maintenance Programs in Bangkok, Thailand’. Science of The Total Environment 409 (10): 1774–85. https://doi.org/10.1016/j.scitotenv.2011.01.051.

Li-Lian, Sharon Seah. 2020. ‘Is ASEAN Ready to Deal with Climate Change’. ASEAN Focus 1/2020: 12–13.

Lim, Cheng Ling, Graham W Prescott, Jose Don T De Alban, Alan D Ziegler, and Edward L Webb. 2017. ‘Untangling the Proximate Causes and Underlying Drivers of Deforestation and Forest Degradation in Myanmar’. Conservation Biology, 31(6): 1362-1372–1372.

Lim, S.B, J.A Malek, M.Y Hussain, Z Tahir, and N.H.M Saman. 2021. ‘SDGs, Smart Urbanism, and Politics: Stakeholder Partnerships and Environmental Cases in Malaysia’. Journal of Sustainability Science and Management.

Lim, Yvonne A.L., and Veeranoot Nissapatorn. 2017. ‘Transmission of Waterborne Parasites in the Association of Southeast Asian Nations (ASEAN): Overview and Direction Forward’. Food and Waterborne Parasitology 8–9 (June): 75–83. https://doi.org/10.1016/j.fawpar.2017.08.001.

Limates, Vilma G., Virginia C. Cuevas, and E. Benigno. 2016. ‘Water Quality and Nutrient Loading in the Coastal Waters of Boracay Island, Malay, Aklan, Central Philippines’. Journal of Environmental Science and Management Special Issue 2-2016.

Lin, Mayuri Mei, and Rafki Hidayat. 2018. ‘Jakarta, the Fastest-Sinking City in the World’. BBC Indonesian, 13 August 2018.

Lin, T. Y., V. M.Van Onselen, and L. P. Vo. 2021. ‘Coastal Erosion in Vietnam: Case Studies and Implication for Integrated Coastal Zone Management in the Vietnamese South-Central Coastline’. In IOP Conference Series: Earth and Environmental Science. Vol. 652. https://doi.org/10.1088/1755-1315/652/1/012009.

Liu, Chen, Toru Nishiyama, Katsuya Kawamoto, and So Sasaki. 2020. ‘CCET Guideline Series on Intermediate Municipal Solid Waste Treatment Technologies: Waste-to-Energy Incineration’.

Liu, Chen, Kazunobu Onogawa, and Dickella Gamaralalage Jagath Premakumara. 2018. ‘Paradigm Shift from Incineration to Resource Management and Town Development: The Case of Oki Town’.

Lloyd's Register. 2019. 'National Ballast Water Management Requirements', March.

Lorenzo, Theresa E., and Ann P. Kinzig. 2020a. 'Double Exposures: Future Water Security across Urban Southeast Asia'. Water (Switzerland) 12 (1). https://doi.org/10.3390/w12010116.

———. 2020b. 'Double Exposures: Future Water Security across Urban Southeast Asia'. Water (Switzerland) 12 (1). https://doi.org/10.3390/w12010116.

Loubser, Callie, Noor Azlin Yahya, Dreyer Johann, Nik Azyyati, and Abdul Kadir. 2014. 'The Effectiveness of Environmental Education Workshops for Teachers, Learners and Schools in Malaysia'. EnvironmenDevelopment and Sustainability; Dordrecht 16 (6): 1163–76.

Ma, Chang, John Rogers, and Sili Zhou. 2020. 'Modern Pandemics: Recession and Recovery'. International Finance Discussion Paper 2020 (1295). https://doi.org/10.17016/ifdp.2020.1295.

Mader, André D, Neil A Waters, Erin C Kawazu, Michelle Marvier, Noémie Monnin, and Daniel J Salkeld. 2022. 'Messaging Should Reflect the Nuanced Relationship between Land Change and Zoonotic Disease Risk'. BioScience, September. https://doi.org/10.1093/biosci/biac075.

Mahat, Hanifah, and Shaharudin Idrus. 2016. 'Education for Sustainable Development in Malaysia: A Study of Teacher and Student Awareness'. Malaysian Journal of Society and Space 12 (6): 77–88.

Marfai, Muh Aris. 2014. 'Impact of Sea Level Rise to Coastal Ecology: A Case Study on the Northern Part of Java Island, Indonesia'. Quaestiones Geographicae 33 (1): 107–14. https://doi.org/10.2478/QUAGEO-2014-0008.

Marks, Danny. 2015. 'The Urban Political Ecology of the 2011 Floods in Bangkok: The Creation of Uneven Vulnerabilities'. Pacific Affairs 88 (3): 623–51. https://doi.org/10.5509/2015883623.

Marlier, Miriam E., Ruth S. DeFries, Patrick S. Kim, Shannon N. Koplitz, Daniel J. Jacob, Loretta J. Mickley, and Samuel S. Myers. 2015. 'Fire Emissions and Regional Air Quality Impacts from Fires in Oil Palm, Timber, and Logging Concessions in Indonesia'. Environmental Research Letters 10 (8): 085005. https://doi.org/10.1088/1748-9326/10/8/085005.

Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, et al. 2021. 'The Physical Science Basis Summary for Policymakers Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change'.

McElwee, Pamela, Hương Vũ, Giang Võ, and Dianne Lê. 2022. 'Patriotism, Place, and Provisioning: Assessing Cultural Ecosystem Services through Longitudinal and Historical Studies in Vietnam'. Ecology and Society 27 (1): art3. https://doi.org/10.5751/ES-12615-270103.

McGee, Terry G. 2008. 'Managing the Rural–Urban Transformation in East Asia in the 21st Century'. Sustainability Science 3 (1): 155–67. https://doi.org/10.1007/s11625-007-0040-y.

———. 2014. 'The Emergence of Desakota Regions in Asia: Expanding a Hypothesis'. In Implosions/Explosions: Towards a Study of Planetary Urbanization, edited by Neil Brenner, 121–37. Berlin: Jovis.

McKenzie, Len J, Lina M Nordlund, Benjamin L Jones, Leanne C Cullen-Unsworth, Chris Roelfsema, and Richard K F Unsworth. 2020. 'The Global Distribution of Seagrass Meadows'. Environmental Research Letters 15 (7): 74041. https://doi.org/10.1088/1748-9326/ab7d06.

McKirdy, Euan. 2018. 'Boracay Reopens to Tourism, but Its Party Days Are Over'. CNN, 26 October 2018.

Meijer, Lourens J. J., Tim van Emmerik, Ruud van der Ent, Christian Schmidt, and Laurent Lebreton. 2021. ‘More than 1000 Rivers Account for 80% of Global Riverine Plastic Emissions into the Ocean’. Science Advances 7 (18). https://doi.org/10.1126/SCIADV.AAZ5803.

Mekong River Commission. 1995. ‘Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin’.

———. 2017. ‘1995 Mekong Agreement and Procedures’.

———. 2019. ‘State of the Basin Report 2018’.

———. 2021. ‘The Integrated Water Resources Management–Based Basin Development Strategy for the Lower Mekong Basin 2021–2030 and the MRC Strategic Plan 2021–2025’. Vientiane: MRC Secretariat.

———. n.d. ‘Mekong River Commission’. Accessed 31 December 2021a. https://www.mrcmekong.org/about/mrc/%0A.

———. n.d. ‘Water Quality Conditions’. Accessed 11 October 2021b. https://portal.mrcmekong.org/monitoring/water-quality.

Mélanie, Jane, Marina Kim, Sam Hester, Peter Berry, Allison Ball, Karen Schneider, Paul Burke, Le Hoa Au Duong, and Adam McCarty. 2005. ‘Enhancing ASEAN Minerals Trade and Investment’. REPSF Project No. 04/009b.

Mertz, O., and T. B. Bruun. 2017. ‘Shifting Cultivation Policies in Southeast Asia: A Need to Work with, Rather than against, Smallholder Farmers.’ In Shifting Cultivation Policies: Balancing Environmental and Social Sustainability, 27–42. Wallingford: CABI. https://doi.org/10.1079/9781786391797.0027.

Miettinen, Jukka, Chenghua Shi, and Soo Chin Liew. 2016. ‘Land Cover Distribution in the Peatlands of Peninsular Malaysia, Sumatra and Borneo in 2015 with Changes since 1990’. Global Ecology and Conservation 6 (April): 67–78. https://doi.org/10.1016/j.gecco.2016.02.004.

Minamata Convention on Mercury Secretariat. 2021. ‘Parties and Signatories’. 2021.

Ministry of Education and Training, UNESCO, and Samsung ESD Initiative. 2015. ‘Working Together for a More Resilient and Sustainable Society’.

Ministry of Environment and Water Malaysia. 2021. ‘Environmental Sustainability in Malaysia 2020 - 2030’. Malaysia.

———. 2022. ‘Environmental Award Sustainable Schools’. 2022. https://www.doe.gov.my/en/environmental-award-sustainable-schools/#:~:text=Definition of Sustainable Schools- Environmental,sustainability of life on earth.

Ministry of Foreign Affairs of the Republic of Korea. 2020. ‘ASEAN and ROK Agree to Establish Dialogue on Environment and Climate Change’. Ministry of Foreign Affairs, Republic of Korea.

———. 2021. ‘Outcome of the 1st ROK-BIMP-EAGA Senior Officials’ Meeting via Video Conference (Oct. 21)’. Ministry of Foreign Affairs, Republic of Korea.

Ministry of Natural Resources and Environment of Malaysia. 2019. ‘6th National Report of Malaysia to the Convention of Biological Diversity’.

Ministry of Natural Resources and Environment of Viet Nam. 2019. ‘The Sixth National Report to the United Nations Convention on Biological Diversity’.

Ministry of Natural Resources and Environment Pollution Control Department of Thailand. 2019. 'Booklet on Thailand State of Pollution 2018'.

Ministry of Natural Resources and Environmental Conservation. 2019. 'Myanmar Climate Change Master Plan (2018–2030)'. The Republic of the Union of Myanmar.

Ministry of Science, Technology and the Environment, Malaysia. 2002. 'Dasar Alam Sekitar Negara National Policy on the Environment'.

Ministry of Sustainability and the Environment Singapore. 2021. 'Key Environmental Statistics 2021'. Government of Singapore. https://www.mse.gov.sg/files/resources/Key-Environmental-Statistics-2021-Publication.pdf.

Ministry of the Environment and Water Resources, Singapore. 2019. Zero Waste Masterplan. Singapore: Ministry of the Environment and Water Resources, Singapore.

