GLOBAL ENVIRONMENT OUTLOOK

GEO-6

REGIONAL ASSESSMENT FOR

ASIA AND THE PACIFIC





Job No: DEW/1966/NA
ISBN: 978-92-807-3546-8

Suggested citation:
UNEP 2016. GEO-6 Regional Assessment for Asia and the Pacific. United Nations Environment Programme, Nairobi, Kenya.

Cover images (from left to right):
Front Cover
Eddie Phantana / Shutterstock.com; Pises Tungittipokai / Shutterstock.com; Sakarin Sawasdinaka / Shutterstock.com; De Visu / Shutterstock.com; chungking / Shutterstock.com

Back Cover
Rich Carey / Shutterstock.com; Palo_ok / Shutterstock.com; Ethan Daniels / Shutterstock.com; ippaPatt / Shutterstock.com; Palo_ok / Shutterstock.com

Cover Design: Audrey Ringler, UNEP
Design and Layout: Audrey Ringler, UNEP; UNON/Publishing Services Section
Printing: UNON/Publishing Services Section/Nairobi, ISO 14001:2004-Certified

The full assessment is available through UNEP Live (uneplive.unep.org), UNEP website (http://www.unep.org/publications) and as an eBook.

GLOBAL ENVIRONMENT OUTLOOK

GEO-6

REGIONAL ASSESSMENT FOR

ASIA AND THE PACIFIC

UNEP


North America priority:
Reducing GHG emissions, energy transition, and city-level innovation
UNEP Live data shows:
Per capita CO_2 emissions increased by 11.5% (1960-2012)
Africa priority:
Land management and use
UNEP Live data shows:
Total arable land increased by 53% but arable land per capita decreased by 59% (1961-2012)
Latin America and the Caribbean priority: Sustainable management of biological resources
UNEP Live data shows:
20.3% of LAC's terrestrial and marine area is protected (2010)