Ministry of the Environment Japan. 2020. 'Import Regulation of Plastic Waste in Asian Countries (Provisional: As of March 2020)'.

———. 2021a. 'G20 Report on Actions against Marine Plastic Litter'.

———. 2021b. 'Outcome of the Japan-ASEAN Summit Meeting on Environmental Cooperation'. Ministry of the Environment, Government of Japan. 2021. https://www.env.go.jp/en/headline/2547.html.

———. 2021c. 'Platform for Redesign 2020'. 2021. https://platform2020redesign.org/.

———. n.d. 'ASEAN-Japan Climate Change Action Agenda 2.0'.

———. n.d. 'Japan-ASEAN Dialogue on Environmental Cooperation'. International Environmental Cooperation toward Sustainable Development. Accessed 31 December 2021. https://www.env.go.jp/earth/coop/coop/english/dialogue/asean_j.html.

———. n.d. Waste Management and Public Cleansing Law.

Ministry of the Environment Japan, and IGES. 2019. Water Environment Partnership in Asia (WEPA): Third Phase Final Report. Ministry of the Environment, Japan and Institute of Global Environmental Strategies.

Minoglou, Minas, Spyridoula Gerassimidou, and Dimitrios Komilis. 2017. 'Healthcare Waste Generation Worldwide and Its Dependence on Socio-Economic and Environmental Factors'. Sustainability 2017, Vol. 9, Page 220 9 (2): 220. https://doi.org/10.3390/SU9020220.

Mitra, Priyanka, Rajib Shaw, Vibhas Sukhwani, Bijon Kumer Mitra, Md Abiar Rahman, Sameer Deshkar, and Devesh Sharma. 2021. 'Urban–Rural Partnership Framework to Enhance Food–Energy–Water Security in the Post-COVID-19 Era'. International Journal of Environmental Research and Public Health 18 (23): 12493. https://doi.org/10.3390/ijerph182312493.

Miyake, Hiroyuki, Yayoi Kodama, Haris Anwar, and Syafrudie Sugeng. 2014. 'Present Situation and Practical Issues of Environmental Education for Sustainable Development in Japan and Indonesia', 39–86.

Miyan, M Alimullah. 2015. 'Droughts in Asian Least Developed Countries: Vulnerability and Sustainability'. Weather and Climate Extremes, 7: 8-23–23.

Mizik, Tamás. 2021. 'Theory vs Practice: Patterns of the ASEAN-10 Agri-Food Trade'. Open Agriculture 6 (1): 152–67. https://doi.org/10.1515/OPAG-2021-0014/MACHINEREADABLECITATION/RIS.

Moedjodo, Haryatiningsih, Payaman Simanjuntak, Peter Hehanussa, and Lufiandi. 2006. ‘Lake Toba’. LakeNet.

Mokshein, Siti Eshah. 2019. ‘Education for Sustainable Development (ESD) in Malaysia : Policy , Program , and Evaluation’. Advances in Social Science, Education and Humanities Research 326 (January 2019): 9–12. https://doi.org/10.2991/iccie-18.2019.2.

MONRE. 2019. ‘National State of Environment Report 2018 - Water Environment Across River Basins (in Vietnamese)’.

———. 2021. ‘National State of Environment Report for the Period of 2016-2020 (in Vietnamese)’.

Morgan, Sam. 2022. ‘Sweden Set to Be World’s First Country to Target Consumption-Based Emission Cuts’. Climate Home News, 8 April 2022.

Mortimer, J.A., and M. Donnelly. 2008. ‘Eretmochelys Imbricata’. The IUCN Red List of Threatened Species 2008. 2008. https://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T8005A12881238.en.

MRC. 2022. ‘Climate’. Mekong River Commission. 13 June 2022. https://www.mrcmekong.org/about/mekong-basin/climate/.

MRC Data and Information Services. n.d. ‘Dissolved Oxygen’. MRC Time-Series Inventory. Mekong River Commission.

Nagabhatla, Nidhi, Ngo Tho Hung, Luong Thi Tuyen, Vu Tran Ngoc Cam, Juliet Dhanraj, Nguyen Thi Thien, and Frederic William Swierczek. 2019. ‘Ecosystem-Based Approach for Planning Research and Capacity Development for Integrated Coastal Zone Management in Southeast Asia’. APN Science Bulletin.

Nagel, Joane. 2015. Gender and Climate Change: Impacts, Science, Policy. 1st ed. New York: Routledge. https://doi.org/10.4324/9781315675275.

National Climate Change Secretariat Singapore. 2020. ‘Charting Singapore’s Low Carbon and Climate Resilient Future’.

———. 2022. ‘Singapore Will Raise Climate Ambition to Achieve Net Zero Emissions By or Around Mid Century, and Revises Carbon Tax Levels from 2024’. Government of Singapore.

National Environment Agency Singapore. 2021. ‘Reduction In Overall Waste Generation In 2020, With Less Waste Sent To Semakau Landfill’.

———. 2022a. ‘Air Quality’. Annex I: Singapore Ambient Air Quality Targets. 2022. https://www.nea.gov.sg/our-services/pollution-control/air-pollution/air-quality.

———. 2022b. ‘Waste Statistics and Overall Recycling’. National Environment Agency. Singapore: Government of Singapore.

National Institute of Technology and Evaluation. 2018. ‘ASEAN-Japan Chemical Safety Database: AJCSD User’s Manual’. 2018. https://www.ajcsd.org/chrip_search/dt/pdf/other/ajcsd_user_manual.pdf.

National Minerals Information Center. 2022. ‘Nickel’.

National News Bureau of Thailand. 2022. ‘Thailand to Tighten Air Quality Safety Standards’. National News Bureau of Thailand. July 15. https://thainews.prd.go.th/en/news/detail/TCATG220715124733629.

National Statistical Office. 2020. ‘Thailand Environment Statistics 2020’.

Natori, Yoji, Devon Dublin, Yasuo Takahashi, and Federico Lopez-Casero. 2018. ‘SEPLS: Socio-Ecological Production Landscapes and Seascapes --Experiences Overcoming Barriers from around the World’.

Nature Conservancy. 2008. ‘Coral Triangle Facts, Figures, and Calculations: Part II: Patterns of Biodiversity and Endemism’.

Nawaz, Muhammad Atif, Muhammad Ali Azam, and Muhammad Azhar. 2019. ‘Natural Resources Depletion and Economic Growth: Evidence from ASEAN Countries’. Pakistan Journal of Economic Studies, 2 (2): 58-77–77.

Naylor, Rosamond L., Ronald W. Hardy, Alejandro H. Buschmann, Simon R. Bush, Ling Cao, Dane H. Klinger, David C. Little, Jane Lubchenco, Sandra E. Shumway, and Max Troell. 2021. ‘A 20-Year Retrospective Review of Global Aquaculture’. Nature 591 (7851): 551–63. https://doi.org/10.1038/s41586-021-03308-6.

Neeratanaphan, Lamyai, Sukanya Khamma, Rachadaporn Benchawattananon, Patcharin Ruchuwararak, Sombat Appamaraka, and Somsak Intamat. 2017. ‘Heavy Metal Accumulation in Rice (Oryza Sativa) near Electronic Waste Dumps and Related Human Health Risk Assessment’. Http://Dx.Doi.Org/10.1080/10807039.2017.1300856 23 (5): 1086–98. https://doi.org/10.1080/10807039.2017.1300856.

NESDB. 2019. ‘National Strategy 2018-2037’.

Nevins, Joseph, and Nancy Lee Peluso. 2008. Commoditization in Southeast Asia. Ithaca: Cornell University Press.

Newman, Peter. 2006. ‘The Environmental Impact of Cities’. Environment and Urbanization 18 (2): 275–95. https://doi.org/10.1177/0956247806069599.

Nguyen, Minh Anh, Sebastian Helgenberger, and Beni Suryadi. 2021. ‘Maximising the Co-Benefits of Climate Action by Enhancing the NDCs of Vietnam and Other ASEAN Member States’.

Nguyen, Thanh Thuy. 2016. ‘An Investigation of the Vietnamese Shipping Industry and Policy Recommendations for Profound Participation into ASEAN Integration’. Asian Journal of Shipping and Logistics 32 (2): 81–88. https://doi.org/10.1016/j.ajsl.2016.05.001.

Nguyen, Thao Phuong. 2017. ‘Environmental Education Education for Sustainable Development in Vietnam : Exploring the Geography Teachers ’ Perspectives Education for Sustainable Development in Vietnam : Exploring the Geography Teachers ’ Perspectives’. International Research in Geographical and Environmental Education 0 (0): 1–16. https://doi.org/10.1080/10382046.2017.1366204.

———. 2019. ‘Reviewing Vietnam Geography Textbooks from an ESD Perspective’, 8–10.

Nguyen, Thao Phuong, Stephanie Leder, and Gabriele Schruefer. 2021. ‘Recontextualising Education for Sustainable Development in Pedagogic Practice in Vietnam : Linking Bernsteinian and Constructivist Perspectives Recontextualising Education for Sustainable Development in Pedagogic Practice in Vietnam : Linking Bernsteinian’. Environmental Education Research 27 (3): 313–37. https://doi.org/10.1080/13504622.2021.1879732.

Nicastro, Rosalinda, and Petronia Carillo. 2021. ‘Food Loss and Waste Prevention Strategies from Farm to Fork’. Sustainability 13 (10): 5443. https://doi.org/10.3390/su13105443.

Nicholls, R J, S Hanson, Celine Herweijer, Nicola Patmore, Stéphane Hallegatte, Jan Corfee-Morlot, Jean Château, and Robert Muir-Wood. 2008. ‘Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates’. OECD Environment Working Papers. Paris: OECD.

NIES. 2021. ‘Policy Dialogue and Network Building of Multi-Stakeholders on Integrated Decentralised Domestic Wastewater Management in ASEAN Countries’.

Ninomiya-lim, Sachi, Jinyoung Kang, Changhwan Kim, and Sabrina Ho Abdullah. 2019. ‘- Overview of Experiences in South Korea , Malaysia , and Japan - Environmental Education in Higher Education Institutes in Asia’, 36–43.

Nishida, Shuhei, and Jun Nishikawa. 2011. ‘Biodiversity of Marine Zooplankton in Southeast Asia (Project-3: Plankton Group)’. In Coastal Marine Science in Southeast Asia —Synthesis Report of the Core University Program of the Japan Society for the Promotion of Science: Coastal Marine Science (2001–2010, edited by S. Nishida, M.D. Fortes, and N. Miyazaki, 59–71. TERRAPUB.

Nishimura, Hidetoshi. 2019. ‘Challenges and Good Practices for the 3R and Circular Economy in ASEAN and East Asia Region’. ERIA.

Nitivattananon, Vilas, and Sirinapha Srinonil. 2019. ‘Enhancing Coastal Areas Governance for Sustainable Tourism in the Context of Urbanization and Climate Change in Eastern Thailand’. Advances in Climate Change Research 10 (1): 47–58. https://doi.org/10.1016/j.accre.2019.03.003.

Noguchi, F. n.d. ‘Local Community-Based Education for Sustainable Development (ESD) during the COVID-19 Pandemic in the Asia and Pacific Region’. In A Resilience Approach to Acceleration of Sustainable Development Goals, edited by Mika Shimizu.

Nomora, Ko, and Osamu Abe. 2005. ‘The Environmental Education Network in Indonesia’. In Environmental Education and NGOs in Indonesia, edited by Ko Nomura and L. Hendarti, 125–37. Jakarta: Yayasan Obor Indonesia.

Nomura, Ko. 2009. ‘Perspective on Education for Sustainable Development: Historical Development of Environmental Education in Indonesia’. International Journal of Educational Development 29: 621–27. https://doi.org/10.1016/j.ijedudev.2008.12.002.

Nomura, Ko, and Osamu Abe. 2008. ‘The Status of Environmental Education in the ASEAN Region : Survey Results and Analysis’, 1–19.

Noordwijk, Meine Van, Beria Leimona, Rohit Jindal, Grace B. Villamor, Mamta Vardhan, Sara Namirembe, Delia Catacutan, John Kerr, Peter A. Minang, and Thomas P. Tomich. 2012. ‘Payments for Environmental Services: Evolution toward Efficient and Fair Incentives for Multifunctional Landscapes’. Annual Review of Environment and Resources 37: 389–420. https://doi.org/10.1146/annurev-environ-042511-150526.

Nor Hamzah, Azi Izwani, Lee Chia Kuang, Zetty Ain Kamaruzzaman, and Nubli Abdul Wahab. 2020. ‘Perceived Sensory Dimension for Mental Health and Well-Being: A Review’. In Charting a Sustainable Future of ASEAN in Business and Social Sciences, 179–89. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-3859-9_17.

Nugroho, Arif Satrio, and Ika Riswanti Putranti. 2018. ‘International Seabed Regime in Southeast Asia: The Lack of ASEAN Member States’ Role in Seabed Mining’. Indonesian Perspective 3 (1): 37–51.

Oanh, Nguyen Thi Kim, Didin A. Permadi, P. Abdul Salam, Pham Khac Lieu, Duong Van Hieu, Prapat Pongkiatkul, Ketwalee Kositkanawuth, et al. 2019. ‘Assessment of Co-Benefits of Using Rice Straw Derived Solid Fuel for Cooking to Reduce Emissions of Agro-Residue Open Burning in Selected GMS Countries’. In Development and Climate Change in the Mekong Region Case Studies, 143–68. Bangkok: SEI.

Ocean Health Index. 2021. ‘Ocean Health Index’. Ocean Health Index. 2021.

OECD. 2019. ‘Economic Outlook for Southeast Asia, China and India 2019: Towards Smart Urban Transportation’. https://doi.org/10.1787/saeo-2019-en.

———. 2020a. ‘A Territorial Approach to the Sustainable Development Goals: Synthesis Report’. OECD Urban Policy Reviews. Paris: OECD Publishing.

———. 2020b. ‘Joint Meeting of the Chemicals Committee and the Working Party on Chemicals, Pesticides, and Biotechnology’.

———. n.d. ‘OECD Programme on a Territorial Approach to the SDGs’.

Olson, David M, Eric Dinerstein, Eric D Wikramanayake, Neil D Burgess, George V N Powell, Emma C Underwood, Jennifer A D’amico, et al. 2001. ‘Terrestrial Ecoregions of the World: A New Map of Life on Earth: A New Global Map of Terrestrial Ecoregions Provides an Innovative Tool for Conserving Biodiversity’. BioScience 51 (11): 933–38. https://doi.org/10.1641/0006-3568(2001)051[0933:TEOTWA]2.0.CO;2.

One Planet Network. 2015. ‘Adiwiyata School Program in Indonesia’. One Planet Network. 2015. https://www.oneplanetnetwork.org/knowledge-centre/projects/adiwiyata-school-program-indonesia.

Open Data Soft. 2019. ‘World Administrative Boundaries - Countries and Territories’. World Food Programme.

Ortiz-Moya, Fernando, Yatsuka Kataoka, Osamu Saito, Bijon Kumer Mitra, and Kazuhiko Takeuchi. 2021. ‘Sustainable Transitions towards a Resilient and Decentralised Future: Japan’s Circulating and Ecological Sphere (CES)’. Sustainability Science 16 (5): 1717–29. https://doi.org/10.1007/s11625-021-00941-y.

Ortiz-Moya, Fernando, Hirotaka Koike, Junko Ota, Yatsuka Kataoka, and Junichi Fujino. 2020. ‘State of the Voluntary Local Reviews 2020: Local Action for Global Impact in Achieving the SDGs’. Hayama, Japan: IGES.

Ortiz-Moya, Fernando, Emma Saraff Marcos, Yatsuka Kataoka, and Junichi Fujino. 2021. ‘State of the Voluntary Local Reviews 2021: From Reporting to Action’. Hayama, Japan: IGES.

Our World In Data. 2021a. ‘Economic Growth’.

———. 2021b. ‘Historic and Projected Population, Vietnam’.

Overland, Indra et al. 2017. ‘Impact of Climate Change on ASEAN International Affairs: Risk and Opportunity Multiplier’.

Park, Edward, Huu Loc Ho, Dung Duc Tran, Xiankun Yang, Enner Alcantara, Eder Merino, and Vu Hai Son. 2020. ‘Dramatic Decrease of Flood Frequency in the Mekong Delta Due to River-Bed Mining and Dyke Construction’. Science of the Total Environment 723: 138066. https://doi.org/10.1016/j.scitotenv.2020.138066.

Park, Jun Hyun. 2018. ‘Environmental Sustainability in Asia : Progress, Challenges and Opportunities in the Implementation of the Sustainable Development Goals Series 2-Cambodia’.

Parker, Lyn, and Kelsie Prabawa-sear. 2020. Environmental Education in Indonesia Creating Responsible Citizens in the Global South? Routledge.

Parmesan, C., M.D. Morecroft, Y. Trisurat, R. Adrian, G.Z. Anshari, A. Arneth, Q. Gao, et al. 2022. ‘Terrestrial and Freshwater Ecosystems and Their Services’. In Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, et al. Cambridge University Press.

Pascual, Unai, Patricia Balvanera, Sandra Díaz, György Pataki, Eva Roth, Marie Stenseke, Robert T Watson, et al. 2017. ‘Valuing Nature’s Contributions to People: The IPBES Approach’. Current Opinion in Environmental Sustainability 26–27 (June): 7–16. https://doi.org/10.1016/j.cosust.2016.12.006.

Pauliuk, Stefan, Niko Heeren, Peter Berrill, Tomer Fishman, Andrea Nistad, Qingshi Tu, Paul Wolfram, and Edgar G. Hertwich. 2021. ‘Global Scenarios of Resource and Emission Savings from Material Efficiency in Residential Buildings and Cars’. Nature Communications 2021 12:1 12 (1): 1–10. https://doi.org/10.1038/s41467-021-25300-4.

PEMSEA. 2018a. ‘SDS-SEA Implementation Plan 2018-2022’.

———. 2018b. ‘Sustainable Shipping and Ports: Policy Brief for the Blue Economy’.

———. 2022. ‘Project ASEANO’. ASEANO. 2022. http://aseano.seaknowledgebank.org/Home/ProjectAseano.

———. n.d. ‘About PEMSEA’. PEMSEA. Accessed 31 December 2021a. http://www.pemsea.org/about-PEMSEA.

———. n.d. ‘Country Partners’. PEMSEA. Accessed 31 December 2021b. https://www.pemsea.org/about-pemsea/our-partners/country-partners.

———. n.d. ‘Regional Marine Strategy’. PEMSEA. Accessed 31 December 2021c. http://pemsea.org/our-work/regional-marine-strategy.

Pennington, John. 2021. ‘Will COVID-19 Erase ASEAN’s Progress on Poverty in Recent Years?’ ASEAN Today.

Petrunoff, Nicholas A., Ng Xian Yi, Borame Dickens, Angelia Sia, Joel Koo, Alex R. Cook, Wee Hwee Lin, et al. 2021. ‘Associations of Park Access, Park Use and Physical Activity in Parks with Wellbeing in an Asian Urban Environment: A Cross-Sectional Study’. International Journal of Behavioral Nutrition and Physical Activity 18 (1): 1–15. https://doi.org/10.1186/S12966-021-01147-2/FIGURES/3.

Pham, Ngoc-Bao, Yukako Inamura, Amila Abeynayaka, Pankaj Kumar, and Bijon Kumer Mitra. 2021. ‘Riverine Microplastic Pollution in ASEAN Countries - Current State of Knowledge’.

Phenrat, Tanapon, Ashijya Otwong, Aphichart Chantharit, and Gregory V. Lowry. 2016. ‘Ten-Year Monitored Natural Recovery of Lead-Contaminated Mine Tailing in Klity Creek, Kanchanaburi Province, Thailand’. Environmental Health Perspectives 124 (10): 1511–20. https://doi.org/10.1289/EHP215.

Phien-wej, N., P.H. Giao, and P. Nutalaya. 2005. ‘Land Subsidence in Bangkok, Thailand’. Engineering Geology.

Phoumin, Han. 2021. ‘The Role of Hydrogen in ASEAN’s Clean Energy Future’. The National Bureau of Asian Research. Vol. August.

Phoumin, Han, and To Minh Thu. 2020. ‘Water Resources Management in the Mekong Basin’. In Subregional Development Strategy in ASEAN after COVID-19: Inclusiveness and Sustainability in the Mekong Subregion (Mekong 2030), edited by Fukunari Kimura, 161–90. Jakarta, Indonesia.