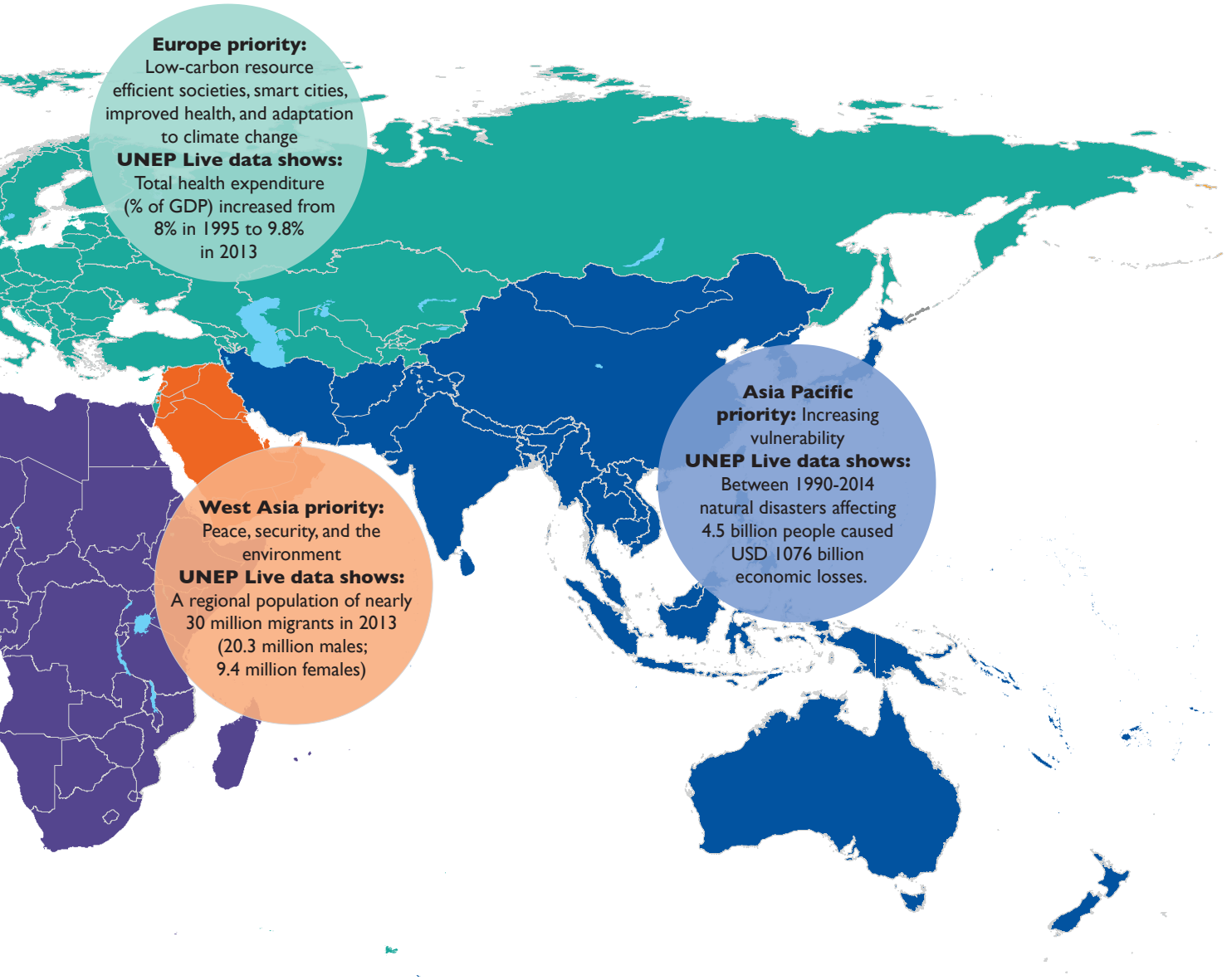

Europe priority:
Low-carbon resource efficient societies, smart cities, improved health, and adaptation to climate change
UNEP Live data shows:
Total health expenditure (% of GDP) increased from 8% in 1995 to 9.8% in 2013
Asia Pacific priority: Increasing vulnerability
UNEP Live data shows:
Between 1990-2014 natural disasters affecting 4.5 billion people caused USD 1076 billion economic losses.
West Asia priority:
Peace, security, and the environment
UNEP Live data shows:
A regional population of nearly 30 million migrants in 2013 (20.3 million males; 9.4 million females)

Table of Contents

Foreword ix

Acknowledgements x

Key Findings and Policy Messages xvi

Introduction 1

Regional Context and Priorities 4

1.1 Changing demographic patterns 5
- 1.1.1 Asia and the Pacific population dynamics 5
- 1.1.2 Inequality and access to basic services 11

1.2 Increasing use of natural resources and declining resource productivity 14
- 1.2.1 Resource efficiency plays an important role for sustainable development in the region 14
- 1.2.2 Material consumption increasing and productivity not improving 15
- 1.2.3 Energy supply, intensity and sustainability under pressure 18
- 1.2.4 Water use is increasing and intensity remains high 23
- 1.2.5 Economic growth is decoupling from resource consumption 25

1.3 Increasing vulnerability to the impacts of natural hazards and extreme events 27
- 1.3.1 Disasters caused by natural hazards in Asia and the Pacific 27
- 1.3.2 Causes of vulnerability and drivers of increasing risk 30
- 1.3.3 Impacts of disasters across Asia and the Pacific 32

1.4 Environmentally-related health risks 34
- 1.4.1 Introduction: health has social and environmental determinants 34
- 1.4.2 Water and food pollution in Asia and the Pacific 36
- 1.4.3 Air pollution, chronic disease and ageing 36
- 1.4.4 Agricultural intensification and ecosystem change 37
- 1.4.5 Climate change and health 38
- 1.4.6 Integrated environmental health risks 39

1.5 Widening of gaps between policy and implementation 39
- 1.5.1 Policy development 40
- 1.5.2 Addressing policy ineffectiveness 40
- 1.5.3 New policy options 42

State and Trends 44

2.1 Atmosphere – air and climate 45
- 2.1.1 Introduction 45
- 2.1.2 Drivers 45
- 2.1.3 Pressures 47
- 2.1.4 State 47
- 2.1.5 Ambient air quality 53
- 2.1.6 Impacts 55

2.2 Land 57
- 2.2.1 Introduction 57
- 2.2.2 Drivers 58
- 2.2.3 Pressures 58
- 2.2.4 State and trends 63
- 2.2.5 Impacts 66

2.3 Biota and ecosystems 68
- 2.3.1 Introduction 68
- 2.3.2 Drivers 69
- 2.3.3 Pressures 71
- 2.3.4 State and trends 74
- 2.3.5 Impacts 78

2.4 Freshwater 80
- 2.4.1 Introduction 80
- 2.4.2 Drivers 80
- 2.4.3 Pressures 81
- 2.4.4 State and trends 81
- 2.4.5 Impacts 86

2.5 Coasts and oceans 87
- 2.5.1 Introduction 87
- 2.5.2 Drivers 88
- 2.5.3 Pressures 93
- 2.5.4 State and trends 95
- 2.5.5 Impacts 98

2.6 Waste 98
2.6.1 Introduction 98
2.6.2 Drivers 99
2.6.3 Pressures 100
2.6.4 State and trends 100
2.6.5 Impacts 106

3 Policies, Goals and Objectives: Review of Policy Responses and Options 110

3.1 Achieving internationally agreed environmental goals 111
3.1.1 Climate and atmosphere 113
3.1.2 Forests and biodiversity 119
3.1.3 Water resources, drinking water and sanitation 125
3.1.4 Other cross-cutting agreements 129
3.1.5 Transformative agenda for post-2015 132

3.2 Success stories 133
3.2.1 Improving access to basic services 133
3.2.2 Promoting the efficient use of resources 135
3.2.3 Improving environmental quality 135
3.2.4 Market instruments 136
3.2.5 Conserving natural ecosystems 136
3.2.6 Addressing vulnerability 138
3.2.7 Much closer attention to socio-economic damage 140
3.2.8 Reducing environment-related health risks 140

3.3 Enabling conditions 141
3.3.1 Encouraging climate change adaptation as a main pillar of sustainable development 141
3.3.2 Providing a platform for developing and sharing sound scientific knowledge and analysis 142
3.3.3 Ensuring governance coherence across different levels of government 142

4 Megatrends, Emerging Issues and Outlooks 146

4.1 Review of major regional outlooks 147

4.2 Megatrends 150
4.2.1 Rapid economic growth and urbanization 150
4.2.2 Increasing pressure on ecosystems and natural capital 152
4.2.3 Climate change and increasing disaster risk 153
4.2.4 An inter-connected Asia and the Pacific region 154
4.2.5 New solutions from collaboration and emerging technologies 154