Phuc, Nguyen Hong, and Nguyen Thi Kim Oanh. 2022. ‘Large Spatio-Temporal Variations of Size-Resolved Particulate Matter and Volatile Organic Compounds in Urban Area with Heavy Traffic’. Environmental Science and Pollution Research 29 (15): 21491–507. https://doi.org/10.1007/s11356-021-16921-9.

Phuong, Ngoc Nam, Thi Thuy Duong, Thi Phuong Quynh Le, Trung Kien Hoang, Ha My Ngo, Ngoc Anh Phuong, Quoc Tuan Pham, et al. 2022. 'Microplastics in Asian Freshwater Ecosystems: Current Knowledge and Perspectives'. Science of The Total Environment 808 (February): 151989. https://doi.org/10.1016/J.SCITOTENV.2021.151989.

Piman, T., T. A. Cochrane, and M. E. Arias. 2013. 'Modelling the Impact of Large Dams on Flows and Hydropower Production of the Sekong, Sesan and Srepok Rivers in the Mekong Basin'. In AGU Fall Meeting Abstracts, H51N-1388.

Piman, Thanapon, and Manish Shrestha. 2017a. 'Case Study on Sediment in the Mekong River Basin: Current State and Future Trends'.

———. 2017b. 'Case Study on Sediment in the Mekong River Basin: Current State and Future Trends'.

Pomeroy, Robert, John Parks, Kitty Courtney, and Nives Mattich. 2016. 'Improving Marine Fisheries Management in Southeast Asia: Results of a Regional Fisheries Stakeholder Analysis'. Marine Policy 65 (March): 20–29. https://doi.org/10.1016/J.MARPOL.2015.12.002.

Pouso, Sarai, Ángel Borja, Lora E. Fleming, Erik Gómez-Baggethun, Mathew P. White, and María C. Uyarra. 2021. 'Contact with Blue-Green Spaces during the COVID-19 Pandemic Lockdown Beneficial for Mental Health'. Science of The Total Environment 756 (February): 143984. https://doi.org/10.1016/j.scitotenv.2020.143984.

PPWSA. 2021. 'Non-Revenue Water'. Phnom Penh Water Supply Authority. 2021. https://www.ppwsa.com.kh/en/index.php?page=non-revenue-water.

Praphornkul, Praphorn. 2021. 'Keeping a Close Watch on Saltwater Intrusion'. National News Bureau of Thailand.

Prasertsin, Samart, and Ganjana Nathapindhu. 2020. 'The Temporal Pattern of Ambient $PM_{2.5}$ and Health Risk Assessment in Thailand'. Indian Journal of Public Health Research & Development 11 (3). https://doi.org/10.37506/ijphrd.v11i3.1546.

Premakumara, Dickella Gamaralalage Jagath, Matthew Hengesbaugh, and Rajeev Kumar Singh. 2019. 'Development of City Action Plans to Reduce GHGs and SLCPs from Municipal Solid Waste Management (MSWM) in Southeast Asia'. Kanagawa.

Premakumara, Dickella Gamaralalage Jagath, and Toshizo Maeda. 2014. 'Municipal Solid Waste: The Burgeoning Environmental Threat'. Routledge Handbook of Environment and Society in Asia, 176–96. https://doi.org/10.4324/9781315774862-21/MUNICIPAL-SOLID-WASTE-BURGEONING-ENVIRONMENTAL-THREAT-DICKELLA-PREMAKUMARA-TOSHIZO-MAEDA.

PUB Singapore's National Water Agency. 2020. 'NEWater'.

Pudin, Susan. 2015. 'Development of an Environmental Education Programme for Waste Management with Local Communities in Sabah, Malaysia'. The University of Waikato.

Purchase, Diane, Golnoush Abbasi, Lieselot Bisschop, Debashish Chatterjee, Christian Ekberg, Mikhail Ermolin, Petr Fedotov, et al. 2020. 'Global Occurrence, Chemical Properties, and Ecological Impacts of e-Wastes (IUPAC Technical Report)'. Pure and Applied Chemistry 92 (11): 1733–67. https://doi.org/10.1515/PAC-2019-0502/ASSET/GRAPHIC/J_PAC-2019-0502_FIG_004.JPG.

Quang Tri, Doan, Linh Nguyen, Anh Phuong Tran, Nguyen Cao Don, Quang Tri Doan, Thi Mai Linh Nguyen, Thi Thanh Tuyet Quach, and Cao Don Nguyen. 2019. ‘Assessment of Water Quality in Coastal Estuaries under the Impact of an Industrial Zone in Hai Phong, Vietnam’. Viet Nam Technical Application Center for Hydrometeorology, no. 8. https://doi.org/10.1016/j.pce.2019.04.003.

Ra, Sungsup, and Zhigang Li. 2018. ‘Closing the Financing Gap in Asian Infrastructure’, no. 57: 1–27.

Ramsar Convention Secretariat. 2021a. ‘About’. Ramsar Site Information Service. 2021. https://rsis.ramsar.org/about.

———. 2021b. ‘Contracting Parties to the Ramsar Convention’. 2021. https://www.ramsar.org/sites/default/files/documents/library/annotated_contracting_parties_list_e.pdf.

Razali, Azlini, Sharifah Norkhadijah Syed Ismail, Suriyani Awang, Sarva Mangala Praveena, and Emilia Zainal Abidin. 2018. ‘Land Use Change in Highland Area and Its Impact on River Water Quality: A Review of Case Studies in Malaysia’. Ecological Processes 7 (1). https://doi.org/10.1186/s13717-018-0126-8.

R.B. Singh, Bathula Srinagesh, Subhash Anand (Editors). 2020. Urban Health Risk and Resilience in Asian Cities. Edited by R.B. Singh, Bathula Srinagesh, and Subhash Anand. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-1205-6.

RCEP Secretariat. 2020a. ‘Regional Comprehensive Economic Partnership Agreement’.

———. 2020b. ‘Summary of the Regional Comprehensive Economic Partnership Agreement’.

Red List Standards and Petitions Subcommittee. 1996. ‘Natator Depressus (Errata Version Published in 2022)’. The IUCN Red List of Threatened Species 1996. 1996. https://www.iucnredlist.org/species/14363/210612474.

Reid, R.S., C. Bedelian, M.Y. Said, R.L. Kruska, M. Mauricio, R, V. Castel, J. Olson, and P.K. Thorton. 2010. ‘Global Livestock Impacts on Biodiversity’. In Livestock in a Changing Landscape, Volume 1 Drivers, Consequences, and Responses, edited by H. Steinfeld, H.A. Mooney, F. Schneider, and L. E. Neville. Island Press.

Republic of Indonesia. 2021. Indonesia’s Voluntary National Review (2021).

———. 2022. ‘Enhanced Nationally Determined Contribution’.

Republic of the Philippines Bases Conversion and Development Authority. 2018. ‘New Clark City’. Bases Conversion and Development Authority. 2018.

Research and Markets. 2020. ‘E-Commerce Plastic Packaging Market - Growth, Trends, COVID-19 Impact, and Forecasts (2020 - 2025)’.

Richards, Daniel R., and Daniel A. Friess. 2016. ‘Rates and Drivers of Mangrove Deforestation in Southeast Asia, 2000-2012’. Proceedings of the National Academy of Sciences of the United States of America 113 (2): 344–49. https://doi.org/10.1073/pnas.1510272113.

Ripple, William J., Katharine Abernethy, Matthew G. Betts, Guillaume Chapron, Rodolfo Dirzo, Mauro Galetti, Taal Levi, et al. 2016. ‘Bushmeat Hunting and Extinction Risk to the World’s Mammals’. Royal Society Open Science 3 (10). https://doi.org/10.1098/rsos.160498.

Ritchie, Hannah, Edouard Mathieu, Lucas Rodés-Guirao, Cameron Appel, Charlie Giattino, Esteban Ortiz-Ospina, Joe Hasell, Bobbie Macdonald, Saloni Dattani, and Max Roser. 2021. ‘Coronavirus Pandemic (COVID-19)’. Our World In Data. https://ourworldindata.org/coronavirus.

Rodlauer, Markus, Sean Nolan, and Michael Keen. 2018. 'ASEAN Progress Towards Sustainable Development Goals and the Role of the IMF'. Vol. 3. Bali, Indonesia.

Rossman, Vadim Joseph. 2017. Capital Cities: Varieties and Patterns of Development and Relocation. Routledge Research in Planning and Urban Design. London ; New York: Routledge, Taylor & Francis Group.

Royal Government of Cambodia. 2021. 'Clean Air Plan of Cambodia'. CCAC.

Ruijven, Bas J. Van, Detlef P. Van Vuuren, Willem Boskaljon, Maarten L. Neelis, Deger Saygin, and Martin K. Patel. 2016. 'Long-Term Model-Based Projections of Energy Use and CO_2 Emissions from the Global Steel and Cement Industries'. Resources, Conservation and Recycling 112 (September): 15–36. https://doi.org/10.1016/J.RESCONREC.2016.04.016.

Sachs, J., C. Kroll, G. Lafortune, G. Fuller, and F. Woelm. 2021. 'Sustainable Development Report 2021'. Sustainable Development Report 2021.

Sachs, J., G. Schmidt-Traub, C. Kroll, G. Lafortune, G. Fuller, and F. Woelm. 2020. Sustainable Development Report 2020: The Sustainable Development Goals and Covid-19. Cambridge: Cambridge University Press.

Sagara, Junko. 2021. 'Surface Water Resources Assessment of the Tonle Sap and Mekong Delta River Basin Groups: Improving Climate Resilience, Productivity, and Sustainability'. https://doi.org/10.22617/BRF210097.

SAICM. 2022. 'SAICM National Focal Points Database'. SAICM. 2022. https://saicm.org/Implementation/FocalPoints/National/tabid/7850/language/en-US/Default.aspx.

Saigoneer. 2017. 'Phu Quoc to Transform Old Airport Into New Urban Zone'. Saigoneer Society, October 2017.

Saikawa, Eri. 2013. 'Policy Diffusion of Emission Standards: Is There a Race to the Top?' World Politics 65 (1): 1–33. https://doi.org/10.1017/S0043887112000238.

Salhofer, Stefan, Aleksander Jandric, Souphaphone Soudachanh, Thinh Le Xuan, and Trinh Dinh Tran. 2021. 'Plastic Recycling Practices in Vietnam and Related Hazards for Health and the Environment'. International Journal of Environmental Research and Public Health 18 (8). https://doi.org/10.3390/ijerph18084203.

Sanderson, Eric W, Joseph Walston, and John G Robinson. 2018. 'From Bottleneck to Breakthrough: Urbanization and the Future of Biodiversity Conservation'. BioScience 68 (6): 412–26. https://doi.org/10.1093/biosci/biy039.

Santos, M., T.A. Munroe, F. Di Dario, H. Hata, F. Torres, and J.P. Quilang. 2018. 'Sardinella Tawilis (Errata Version Published in 2019)'. The IUCN Red List of Threatened Species 2018. 2018. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T98836352A143839946.en.

Sao, Socheata. 2021. 'Land Grabs in ASEAN: Access to Remedies in Agribusiness Industry'. In Business and Human Rights in Asia, 167–94. https://doi.org/10.1007/978-981-15-7273-9.

Saputra, Erlis, Tejo Spit, and Annelies Zoomers. 2019. 'Living in a Bottomless Pit: Households' Responses to Land Subsidence, an Example from Indonesia'. Journal of Environmental Protection 10 (01): 1–21. https://doi.org/10.4236/JEP.2019.101001.

Sarkodie, Samuel Asumadu, and Phebe Asantewaa Owusu. 2021. 'Impact of COVID-19 Pandemic on Waste Management'. Environment, Development and Sustainability 23 (5): 7951–60. https://doi.org/10.1007/s10668-020-00956-y.

Satoh, Yusuke, Taher Kahil, Edward Byers, Peter Burek, Günther Fischer, Sylvia Tramberend, Peter Greve, et al. 2017. 'Multi-Model and Multi-Scenario Assessments of Asian Water Futures: The Water Futures and Solutions (WFaS) Initiative'. Earth's Future 5 (7): 823–52. https://doi.org/10.1002/2016EF000503.

Schlossberg, Tatiana. 2021. 'The Race for EV Parts Leads to Risky Deep-Ocean Mining'. Yale Environment 360.

Schneider, A, C M Mertes, A J Tatem, B Tan, D Sulla-Menashe, S J Graves, N N Patel, et al. 2015. 'A New Urban Landscape in East–Southeast Asia, 2000–2010'. Environmental Research Letters 10 (3): 34002. https://doi.org/10.1088/1748-9326/10/3/034002.

SEAFDEC. 2015. 'ASEAN Guidelines for Preventing the Entry of Fish and Fishery Products from IUU Fishing Activities into the Supply Chain'.

———. 2018. 'Fishery Statistic Summary 2018'. 2018. www.seafdec.org/fishstat2018/.

———. 2019a. 'Fisheries Country Profile of ASEAN Member States'. SEAFDEC. 2019.

———. 2019b. 'Fishery Statistic Summary 2019'. SEAFDEC. 2019. http://www.seafdec.org/stat2019/.

Secretariat of the Basel Convention. n.d. 'Total Amount of Generation of Hazardous Wastes and Other Wastes'. Basel Convention Reports Dashboard.

Seebens, Hanno, Tim M. Blackburn, Ellie E. Dyer, Piero Genovesi, Philip E. Hulme, Jonathan M. Jeschke, Shyama Pagad, et al. 2017. 'No Saturation in the Accumulation of Alien Species Worldwide'. Nature Communications 8: 1–9. https://doi.org/10.1038/ncomms14435.

Sein, U Thein. 2014. 'Chairman's Statement of the 25th ASEAN Summit: "Moving Forward in Unity to a Peaceful and Prosperous Community"'. ASEAN Secretariat.

Seminoff, J.A. 2004. 'Chelonia Mydas'. The IUCN Red List of Threatened Species 2004. 2004. https://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T4615A11037468.en.

Seneviratne, S.I., X. Zhang, M. Adnan, W. Badi, C. Dereczynski, A. Di Luca, S. Ghosh, et al. 2021a. 'Weather and Climate Extreme Events in a Changing Climate'. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, et al.

Seneviratne, S.I., X. Zhang, M. Adnan, W. Badi, C. Dereczynski, A. Di Luca, S. Ghosh, et al. 2021b. 'Weather and Climate Extreme Events in a Changing Climate'. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by V. Masson-Delmotte, P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, et al.

Setiawan, B. B., and S. P. Hadi. 2007. 'Regional Autonomy and Local Resource Management in Indonesia'. Asia Pacific Viewpoint 28 (1): 72–84.

Seto, Karen C., Robert K. Kaufmann, and Curtis E. Woodcock. 2000. 'Landsat Reveals China's Farmland Reserves, but They're Vanishing Fast [1]'. Nature 406 (6792): 121. https://doi.org/10.1038/35018267.

Shan, Vandana, S K Singh, and A K Haritash. 2020. 'Water Crisis in the Asian Countries: Status and Future Trends'. In Resilience, Response, and Risk in Water Systems : Shifting Management and Natural Forcings Paradigms, edited by Manish Kumar, Francisco Munoz-Arriola, Hiroaki Furumai, and Tushara Chaminda, 173–94. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-4668-6_10.

Sharma, Anket, Vinod Kumar, Babar Shahzad, Mohsin Tanveer, Gagan Preet Singh Sidhu, Neha Handa, Sukhmeen Kaur Kohli, et al. 2019. 'Worldwide Pesticide Usage and Its Impacts on Ecosystem'. SN Applied Sciences 1 (11). https://doi.org/10.1007/S42452-019-1485-1.

Shenkin, Alexander, Chris J Chandler, Doreen S Boyd, Toby Jackson, Mathias Disney, Noreen Majalap, Reuben Nilus, et al. 2019. 'The World's Tallest Tropical Tree in Three Dimensions '. Frontiers in Forests and Global Change .

Shi, Xunpeng, Hari Malamakkavu Padinjare Variam, and Yifan Shen. 2019. 'Trans-ASEAN Gas Pipeline and ASEAN Gas Market Integration: Insights from a Scenario Analysis'. Energy Policy 132 (September): 83–95. https://doi.org/10.1016/j.enpol.2019.05.025.

Shrestha, Rajendra P. 2011. 'Land Degradation and Biodiversity Loss in Southeast Asia'. In Land Use, Climate Change and Biodiversity Modeling, 303–27. IGI Global. https://doi.org/10.4018/978-1-60960-619-0.ch015.

Simarmata, Hendricus Andy. 2020. 'Building Transformative Adaptation to Sea Level Rise'. ASEAN Focus 1/2020: 16–17.

Simmons, R. W., P. Pongsakul, D. Saiyasitpanich, and S. Klinphoklap. 2005. 'Elevated Levels of Cadmium and Zinc in Paddy Soils and Elevated Levels of Cadmium in Rice Grain Downstream of a Zinc Mineralized Area in Thailand: Implications for Public Health'. Environmental Geochemistry and Health 2005 27:5 27 (5): 501–11. https://doi.org/10.1007/S10653-005-7857-Z.

Singapore National Eye Centre. 2021. 'New Biodiversity Medicine Institute Launched at SingHealth Duke-NUS Scientific Congress 2021'. 2021. https://www.snec.com.sg/news/research/new-biodiversity-medicine-institute-launched-at-singhealth-duke-nus-scientific-congress-2021.

Singleton, I., S.A. Wich, M. Nowak, G Usher, and S.S Utami-Atmoko. 2017. 'Pongo Abelii (Errata Version Published in 2018)'. The IUCN Red List of Threatened Species 2017.

SNV Netherlands. 2022. 'IMIS: Improving Municipal-Led FSM Service Efficiency and Accountability'. 13 June 2022. https://snv.org/update/imis-improving-municipal-led-fsm-service-efficiency-and-accountability.

Souter, David, Serge Planes, Jeremy Wicquart, Murray Logan, David Obura, and Francis Staub (eds.). 2020. 'Chapter 7. Status and Trends of Coral Reefs of the East Asian Seas Region'. In Status of Coral Reefs of the World: 2020.

Species in Ancient Lakes. 2012. 'Other Lakes'. 2012. http://www.sial-online.org/index.php/lakes/others.

Squires, Dale. 2014. 'Biodiversity Conservation in Asia'. Asia and the Pacific Policy Studies 1 (1): 144–59. https://doi.org/10.1002/app5.13.

Srikanth, P.K., Lertsanthia N., A. Abeynayaka, and C. Visvanathan. 2022. 'Plastic Consumption Behavior and Brand Auditing: A Case Study in Thailand during the COVID-19'. In 3RINCs International Conference. Yokohama.

Srithawirat, T., and M. T. Latif. 2015. 'Concentration of Selected Heavy Metals in the Surface Dust of Residential Buildings in Phitsanulok, Thailand'. Environmental Earth Sciences 74 (3): 2701–6. https://doi.org/10.1007/s12665-015-4291-0.

Stapp, William. 1969. 'The Concept of Environmental Education'. Journal of Environmental Education 1 (1): 33–35.

Statista. 2021a. ‘Production Volume of Cement in Indonesia from 2010 to 2020’.

———. 2021b. ‘Production Volume of Cement in Vietnam from 2010 to 2020’.

———. 2021c. ‘Southeast Asia Specialty Chemical Market Size by Country 2016’. 2021. https://www.statista.com/statistics/606246/size-of-the-south-east-asia-specialty-chemical-market/.

———. 2021d. ‘Total Population of the ASEAN Countries 2011-2021’. 2021. https://www.statista.com/statistics/796222/total-population-of-the-asean-countries/.

———. 2021e. ‘Tourist Arrivals in Southeast Asia in 2019, by Country (in Millions)’. Statista Research Department.

———. 2022. ‘Annual Production of Plastics Worldwide from 1950 to 2020(in Million Metric Tons)’. Statista. 2022.

Steffen, Will, Katherine Richardson, Johan Rockström, Sarah E. Cornell, Ingo Fetzer, Elena M. Bennett, Reinette Biggs, et al. 2015. ‘Planetary Boundaries: Guiding Human Development on a Changing Planet’. Science 347 (6223). https://doi.org/10.1126/SCIENCE.1259855.

Sterling, Stephen. 2004. ‘An Analysis of the Development of Sustainability Education Internationally: Evolution, Interpretation and Potential Transformation’. In The Sustainability Curriculum: The Challenge for Higher Education, 43–62. Earthscan.

Sudo, Kenji, and Masahiro Nakaoka. 2020. ‘Fine□scale Distribution of Tropical Seagrass Beds in Southeast Asia’. Ecological Research 35 (6): 994–1000. https://doi.org/10.1111/1440-1703.12137.