4.3 Emerging issues 156
4.3.1 Sustainable consumption and production 156
4.3.2 Shifting patterns of extreme climate and disasters 157
4.3.3 Transboundary issues: infrastructure and common market development 159
4.3.4 Environmental governance: large data-enhanced systems 159
4.3.5 Larger and smarter cities 160

4.4 Outlooks 161
4.4.1 Overview of regional and sub-regional outlooks 161
4.4.2 The Pacific sub-region, including Australia and New Zealand 162
4.4.3 Southeast and Northeast Asia sub-region 163
4.4.4 South Asia sub-region 164
4.4.5 The Sustainable Development Goals and Asia and the Pacific highlights 164

4.5 Transformative pathways and the Sustainable Development Goals 167
4.5.1 Transformative and greener pathways 167
4.5.2 Transitions towards sustainable low-carbon development 170
4.5.3 Low-emission development strategies 171

Acronyms and Abbreviations 175

List of Figures 180

List of Tables 183

List of Boxes 183

References 184

Foreword

The sixth Global Environment Outlook (GEO-6) Regional Assessment for Asia and the Pacific paints a comprehensive picture of the environmental factors contributing to human health and well-being at the regional level. Backed by a large body of recent, credible scientific evidence, regional-wide consultations and a robust intergovernmental process, the assessment demonstrates economic growth and improved access to basic services in the region. It also highlights the complexity of the interlinked environmental, social and economic challenges now confronting decision makers.

The launch of the *GEO-6 Regional Assessment for Asia and the Pacific* comes at a critical time. The world is on a new pathway to combat climate change and unleash actions and investment towards a low carbon, resource-efficient, resilient and sustainable future. At the same time, the 2030 Agenda for Sustainable Development provides a clear pathway to a world in which everyone can enjoy prosperity within the ecological limits of the planet.

The Asia and the Pacific region has seen rapid economic growth, urbanization and lifestyle changes that are unprecedented. Scientific analysis, however, shows the current approach to development in the region inflicts a significant cost on health and the environment. Soon, development will start to undermine itself. The region is also highly vulnerable to climate change; unchecked, its adverse effects can reverse the recent gains in development.

The region has made significant commitments to mitigate climate change. Almost all the countries submitted their Intended Nationally Determined Contribution (INDC) targets to the United Nations Framework Convention on Climate Change before the Paris Conference. In fact, there is optimism that larger economies will go further than their INDCs, taking additional transformative measures to lower greenhouse gas emissions and develop resource-efficient development solutions. Large and increasing investment in infrastructure is expected in the region over the next two to three decades. This provides great potential for countries to leapfrog to smarter solutions for resilient development and lasting prosperity, including through technological innovation and regional cooperation mechanisms.

I would like to extend my gratitude to the large body of policymakers, leading scientists and representatives from major stakeholder groups and partners who contributed to this comprehensive and illustrative assessment report. I extend an invitation to all countries in the region to engage with this report and use the opportunity provided to transform the vision of the 2030 Agenda for Sustainable Development and its Sustainable Development Goals into a reality for Asia and the Pacific.

Achim Steiner

United Nations Under-Secretary-General and
Executive Director, United Nations Environment Programme

Acknowledgements

Funding and in-kind support provided by:

Ministry of Environment, Republic of Korea

Elion Foundation, China

Institute for Global Environmental Strategies (IGES), Japan

Co-Chairs: Leilani Duffy-Iosefa (Conservation International Pacific Islands Program, Samoa, Peter King (Institute for Global Environmental Strategies (IGES), Thailand), Guomei Zhou (China-ASEAN Environmental Cooperation Centre, China)

High Level Intergovernmental and Stakeholder Advisory Group (HLG) Members: Laksmi Dhewanthi (Ministry of Environment, Indonesia), Yi Huang (Peking University, China), Asadaporn Krairapanond (Ministry of National Resources and Environment, Thailand; from *March 2016*), Tai Van Nguyen (Institute for Strategy and Policy on Natural Resources and Environment, Viet Nam), Eva Ocfemia (Department of Environment and Natural Resources, Philippines), Sunita Singh (Ministry of Environment, Forest and Climate Change, India; *February 2015–February 2016*)), Peter Johnson Mannepalli (Ministry of Environment, Forest and Climate Change, India; from *March 2016*), Majid Shafiepour Motlagh (Department of Environment, Iran), Wijarn Simachaya (Pollution Control Department, Thailand; *February 2015–February 2016*), Faamoetauloa Lealaiauloto Taito Faale Tumaalii (Minister of Natural Resources and Environment, Samoa), Gillian Bowser (Colorado State University, USA; stakeholder)

Scientific Advisory Panel (SAP): Patila Malua Amosa (National University of Samoa), Anthony Capon (United Nations University, Japan), Byung-Kook Lee (Korea Environment Institute), Anand Patwardhan (Indian Institute of Technology Bombay), N.H. Ravindrath (Indian Institute of Science), Danling Tang (South China Sea Institute of Oceanology, China), Naohiro Yoshida (Tokyo Institute of Technology, Japan)