Sulastri, S., E. Harsono, I. Ridwansyah, R. Dina, and I. Melati. 2020. ‘Endemic and Invasive Species of Lake Matano and Allowable Suspended Solid Load to Sustain High Species Endemism’. IOP Conference Series: Earth and Environmental Science 535 (1). https://doi.org/10.1088/1755-1315/535/1/012026.

Suriyankietkaew, Suparak, and Suthep Nimsai. 2021. ‘COVID-19 Impacts and Sustainability Strategies for Regional Recovery in Southeast Asia: Challenges and Opportunities’. Sustainability 13 (16): 8907. https://doi.org/10.3390/su13168907.

SWOT. n.d. ‘Meet the Turtles’. State of the World’s Sea Turtles. Accessed 4 August 2022. https://www.seaturtlestatus.org/meet-the-turtles.

Tang, Van Tai, N. T. Kim Oanh, Eldon R. Rene, and Tran Ngoc Binh. 2020. ‘Analysis of Roadside Air Pollutant Concentrations and Potential Health Risk of Exposure in Hanoi, Vietnam’. Journal of Environmental Science and Health, Part A 55 (8).

Taormina, B., J. Bald, A., Want, G. Thouzeau, M. Lejart, N. Desroy, and A. Carlier. 2018. ‘A Review of Potential Impacts of Submarine Power Cables on the Marine Environment: Knowledge Gaps, Recommendations and Future Directions’. Renewable and Sustainable Energy Reviews. 2018. https://reader.elsevier.com/reader/sd/pii/S1364032118305355?token=4DF257ACEFC4FAF5BCC3F3DF76F8023F1CC7D6F3FEC013CEF6B2F7F67447F8F51D97FFFC01C3430EA28A6AA83022A3E3&originRegion=eu-west-1&originCreation=20210804042925.

Tarasawatpipat, Chaisri, and Witthaya Mekhum. 2020. ‘Rethinking the Reasons of Greenhouse Gases Emission in ASEAN Countries: Finding Reasons in Urbanization, Industrialization and Population Growth’. International Journal of Energy Economics and Policy 11 (1): 544–50. https://doi.org/10.32479/ijeep.10688.

TEEB. 2010. ‘The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB’.

Tekken, Vera, Joachim H. Spangenberg, Benjamin Burkhard, Monina Escalada, Susanne Stoll-Kleemann, Dao Thanh Truong, and Josef Settele. 2017. ‘“Things Are Different Now”: Farmer Perceptions of Cultural Ecosystem Services of Traditional Rice Landscapes in Vietnam and the Philippines’. Ecosystem Services 25 (June): 153–66. https://doi.org/10.1016/j.ecoser.2017.04.010.

TeleGeography. 2022. ‘Submarine Cable Map’.

Teng, Paul S, and Sally Trethewie. 2012. ‘Tackling Urban and Rural Food Wastage in Southeast Asia: Issues and Interventions’.

Teoh, Shom. 2018. ‘Early Views of ASEAN’s “Frontrunner Cities” on the Sustainable Development Goals (SDGs) and Local Data Management’.

Teoh, Wei Chin. 2021. ‘Project Completion Report of the ASEAN SDGs Frontrunner Cities Programme’. Bangkok, Thailand: AWGESC.

Thailand Board of Investment. 2020. ‘Water Supply’.

Tham, Siew Yean, and Wee Jin Yeoh. 2020. ‘Chinese Steel Investments in ASEAN’. Perspective 2020 (50): 1–11.

The White House. 2021. ‘Fact Sheet: New Initiatives to Expand the U.S.-ASEAN Strategic Partnership’. Washington, DC.

Thuy, Pham Thi, Steven van Geluwe, Viet Anh Nguyen, and Bart van der Bruggen. 2012. ‘Current Pesticide Practices and Environmental Issues in Vietnam: Management Challenges for Sustainable Use of Pesticides for Tropical Crops in (South-East) Asia to Avoid Environmental Pollution’. Journal of Material Cycles and Waste Management 14 (4): 379–87. https://doi.org/10.1007/s10163-012-0081-x.

Tran, Thi Thu Huong, Manfred Zeller, and Diana Suhardiman. 2016. ‘Payments for Ecosystem Services in Hoa Binh Province, Vietnam: An Institutional Analysis’. Ecosystem Services 22 (September): 83–93. https://doi.org/10.1016/j.ecoser.2016.10.001.

Tsukiji, M, D G J Premakumara, I S Y Pratomo, K Onogawa, K Alverson, S Honda, D Ternald, M Dilley, J Fujioka, and D Condrorini. 2020. ‘Waste Management during the COVID-19 Pandemic: From Response to Recovery’. Osaka.

Tuantong, Jutagate, Grudpan Chaiwut, and Suvarnaraksha Apinun. 2016. ‘Freshwater Fish Diversity in Thailand and the Challenges on Its Prosperity Due To River Damming’. In Aquatic Biodiversity Conservation and Ecosystem Services, edited by Shin-ichi Nakano, Tetsukazu Yahara, and Tohru Nakashizuka, 31–39. Springer Singapore.

Tue, Nguyen Minh, Shin Takahashi, Annamalai Subramanian, Shinichi Sakai, and Shinsuke Tanabe. 2013. ‘Environmental Contamination and Human Exposure to Dioxin-Related Compounds in e-Waste Recycling Sites of Developing Countries’. Environmental Science: Processes & Impacts 15 (7): 1326–31. https://doi.org/10.1039/C3EM00086A.

Turkelboom, F, J Poesen, and G Trébuil. 2008. ‘The Multiple Land Degradation Effects Caused by Land-Use Intensification in Tropical Steeplands: A Catchment Study from Northern Thailand’. CATENA 75 (1): 102–16. https://doi.org/10.1016/j.catena.2008.04.012.

UCLG. n.d. ‘Localizing the SDGs: A Boost to Monitoring & Reporting’. Global Observatory on Local Democracy and Decentralization.

UCLG, and UN-Habitat. 2020. ‘Guidelines for Voluntary Local Reviews: Volume 1, A Comparative Analysis of Existing VLRs’. Barcelona, Spain and Nairobi, Kenya: UCLG and UN-Habitat.

Uhm, Yeeun. 2021. ‘Plastic Waste Trade in Southeast Asia After China’s Import Ban: Implications of the New Basel Convention Amendment and Recommendations for the Future’. California Western Law Review 57 (1).

UN Statistics Division. 2018. Manual on the Basic Set of Environment Statistics of the FDES 2013: Generation and Management of Waste.

UNCCD. 2021. ‘Status of Ratification’. United Nations Treaty Collection. 2021. https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-10&chapter=27&clang=_en#1.

UNCRD. 2018a. ‘State of the 3Rs in Asia and the Pacific, Experts’ Assessment of Progress in Ha Noi 3R Goals’.

———. 2018b. ‘State of the 3Rs in Asia and the Pacific, Experts’ Assessment of Progress in Ha Noi 3R Goals’.

UNDESA. 2015. ‘Population 2030: Demographic Challenges and Opportunities for Sustainable Development Planning (ST/ESA/SER.A/389)’. United Nations.

———. 2018a. ‘2018 Revision of World Urbanization Prospects’. 2018.

———. 2018b. ‘World Urbanization Prospects 2018’. New York: United Nations.

———. n.d. ‘Voluntary Local Reviews’. United Nations Department of Economic and Social Affairs.

UNEP. 2011a. ‘Decoupling Natural Resource Use and Environmental Impacts from Economic Growth’. Edited by M. Fischer-Kowalski, M. Swilling, E.U. von Weizsäcker, Y. , Ren, Y. Moriguchi, W. Crane, F. Krausmann, et al.

———. 2011b. ‘Resource Efficiency: Economics and Outlook for Asia-Pacific’, 265.

———. 2016. ‘GEO-6: Regional Assessment for Asia and the Pacific’.

———. 2017. ‘Annual ASEAN Green Investment Needs to Grow 400% to Guard against Environmental Risks’. Singapore.

———. 2018a. ‘Exploring the Potential for Adopting Alternative Materials to Reduce Marine Plastic Litter’.

———. 2018b. ‘Mapping of Global Plastics Value Chain and Plastics Losses to the Environment: With a Particular Focus on Marine Environment’. Nairobi.

———. 2018c. ‘Mapping of Global Plastics Value Chain and Plastics Losses to the Environment: With a Particular Focus on Marine Environment’. Nairobi.

———. 2019a. ‘Air Pollution in Asia and the Pacific: Science-Based Solution’. Paris.

———. 2019b. ‘Air Pollution in Asia and the Pacific: Science-Based Solutions’. Paris.

———. 2019c. ‘GEO-6 for Industry in Asia-Pacific’.

———. 2019d. ‘Making Infrastructure Resource Efficient’.

———. 2019e. ‘Sand and Sustainability: Finding New Solutions for Environmental Governance of Global Sand Resources’. Geneva, Switzerland.

———. 2021a. ‘From Pollution to Solution: A Global Assessment of Marine Litter and Plastic Pollution’. Nairobi.

———. 2021b. ‘Global Chemicals and Waste Indicator Review Document’. Nairobi: United Nations Environment Programme.

———. 2021c. ‘Measuring Progress: Environment and the SDGs’.

———. 2021d. ‘Progress on Ambient Water Quality: Global Indicator 6.3.2 Updates and Acceleration Needs’.

———. 2021e. ‘UNEP Food Waste Index Report 2021’.

———. n.d. ‘What We Do’. Asia Pacific Clean Air Partnership.

UNEP and CCAC. 2021. ‘Global Methane Assessment’. Nairobi.

UNEP ROAP, UNICEF EAPRO, and AIT. 2021. ‘Child-Centred Clean Air Solutions’.

UNEP-WCMC. 2014. ‘Seagrass’. Biodiversity A to Z.

———. 2021a. ‘Protected Area Profile for Brunei Darussalam’. World Database of Protected Areas.

———. 2021b. ‘Protected Area Profile for Cambodia’. World Database of Protected Areas.

———. 2021c. ‘Protected Area Profile for Indonesia’. World Database of Protected Areas.

———. 2021d. ‘Protected Area Profile for Lao People’s Democratic Republic’. World Database of Protected Areas.

———. 2021e. ‘Protected Area Profile for Malaysia’. World Database of Protected Areas.

———. 2021f. ‘Protected Area Profile for Myanmar’. World Database of Protected Areas.

———. 2021g. ‘Protected Area Profile for Philippines’. World Database of Protected Areas.

———. 2021h. ‘Protected Area Profile for Singapore’. World Database of Protected Areas.

———. 2021i. ‘Protected Area Profile for Thailand’. World Database of Protected Areas.

———. 2021j. ‘Protected Area Profile for Viet Nam’. World Database of Protected Areas.

UNEP-WCMC, and IUCN. 2022. ‘Protected Planet: The World Database on Protected Areas (WDPA) and World Database on Other Effective Area-Based Conservation Measures (WD-OECM)’. Cambridge, United Kingdom: UNEP-WCMC and IUCN.

UNESCAP. 2009. ‘Payments for Ecosystem Services’.

———. 2017. ‘Asia and the Pacific SDG Progress Report’. Bangkok, Thailand: United Nations Economic and Social Commission for Asia and the Pacific.

———. 2019. ‘Asia and the Pacific SDG Progress Report 2019’. Bangkok.

———. 2020a. ‘Asia and the Pacific SDG Progress Report 2020’. Bangkok: UNESCAP. https://doi.org/10.1017/s0165115300023056.

———. 2020b. ‘Asia and the Pacific SDG Progress Report 2020’.

———. 2020c. ‘Ready for the Dry Years: Building Resilience to Drought in South-East Asia’. Bangkok, Thailand.

———. 2021a. ‘Asia and the Pacific - SDG Progress Report 2021’.

———. 2021b. ‘Asia and the Pacific SDG Progress Report 2021’. Bangkok.

———. 2021c. ‘Resilience in a Riskier World: Asia-Pacific Disaster Report 2021’.

———. 2021d. ‘The Future of Asian Pacific Cities: Transformative Pathways Towards Sustainable Urban Development in the Post COVID-19 Era’. Bangkok, Thailand: UNESCAP.

———. 2022. ‘Asia and the Pacific SDG Progress Report 2022: Widening Disparities amid COVID-19’. Bangkok, Thailand: United Nations Economic and Social Commission for Asia and the Pacific.

UNESCAP, and UN-Habitat. 2019. ‘The Future of Asian & Pacific Cities Transformative Pathways towards Sustainable Urban Development’. Bangkok: United Nations.

UNESCO. 1997. ‘Thessaloniki Declaration UNESCO-EPD-97KONF.40 LKLD.2 12.’

———. 2011. Education for Sustainable Development Country Guidelines for Changing the Climate of Teacher Education to Address Sustainability: Putting Transformative Education into Practice. Jakarta: UNESCO.

———. 2014. National Journeys towards Education for Sustainable Development. Paris: UNESCO.

———. 2016. ‘1,000 Viet Nam Schools Enhance Environmental Threat Responses through ESD’. 2016. https://en.unesco.org/news/1000-viet-nam-schools-enhance-environmental-threat-responses-through-esd.

———. 2017. ‘Implementing the Whole-School Approach under the Global Action Programme on Education for Sustainable Development’.

———. 2020. ‘Education for Sustainable Development: A Roadmap’.

———. 2021a. ‘Domestic Spending on Research and Development as a Share of GDP, 1996–2018 (%)’. 2021.

———. 2021b. ‘Sub-Education Policy Review Report: Education for Sustainable Development (ESD)’.

———. n.d. ‘Education for Sustainable Development’. Accessed 26 August 2022. https://www.unesco.org/en/education/sustainable-development.

———. n.d. ‘What Is Education for Sustainable Development?’ UNESCO.

UNESCO Hanoi. 2019. Manual on the Implementation of Education for Sustainable Development Policies at the Preschool and General Education Levels in Vietnam. Hanoi: UNESCO.

UNFCCC. 2020. ‘Bilateral Country Receipts by Sector’.

UN-Habitat. 2011. ‘Cities and Climate Change: Global Report on Human Settlements 2011’. Nairobi: United Nations Human Settlements Programme.

———. 2017. ‘New Urban Agenda’. Nairobi: United Nations.

———. 2020. The Value of Sustainable Urbanization. World Cities Report. Nairobi, Kenya: UN-Habitat.

———. 2021. ‘Cities and Pandemics: Towards a More Just, Green and Healthy Future’. UN-Habitat.

———. n.d. ‘Voluntary Local Reviews’. UN-Habitat.

UN-Habitat, and WHO. 2021. ‘Progress on Wastewater Treatment - Global Status and Acceleration Needs for SDG Indicator 6.3.1’.

UNICEF. 2021. ‘Drinking Water’. UNICEF Data. 2021. https://data.unicef.org/topic/water-and-sanitation/drinking-water/.

UNIDO. n.d. ‘Circular Economy and Agrobusiness Development’.

United Nations. 1972. ‘United Nations Conference on the Human Environment, Stockholm, 1972’.

———. 2021a. ‘The Second World Ocean Assessment II. Volume I’. Vol. I.

———. 2021b. ‘The Second World Ocean Assessment II. Volume II’. Vol. II.

———. n.d. ‘UN Comtrade Database’. Accessed 14 January 2022. https://comtrade.un.org/data/.

United Nations Department of Economic and Social Affairs Population Division. 2022. ‘World Population Prospects 2022’.

University of East Anglia Climate Research Unit, Ian C. Harris, Philip D. Jones, and Tim Osborn. 2021. ‘CRU CY4.05: Climatic Research Unit Year-by-Year Variation of Selected Climate Variables by Country Version 4.05 (Jan. 1901 - Dec. 2020)’. CEDA Archive. NERC EDS Centre for Environmental Data Analysis.

UNODC. 2022. ‘5 Things You Should Know about Waste Trafficking in Southeast Asia’. United Nations Office on Drugs and Crime. 2022. https://www.unodc.org/unodc/en/environment-climate/webstories/waste-trafficking-southeast-asia.html.

Unsworth, Richard K.F., Rohani Ambo-Rappe, Benjamin L. Jones, Yayu A. La Nafie, A. Irawan, Udhi E. Hernawan, Abigail M. Moore, and Leanne C. Cullen-Unsworth. 2018. ‘Indonesia’s Globally Significant Seagrass Meadows Are under Widespread Threat’. Science of the Total Environment 634: 279–86. https://doi.org/10.1016/j.scitotenv.2018.03.315.

UNU-IAS. 2014. ProSPER.Net: Transforming Higher Education and Creating Sustainable Societies. Edited by Aurea C. Tanaka and Mario T. Tabucanon. Tokyo: UNU-IAS.

———. 2021. ‘Roadmap for the RCE Community 2021-2030’. UNU-IAS.

———. 2022. ‘ProSPER.Net: Enabling Higher Education for the Sustainable Development Goals 2015-2021’. Edited by Mario Tabucanon and Jonghwi Park.

UN-Water. 2016. ‘Water and Sanitation Interlinkages across the 2030 Agenda for Sustainable Development’.

———. 2020. ‘The Sustainable Development Goal 6 Global Acceleration Framework’.

———. 2021. ‘Summary Progress Update 2021 : SDG 6 — Water and Sanitation for All’. UN-Water Integrated Monitoring Initiative.

———. 2022. ‘SDG 6 Data Portal’. UN-Water. 2022. https://www.sdg6data.org/maps.

UOB Global Economics & Markets Research. 2020. ‘Quarterly Global Outlook 1Q 2021: “Global Vaccine Reflation”’. Singapore.

Urban Redevelopment Authority. 2012. ‘Designing Our City: Planning for a Sustainable Singapore’.

U.S. Department of State. 2021. ‘U.S. Support for the ASEAN Outlook on the Indo-Pacific’. U.S. Department of State.

US EPA. 2021. ‘Endocrine Disruption’.

U.S. Mission to ASEAN. n.d. ‘Advancing Sustainable Recovery’. U.S. Mission to ASEAN. Accessed 31 December 2021a. https://asean.usmission.gov/connect/advancingsustainablerecovery/.

———. n.d. 'History of the U.S. and ASEAN Relations'. U.S. Mission to ASEAN. Accessed 31 December 2021b. https://asean.usmission.gov/our-relationship/policy-history/usasean/%0A.

———. n.d. 'Learn More about Connect'. U.S. Mission to ASEAN. Accessed 31 December 2021c. https://asean.usmission.gov/connect/learnmore/.

———. n.d. 'U.S.-ASEAN Connect Response to the ASEAN Comprehensive Recovery Framework'. U.S. Mission to ASEAN. Accessed 31 December 2021d. https://asean.usmission.gov/connect/acrf/%0A.

USGS. 2021. 'Mineral Commodity Summaries 2021'.

Vadrevu, Krishna Prasad, Kristofer Lasko, Louis Giglio, Wilfrid Schroeder, Sumalika Biswas, and Chris Justice. 2019. 'Trends in Vegetation Fires in South and Southeast Asian Countries'. Scientific Reports 2019 9:1 9 (1): 1–13. https://doi.org/10.1038/s41598-019-43940-x.

Valencia, Minda I. Cabilao. 2018. 'Introducing Education for Sustainable Development (ESD) in the Educational Institutions in the Philippines'. Journal of Sustainable Development Education and Research2 2 (1): 51–57.

Vaughan, Adam. 2021. 'UN Plan Would Protect 30% of Oceans and Land to Stem Extinctions'. New Scientist.

Viet Nam. 2018. 'Viet Nam's Voluntary National Review of the Sustainable Development Goals'.

Vietnam News Agency. 2011. 'Experts Worry about Mekong River Power Plant'. VNEconomyNews.Com, 2011.

Vijay, Varsha, Stuart L. Pimm, Clinton N. Jenkins, and Sharon J. Smith. 2016. 'The Impacts of Oil Palm on Recent Deforestation and Biodiversity Loss'. PLOS ONE 11 (7): e0159668. https://doi.org/10.1371/JOURNAL.PONE.0159668.

Visvanathan, Chettiyappan, and Venkatachalam Anbumozhi. 2018. 'Evolutionary Acts and Global Economic Transition: Progress of the Circular Economy in ASEAN'. In Industry 4.0: Empowering ASEAN for the Circular Economy, edited by Venkatachalam Anbumozhi and Fukunari Kimura, 67–105. ERIA.

Vu, Thi Hong Hanh, and Thanh Hai Truong. 2021. 'Climate Change and Cities in the Mekong Delta, Vietnam'. In Advances in 21st Century Human Settlements. https://doi.org/10.1007/978-981-15-5608-1_1.

Wallace, B.P., M. Tiwari, and M. Girondot. 2013. 'Dermochelys Coriacea'. The IUCN Red List of Threatened Species 2013. 2013.