Author teams

Chapter 1: Regional Context and Priorities

Section 1.1: Changing demographic patterns

Coordinating Lead Author: Sedigheh Babran (Islamic Azad University, Iran)
Lead Authors: Manjushree Banerjee (The Energy and Resources Institute (TERI), India), Alvin Chandra (The University of Queensland, Australia)

Section 1.2: Increasing use of natural resources and declining resource productivity

Coordinating Lead Authors: Heinz Schandl (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia)), Nguyen Trung Thang (Institute for Strategy and Policy on Natural Resources and Environment (ISPONRE), Viet Nam)

Lead Authors: Shilpi Kapur (The Energy and Resources Institute (TERI), India), Takako Wakiyama (Institute for Global Environmental Strategies (IGES), Japan), James West (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia)

Section 1.3: Increasing vulnerability to the impacts of natural hazards and extreme events

Coordinating Lead Author: Frank Thomalla (Stockholm Environment Institute (SEI) – Asia, Thailand)

Lead Authors: Sri Ramachandra Murthy Manchiraju (International Centre for Integrated Mountain Development (ICIMOD), Nepal)

Section 1.4: Increasing environmentally-related health risks

Coordinating Lead Author: Colin Butler (University of Canberra, Australia)

Lead Author: Ying (Grace) Wang (Tongji University, China)

Section 1.5: Widening of gaps between policy and implementation

Coordinating Lead Author: Chazhong Ge (Chinese Academy for Environmental Planning (CAEP), China)

Lead Authors: Dida Gardera (Ministry of Environment, Indonesia), Angel Hsu (Yale University, USA)

Chapter 2: State and Trends

Section 2.1: Atmosphere-air and climate

Coordinating Lead Author: Vanisa Surapipith (International Centre for Integrated Mountain Development (ICIMOD), Nepal)

Lead Authors: Rajasekhar Balasubramanian (National University of Singapore), Rajiv Kumar Chaturvedi (Indian Institute of Science), R Driejana (Bandung Institute of Technology, Indonesia), Indu K Murthy (Indian Institute of Science), Siwatt Pongpiachan (National Institute of Development Administration (NIDA), Thailand), Yousef Rashidi (Shahid Beheshti University, Iran), (Sunny Seuseu Secretariat of the Pacific Regional Environment Programme (SPREP), Samoa), Yuqing Yu (Institute for Global Environmental Strategies (IGES), Japan)

Section 2.2: Land

Coordinating Lead Author: Sivapuram V.R.K. Prabhakar (Institute for Global Environmental Strategies (IGES), Japan)

Lead Authors: Divya Datt (The Energy and Resources Institute (TERI), India), Fereydoun Ghazban (University of Tehran), Indu K Murthy (Indian Institute of Science (Indian Institute of Science), Sri Ramachandra Murthy Manchiraju (International Centre for Integrated Mountain Development (ICIMOD), Nepal), MP Sukumaran Nair (Centre for Green Technology and Management, India), Shilpanjali Deshpande Sarma (The Energy and Resources Institute (TERI), India)

Section 2.3: Biota and ecosystems

Coordinating Lead Author: Yongyut Trisurat (Kasetsart University, Thailand)

Lead Authors: Rajiv Kumar Chaturvedi (Indian Institute of Science), Leilani Duffy-Iosefa (Conservation International Pacific Islands Program, Fiji), Easter Catherine Galuvao (Secretariat of the Pacific Regional Environment Programme (SPREP), Samoa), Sri Ramachandra Murthy Manchiraju (International Centre for Integrated Mountain Development (ICIMOD), Nepal), Jiang Zhiang (Institute of Zoology, China)

Section 2.4: Freshwater

Coordinating Lead Author: Malini Balakrishnan (The Energy and Resources Institute (TERI), India)

Lead Authors: Samjwal R Bajracharya (International Centre for Integrated Mountain Development (ICIMOD), Nepal), Vidya S Batra (The Energy and Resources Institute (TERI), India), Muhammad Zia Ur Rahman Hashmi (Global Change Impact Studies Centre (GCISC), Pakistan), Arun Bhakta Shrestha (International Centre for Integrated Mountain Development (ICIMOD), Nepal)

Section 2.5: Coasts and oceans

Coordinating Lead Author: Poh Poh Wong (The University of Adelaide, Australia)

Lead Authors: Leilani Duffy-Iosefa (Conservation International Pacific Islands Program, Samoa), Paul Anderson (Secretariat of the Pacific Regional Environment Programme (SPREP, Samoa)

Section 2.6: Waste

Coordinating Lead Author: Nguyen Trung Thang (Institute for Strategy and Policy on Natural Resources and Environment (ISPONRE), Viet Nam)

Lead Authors: Sunil Herat (Griffith University, Australia), Yasuhiko Hotta (Institute for Global Environmental Strategies (IGES), Japan), Prasad Modak (Environment Management Centre, India)

Chapter 3: Environmental Policies, Goals and Objectives: Review of policy responses and options

Section 3.1: Achieving the internationall agreed environmental goals

Section 3.2: Success stories

Section 3.3: Enabling conditions

Coordinating Lead Authors: Souvik Bhattacharjya (The Energy and Resources Institute (TERI), India), Hoon Chang (Korea Environment Institute (KEI)), Binaya Raj Shivakoti (Institute for Global Environmental Strategies (IGES), Japan)