Wallach, Omri. 2021. 'Race to Net Zero: Carbon Neutral Goals by Country'. Visual Capitalist.

WBCSD. 2021. 'Vision 2050: Time to Transform'.

WEPA. 2022. 'Outlook on Water Environmental Management in Asia'.

———. n.d. 'Thailand'. State of Water Environmental Issues. Accessed 12 January 2022. http://www.wepa-db.net/policies/state/thailand/thailand.htm.

———. n.d. 'Viet Nam'. State of Water Environmental Issues. http://www.wepa-db.net/policies/state/vietnam/waterquality.htm.

Wetchayont, Parichat, Tadahiro Hayasaka, and Pradeep Khatri. 2021. 'Air Quality Improvement during COVID-19 Lockdown in Bangkok Metropolitan, Thailand: Effect of the Long-Range Transport of Air Pollutants'. Aerosol and Air Quality Research 21 (7): 200662. https://doi.org/10.4209/aaqr.200662.

White, Patrick. 2017. ‘Aquaculture Pollution: An Overview of Issues with a Focus on China, Vietnam, and the Philippines’. Aquaculture Pollution.

WHO. 1997. Water Pollution Control: A Guide to the Use of Water Quality Management Principles. Edited by Richard Helmer and Ivanildo Hespanhol. London: E & FN Spon.

———. 2017. ‘Report on Health-Care Waste Management (HCWM) Status in Countries of the South-East Asia Region (SEA Region)’. New Delhi.

———. 2021a. ‘WHO Global Air Quality Guidelines’.

———. 2021b. ‘WHO Human Health Risk Assessment Toolkit: Chemical Hazards, Second Edition’.

Wijesinghe, Dhanuska, and Dara M. Park. 2017. ‘Soil Erosion in Southeast Asia: A Review’. In MANAGING GLOBAL RESOURCES FOR A SECURE FUTURE. Tampa, FL: American Society of Agronomy.

Wilcove, David S., and Lian Pin Koh. 2010. ‘Addressing the Threats to Biodiversity from Oil-Palm Agriculture’. Biodiversity and Conservation 2010 19:4 19 (4): 999–1007. https://doi.org/10.1007/S10531-009-9760-X.

Williams, C., S.K. Tiwari, V.R. Goswami, S. de Silva, A. Kumar, N. Baskaran, K. Yoganand, and V. Menon. 2020. ‘Elephas Maximus’. The IUCN Red List of Threatened Species 2020.

Williams, Joseph, and Jeffrey Voas. 2021. ‘Asian Development Outlook 2021: Financing a Green and Inclusive Reovery’. Asian Development Bank. Vol. 54. https://doi.org/10.1109/mc.2020.3033612.

WLE Greater Mekong. n.d. ‘Greater Mekong Dams Observatory’.

Wong, Poh Poh. 2016. ‘Coastal Erosion and Its Remediation in Six Southeast Asian Countries’. In Second China-ASEAN Academy on Ocean Law and Governance.

Woods, John S., Francesca Verones, Olivier Jolliet, Ian Vázquez-Rowe, and Anne Marie Boulay. 2021. ‘A Framework for the Assessment of Marine Litter Impacts in Life Cycle Impact Assessment’. Ecological Indicators 129 (October): 107918. https://doi.org/10.1016/J.ECOLIND.2021.107918.

World Bank. 2010. ‘Climate Risks and Adaptation in Asian Coastal Megacities’.

———. 2013. ‘East Asia Pacific Region Urban Sanitation Review: Indonesia Country Study’. World Bank, no. September: 1–68.

———. 2018. ‘Aquaculture Production (Metric Tons)’. World Development Indicators. World Bank. 2018.

———. 2021a. ‘A Trade-Based Analysis of the Economic Impact of Non-Compliance with Illegal, Unreported and Unregulated Fishing: The Case of Vietnam’.

———. 2021b. ‘DataBank | World Development Indicators’. Data Bank. 2021. https://databank.worldbank.org/reports.aspx?source=world-development-indicators.

———. 2021c. ‘GDP Growth (Annual %) - East Asia & Pacific (Excluding High Income)’. 2021.

———. 2021d. ‘Global Consumption Database’. 2021. https://datatopics.worldbank.org/consumption/.

———. 2021e. ‘Manufacturing, Value Added (Current US$)’. 2021. https://data.worldbank.org/indicator/NV.IND.MANF.CD.

———. 2021f. ‘Municipal Spatial Data Infrastructure’.

———. 2021g. ‘Opening the Door to Community Forest Access and Management in Indonesia’. 2021.

———. 2021h. ‘Population, Total - East Asia & Pacific’. 2021.

———. 2021i. ‘Urban Population’. World Bank.

———. 2021j. ‘Municipal Spatial Data Infrastructure: MSDI Manual’.

———. 2022a. ‘GDP (Current US$)’. https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

———. 2022b. ‘World Development Indicators’. World Bank.

World Bank Group. 2019. ‘Country Environmental Analysis: A Road towards Sustainability, Peace, and Prosperity: Synthesis Report’.

World Bank Group, and ADB. 2021. ‘Climate Risk Profile: Indonesia’.

World Commission on Environment and Development. 1987. ‘Our Common Future’.

World Economic Forum. 2020. ‘Future of Consumption in Fast-Growth Consumer Markets: ASEAN’. Geneva, Switzerland.

World Population Review. 2021. ‘Asia Cities by Population 2021’.

Wu, Junjun, Xin Wang, Bo Zhong, Aixia Yang, Kunsheng Jue, Jinhua Wu, Lan Zhang, et al. 2020. ‘Ecological Environment Assessment for Greater Mekong Subregion Based on Pressure-State-Response Framework by Remote Sensing’. Ecological Indicators 117 (October): 106521. https://doi.org/10.1016/j.ecolind.2020.106521.

Wulp, Simon A. van der, Larissa Dsikowitzky, Karl Jürgen Hesse, and Jan Schwarzbauer. 2016. ‘Master Plan Jakarta, Indonesia: The Giant Seawall and the Need for Structural Treatment of Municipal Waste Water’. Marine Pollution Bulletin 110 (2): 686–93. https://doi.org/10.1016/J.MARPOLBUL.2016.05.048.

WWF. 2021a. ‘Ecoregions’. 2021. https://web.archive.org/web/20211115042827/worldwildlife.org/biomes.

———. 2021b. ‘Greater Mekong’. 2021. https://greatermekong.panda.org/discovering_the_greater_mekong/species/new_species/new_species_on_the_block/.

———. 2022. ‘Coral Triangle’. World Wildlife Fund. 2022. https://www.worldwildlife.org/places/coral-triangle.

WWF-Greater Mekong. 2021. ‘New Species Discoveries in the Greater Mekong 2020’.

Yadav, Durgesh Singh, Bhavna Jaiswal, Meenu Gautam, and Madhoolika Agrawal. 2020. ‘Soil Acidification and Its Impact on Plants’. In Plant Responses to Soil Pollution, edited by Pratibha Singh, Sunita Kumari Singh, and Sheo Mohan Prasad, 1–26. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-15-4964-9_1.

Yamaguchi, Asuka. 2021. ‘Timber Trade in Industrialization of Modern Asia’.

Yang, Hee Cheol, Jeongmi Cha, Sunhwa Kim, and Hyunjoo Kim. 2018. ‘Entry into Force of Ship Ballast Water Management Convention and Its Implementation from Perspective of Northeast Asia’. Journal of International Maritime Safety, Environmental Affairs, and Shipping 1 (1): 19–21. https://doi.org/10.1080/25725084.2017.1427322.

Yang, Lie, Xiao Yu, Xiaolong Wu, Jia Wang, Xiaoke Yan, Shen Jiang, and Zhuqi Chen. 2021. ‘Emergency Response to the Explosive Growth of Health Care Wastes during COVID-19 Pandemic in Wuhan, China’. Resources, Conservation and Recycling 164: 105074. https://doi.org/10.1016/J.RESCONREC.2020.105074.

Yap, K S. 2012. ‘The Challenges of Promoting Productive, Inclusive and Sustainable Urbanization’. In Urbanization in Southeast Asia: Issues & Impacts, edited by K S Yap and Moe Thuzar, 10–77. Singapore: Institute of Southeast Asian Studies.

Yudiarso, Permana. 2012. 'The Development of Marine Spatial Planning in Indonesia'. In APEC MSP Training Workshop, 23-28 September 2012 Xiamen, China.

Zeng, Joshua Woo Sze. 2020. 'Evaluating the Penang South Reclamation (PSR) Project According to the United Nations' Sustainable Development Goals'. Penang Institute Issues, May.

Zeng, Zhenzhong, Lyndon Estes, Alan D Ziegler, Anping Chen, Timothy Searchinger, Fangyuan Hua, Kaiyu Guan, Attachai Jintrawet, and Eric F. Wood. 2018. 'Highland Cropland Expansion and Forest Loss in Southeast Asia in the Twenty-First Century'. Nature Geoscience 11 (8): 556–62. https://doi.org/10.1038/s41561-018-0166-9.

Zhang, Wei, Lei Chen, Rong Zhang, and Kuangfei Lin. 2016. 'High Throughput Sequencing Analysis of the Joint Effects of BDE209-Pb on Soil Bacterial Community Structure'. Journal of Hazardous Materials 301 (January): 1–7. https://doi.org/10.1016/J.JHAZMAT.2015.08.037.

Ziegler, Alan D., Jefferson M. Fox, and Jianchu Xu. 2009. 'The Rubber Juggernaut'. Science 324 (5930): 1024–25. https://doi.org/10.1126/SCIENCE.1173833.

Ziv, Guy, Eric Baran, So Nam, Ignacio Rodríguez-Iturbe, and Simon A Levin. 2012. 'Trading-off Fish Biodiversity, Food Security, and Hydropower in the Mekong River Basin'. Proceedings of the National Academy of Sciences 109 (15): 5609 LP – 5614. https://doi.org/10.1073/pnas.1201423109.

Zusman, Eric, Charlotte Unger, Nathan Borgford parnell, and Kathleen A. Mar. 2021. 'One Atmosphere: Integrating Air Pollution and Climate Policy and Governance'. Atmosphere 12 (12): 1–17. https://doi.org/10.3390/atmos12121570.

ASEAN: A Community of Opportunities for All

ASEAN

@ASEAN

@asean

www.asean.org

ISSN 3046-8701