Chapter 4: Megatrends, Emerging Issues and Outlooks

Section 4.1: Review of major regional outlooks

Coordinating Lead Authors: Mark Elder (Institute for Global Environmental Strategies (IGES), Japan), Sivapuram V.R.K. Prabhakar (Institute for Global Environmental Strategies (IGES), Japan)

Section 4.2: Megatrends

Section 4.3: Emerging issues

Section 4.4: Outlooks

Section 4.5: Transformative pathways and the Sustainable Development Goals

Coordinating Lead Authors: Mark Elder (Institute for Global Environmental Strategies (IGES), Japan) , Gensuo Jia (CAS Institute of Atmospheric Physics, China), Bundit Limmeechokchai (Sirindhorn International Institute of Technology (SIIT), Thailand)

A special acknowledgement of the contribution made by Peter Kouwenhoven as a Coordinating Lead Author who passed away while attending the 2nd Authors' Meeting held in IGES, Tokyo, Japan on 22–24 July 2015.

UNEP team

Overall coordination: Ananda Dias, Panvirush Vittayapraphakul, Jinhua Zhang

ROAP Support: Satwant Kaur, Isabelle Louis, Imae Mojado, Kaveh Zahedi (upto March 2016)

Support: Johannes Akiwumi, Joana Akrofi, Pierre Boileau (Head of GEO Unit), Elisabetta Bonotto, Jillian Campbell, Ludgrade Coppens, Gerard Cunningham, Harsha Dave, Volodymyr Demkine, Priyanka DeSouza, Sami Dimassi, Angeline Djampou, Philip Drost, Ngina Fernandez, Valentin Foltescu, Sandor Frigyik, Betty Gachao, Winnie Gaitho, Dany Ghafari, Loise Gichimu, Virginia Gitari, Tessa Goverse, Caroline Kaimuru, Esther Katu, Fredrick Lerionka, Erick Litswa, Esther Marsha, Elizabeth Masibo, Jacqueline McGlade, Patrick M'Mayi, Pascil Muchesia, Pauline Mugo, Ruth Mukundi, Josephine Mule, Caroline Mureithi, Jane Muriithi, Onesmus Mutava, Nyokabi Mwangi, Monica Mwove, Joyce Ngugi, Trang Nguyen, Victor Nthusi, Franklin Odhiambo, Hanul OH, Brigite Ohanga, Thierry Oliveira, Evelyn Ongige, Samuel Opiyo, Neeyati Patel, Christina Power, Audrey Ringler, Pinya Sarassas, Gemma Shepherd, Asha Sitati, Simone Targetti Ferri, Mwangi Theuri, Kaisa Uusimaa, Peninah Wairimu-kihuha, Josephine Wambua, Jochem Zoetelief, Zinta Zommers

Community of Practice Moderators: Carolina Adler (ETH Zurich, Switzerland), Simone Maynard (Simone Maynard Consulting, Australia)

Governmental, UN, stakeholder, scientific and expert reviewers: Neil Burgess (UNEP/WCMC, UK), Elenita Dano (Erosion, Technology and Concentration (ETC), Canada), Philip Drost (UNEP), Valentin Foltescu (UNEP), Karin Fernando (Centre For Poverty Analysis (CEPA), Sri Lanka), Yngvil Foss (UNEP), Neil C. Hawkins (The Dow Chemical Company), Yuyun Ismawati (BaliFokus/IPEN, Indonesia), Nawarat Krairapanond (Ministry of Natural Resources and Environment, Thailand), Byung Kook Lee (Korea Environment Institute), Jinhui Li (Tsinghua University, China), Ghulam Mohd Malikyar (National Environment Protestion Agency, Afghanistan), Cai Mantang (Beijing University, China), Melchior Mataki (Ministry of Environment, Conservation and Meteorology, Solomon Islands), Shahlla Matin (National Environment Protestion Agency, Afghanistan), Miak Aw Hui Min (Ministry of the Environment and Water Resources, Singapore), Ong Choon Nam (NUS Environmental Research Institute, Singapore), Simon Hoiberg Olsen (Institute for Global Environmental Strategies (IGES), Thailand), Kareff Limocon Rafisura (ESCAP, Thailand), Nilapha Ratanavong (AIT/RRC.AP, Thailand), N.H. Ravindrath (Indian Institute of Science), Anshuman Saikia (International Union for Conservation of Nature and Natural Resources (IUCN, Thailand), Sunita Singh (Ministry of Environment, Forest and Climate Change, India), Subrata Sinha (UNEP), Aree Suwanmanee (Ministry of Natural Resources & Environment, Thailand), Eiji Tanaka (Ministry of Environment, Japan), Shuxiao Wang (Tsinghua University, China), Jinhua Zhang (UNEP), Uchita de Zoysa (Centre for Environment and Development, Sri Lanka)

Partners (e.g. institutions that contributed with specific data, information, funding or services): Ministry of Environment, Republic of Korea for financial support, Institute for Global Environmental Strategies, Tokyo for hosting the 2nd Authors' Meeting

REIN Conference participants:

Government Delegates: Ahmed Anwar Abdul Azeez (Ministry of Environment and Energy, Maldives), Jay Ram Adhikari (Ministry of Science, Technology and Environment, Nepal), Miak Aw Hui Min (Ministry of the Environment and Water Resources, Singapore), Yeruult Bayart (Ministry of Environment, Green Development and Tourism, Mongolia), Jacqueline A. Caancan (Environmental Management Bureau, Philippines), Hoon Chang (Korea Environment Institute, Republic of Korea), Wacharee Chuaysri (Ministry of Natural Resources and Environment, Thailand), Virasack Chundara (Natural Resources and Environment Institute, Lao PDR), Himali De Costa (Ministry of Mahaweli Development and Environment, Sri Lanka), Ariuntuya Dorjsuren (Ministry of Environment, Green Development, and Tourism, Mongolia), Gamini Gamage (Ministry of Mahaweli Development and Environment, Sri Lanka), Abdul Hai (Department of Environment, Bangladesh), Mazhar Hayat (Ministry of Climate Change, Pakistan), Ali G Holampour (Embassy of Iran in Thailand), Md. Afzal Hossain (Ministry of Environment and Forest, Bangladesh), Yi Huang (Peking University, China), Srisuda Jarayabhand (Ministry of Natural Resources and Environment, Thailand), Nawarat Krairapanond (Ministry of Natural Resources and Environment, Thailand), Siosiua Latu (Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communication, Tonga), Carlos Lopes Ximenes (Ministry of Commerce, Industry and Environment, Timor Leste), Nelson Madeira (Department for Climate Change, Timor Leste), Leila Mostafavi (Department of Environment, Iran), Nuke Mutikania (Ministry of Environment, Indonesia), Ibrahim Naeem (Environment Protection Agency, Maldives), Yong Ni (China National Environmental Monitoring Centre, China), San Oo (Ministry of Environmental Conservation and Forestry, Myanmar), Rungnapar Pattanavibool (Ministry of Natural Resources and Environment, Thailand), Majid Shafie-Pour (Department of Environment, Iran), Pramod Simkhada (Ministry of Science, Technology, and Environment, Nepal), Arkar San (Ministry of Environmental Conservation and Forestry, Myanmar), Vilaysook Sisoulath (Lao Statistics Bureau, Lao PDR), Wijarn Simachaya (Pollution Control Department, Thailand), Nonglak Sopakayoung (Ministry of Natural Resources and Environment, Thailand), Aree Suwanmanee (Ministry of Natural Resources and Environment, Thailand), Tshering Tashi (National Environment Commission, Bhutan), Do Nam Thang (Ministry of Natural Resources and Environment, Viet Nam), Karma Tshering (National Environment Commission, Bhutan), Sudarmanto (Ministry of Environment, Indonesia)

Experts:

Carolina Adler (ETH Zurich, Switzerland), Sedigheh Babran (Islamic Azad University, Iran), Malini Balakrishnan (The Energy and Resources Institute (TERI)), Souvik Bhattacharya (The Energy and Resources Institute (TERI), India), Anthony Capon (International Institute for Global Health, United Nations University, Malaysia), Hoon Chang (Korea Environment Institute, Republic of Korea), Liu Chuang (Institute of Geographical Sciences and Natural Resources Research, China), Daniel Clarke (ESCAP, Thailand), Leilani Duffy-losefa (Conservation International Pacific Islands Program, Samoa), Mark Elder (Institute for Global Environmental Strategies (IGES), Japan), Dida Gardera (Ministry of Environment, Indonesia), Fereydoun Ghazban (University of Tehran, Iran), Rikke Hansen (ESCAP, Thailand), Gensuo Jia (CAS Institute of Atmospheric Physics, China), Peter King (Institute for Global Environmental Strategies (IGES), Thailand), Bundit Limmeechokchai (Sirindhorn International Institute of Technology (SIIT), Thailand), Jane Lawton International Union for the Conservation of Nature (IUCN), Switzerland, Simone Maynard (Simone Maynard Consulting, Australia), MP Sukumaran Nair (Centre for Green Technology and Management, India), Simon Olsen (Institute for Global Environmental Strategies (IGES), Thailand), Sivapuram V.R.K. Prabhakar (Institute for Global Environmental Strategies (IGES), Japan), N.H. Ravindranath Indian Institute of Science), Binaya Raj Shivakoti (Institute for Global Environmental Strategies (IGES), Japan), Vanisa Surapipith (International Centre for Integrated Mountain Development (ICIMOD), Nepal), Nguyen Trung Thang (Institute for Strategy and Policy on Natural Resources and Environment, Viet Nam), Frank Thomalla (Stockholm Environment Institute (SEI) – Asia, Thailand), Terrence Thompson (Water & Environment International, the Philippines) Yongyut Trisurat (Kasetsart University, Thailand), George C. Varughese (Development Alternatives), Takako Wakimaya (Institute for Global Environmental Strategies (IGES), Japan), Guomei Zhou (China-ASEAN Environmental Cooperation Centre, China)

Credit: Maman Sukirman, Indonesia ▶

Key Findings and Policy Messages

Overall Picture

The GEO-6 Asia and the Pacific Regional Assessment is based on scientific review of critical environmental trends identified by member States and stakeholders at the Regional Enviromental Informaton Network(REIN) Conference held in Bangkok, 27-28 April 2015. The First Forum of Ministers and Environment Authorities of Asia and the Pacific, held shortly after the REIN, decided on priority environmental actions for the region mirroring these critical trends.

Changing demography, lifestyles and access to basic services: Rapid urbanization, affluent life-styles, and increased demand for resources and services associated with economic growth are exerting increasing pressure on ecosystem resources;

Increasing inefficiency in the use of resources: Increasing resource use, with little improvement in the efficiency of such use, is causing widespread environmental degradation, loss of ecosystem services, generation of excessive waste and additional financial burdens;

Increasing vulnerability to the impacts of natural hazards and extreme events: The effect of climate change and disasters and increasing vulnerability due to unplanned development and urban migration will continue to impose economic losses that could offset development gains, increase poverty and inequity, and threaten water and food security;

Increasing environmentally related health risks: While there is improvement in life expectancy, there are increased health threats often with disparate effects based on gender and age, along with costs from widespread air pollution, harmful chemicals and heavy metals, and emergence and spread of vector-borne diseases; and

Widening gaps across the landscape of policies and legislation and their implementation: There has been increasing policy intervention to cope with existing issues but the policy gap is widening due to ineffective policy implementation, a poor scientific base for policy formulation, and rapidly emerging environmental issues.

Key Findings

The analysis of key environmental themes on air, land, biota an ecosystems, freshwater, coasts and oceans, and waste using the *drivers-pressures-state-impact-response* (DPSIR) framework shows accelerating environmental degradation widely across the region and its impact on human well-being. Key findings of the Assessment are:

Air: Sulphur dioxide and nitrogen oxide emissions have reduced, but ambient concentrations of ozone and fine particles (short-lived climate pollutants (SLCPs) such as black carbon) have continued to increase. Trans-boundary smoke haze pollution, due to open biomass burning and improper land-use practices, is becoming the key regional air quality problem in Southeast Asia, and highlights the urgency of multilateral solutions and regional cooperation. Indoor air pollution from burning poor quality fuels or biomass impacts women and children throughout the region contributing to health effects. Climate change impacts on cities and infrastructure are intensified in some coastal zones and Pacific island countries, while extreme climate events are becoming the major cause of disasters in the region.

Land: Land degradation has been intensified over most of the region, with consequent displacement of indigenous people, loss of biodiversity, and reduction in important forest products. Land degradation has additional implications for water resources in terms of soil water content and groundwater recharge. The total forest area has increased in some areas of Asia since 1990 due to reforestation efforts, but there are significant sub-regional differences. Meanwhile, there is continuous loss of wilderness, natural forest systems, mangroves and other natural systems to croplands and urban growth.

Biota and ecosystems: Ecosystems integrity and biodiversity are threatened throughout the region due to extensive agriculture, oil palm and rubber plantations, aquaculture and illegal wildlife trade. Natural forest areas in Southeast Asia and the Pacific, recognized as global biodiversity hotspots, declined drastically in 1990–2015. The number of threatened mammal and plant species increased by more than 10 and 18 per cent respectively in the last decade.Three-quarters of all threatened birds on oceanic islands are also in danger from invasive species. A quarter of all conifers and cycad species are threatened, as are one fifth of marine mammal species. In the oceanic countries and Small Island States, over 25 per cent of hard warm-water corals are experiencing bleaching, mainly due to high thermal stress, and are impacted by dumping of plastic debris and micro-plastic hazardous waste in the oceans.

Freshwater: Water scarcity and deteriorating water quality are commonplace throughout the region especially in Northeast and South Asia. As climate change impacts on water resources become more pronounced, particularly in rivers originating in the Hindu Kush Himalayas, flood and drought events will become more frequent and intensified. Contamination of water sources from human and livestock sewage is a major concern across the region; and the widespread contamination of ground water by pharmaceutical and personal care products, nanomaterials, and organochlorides increase the exposure to human health risk, especially for women and young children. Water related diseases and unsafe water contribute to 1.8 million deaths annually and 24.8 million disability-adjusted life years in the region.

Coasts and oceans: The coastal zone is inherently attractive for human settlement and continued urbanization draws in greater populations, with 325 million more people expected to live in the coastal zone by 2025. About 60 per cent of the coastal mangroves in Asia and the Pacific have been cleared for development and more than 80 per cent of the coral reefs are at risk. Severe erosion prevails on one-quarter to one-third of the coastlines in Southeast Asia. Pollution caused by plastic debris and microplastics is an increasing concern in the region.

Waste: Municipal solid waste generation is expected to rise from 870 million tonnes in 2014 to 1.4 billion tonnes annually by 2030 in the region. New and complex waste streams like e-waste, food waste, construction/demolition waste, disaster waste and marine litter are emerging. Uncontrolled dumping is still the main waste disposal method in the region, leading to leachate run off, methane emission, spontaneous combustion, and other environmental problems. However, recent emergence of waste to energy investment programs could be further enhanced to provide better waste disposal.

The Way Forward: Policy Messages

Regional economic growth and urbanization have helped lift millions out of poverty to middle class affluence, and improved access to basic services. These achievements, however, have come with heavy costs to natural capital, biodiversity, ecosystem functioning, and human health. These stressors contribute to gender and economic inequalities and undermine regional economic growth itself. Climate change, air pollution and ecosystem disturbance are emerging issues and could reverse recent progress in human development.

To counteract the socioeconomic drivers leading to environmental degradation, an economic transformation that is particularly based on improved energy and transportation systems and smart green growth for urban areas is urgently needed. Thirty nine countries out of forty one in the region, submitted their respective *Intended Nationally Determined Contributions* (INDCs) to the UNFCCC before the Paris Conference, illustrating the region's commitment to mitigate climate change. The region could strive for more transformational change aiming at low-emission development strategies to achieve more than the laudable commitments in their INDCs.

The SDGs will help to promote a more integrated and holistic approach to resource management and ecosystem preservation. With increasing and large investments in new infrastructure expected over the next two-to-three decades, there is optimism in the region that the countries can

leapfrog to smarter solutions for resilient development and lasting prosperity.

Decarbonize development and improve resource efficiency for transition to an inclusive green economy. The region has been taking a development path which is carbon-intensive, and is contributing to emission levels unsafe for life and disruptive to the global climate. Most important areas for decarbonizing economies are energy, infrastructure, cities and transportation. There is a large potential for achieving energy efficiency through energy demand management combined with regulations and economic instruments. The transition to renewable energy requires stable regulatory regimes aligned with long-term vision for energy systems, to build investor confidence. The urban and transportation infrastructure sectors require innovative low-carbon policies, market-based instruments and technology solutions to ensure that the development is environmentally sustainable. Overall, decarbonizing strategies will generate technology innovation, business development and job creation, contributing to broader socioeconomic development.

Regional consumption of minerals, ores, fossil fuel and biomass exceeds the other regions and is leading to the rapid depletion of regional resources. Transition to sustainable production and consumption practices would curb demand for materials and a range of policy tools are available to help change resource use patterns. Taxes and market-based instruments that shift consumer preferences and promote green investment and innovation are essential. Governments could invest in stimulating green-reforms in key economic sectors and limit spending in areas that deplete natural capital. Many communities in the region already live within ecologically sustainable limits and these lifestyles could be protected as development takes place.

Protect and enhance natural capital and ecosystem integrity. The region's diverse ecosystems and rich biodiversity provide food, nutrition, water, clean air, and the materials for infrastructure. Ensuring ecosystem integrity requires accounting for natural capital in the system of national accounts and incorporating ecosystem services values into decision-making and policy formulation by governments. Regulatory and incentive-based policies are required for protecting natural capital. Market-based mechanisms such as tax on pollution and non-renewable resource use are effective tools to minimize pressures on natural capital. Regulatory policies would include zoning, establishment of protected areas and Environmental Impact Assessments (EIA) of projects. Governments also need to invest in conservation and restoration of degraded natural capital. Engaging local communities in the protection and management of natural habitats and protected areas are among the most effective tools for resource protection in many countries, which could be up scaled and replicated.

Build resilience to natural hazards and extreme climate events. The region has more reported natural disasters and extreme events than any other area in the world. The frequency, magnitude and impact of climate related disasters has increased recently and ensuring the safety of people, security of their livelihoods, and protecting ecosystems and their services require multiple measures. One priority is to reinforce early-warning systems and build regional capacity for disaster management, recovery and rebuilding. Ecosystems approach addresses the crucial link between land, water and living resources and thus provides a promising strategy to increase the resilience of ecosystems and support sustainable livelihoods. Ecosystem-based adaptation measures would include alternative livelihoods, infrastructure upgrades, soil conservation, water regulation, etc. Adaptation strategies yield multiple development benefits and maximizing these synergies requires mainstreaming climate change adaptation into national planning.

Respond to environmental health risks. Widespread pollution and the impacts of extreme environmental events are root causes of disease burdens especially among lower economic strata and women. There is widespread risk of environmentally induced mortality and morbidity from indoor and urban air pollution, drinking water contamination, poor sanitation, and vector-borne diseases. Air and water quality

standards establishment and enforcement, Cartagena bio-safety protocol enforcement, climate and disaster related responses, and integrated vector management are critical policy responses for the region. To reduce pollution requires both regulatory and economic approaches to accelerate needed energy and resource efficiencies, to promote renewable energy and develop sustainable transportation infrastructure. Integrated land-water-waste management including the agro-forestry sector is necessary to reduce pollution of land and water resources and to control the spread of vector-borne diseases.

Strengthen environmental governance for effective policy diffusion at multiple scales. Environmental regimes and institutions are still inadequate in many countries of the region, which leads to inadequate policy responses, weak enforcement of laws and regulations, and poor compliance with MEAs. Mandates, operational arrangements and capacity of these national institutions need to be assessed and revitalized so that they are able to effectively discharge their current responsibilities, and in the future, respond to increased demand from SDGs which call for governments to take strong and decisive environmental actions. Since governments are organized by sectors, a new way of thinking about environment and development, including the gender dimensions, based on an SDG's integrated approach needs to be established across ministries and among political leadership. In addition, implementation of the SDGs requires strong science-policy dialogues, effective environmental assessments and monitoring, and the finance and technology support. Governments could also promote civil society and public participation in solutions to improve environmental quality.

Strengthen science-policy interface and access to knowledge. Environmental issues and their links to development are complex, so scientific knowledge of this relationship is fundamental to achieving sustainable development. National platforms and other mechanisms are necessary to facilitate science-policy discussions on national environmental issues among the government, business and scientific/research community. A high national priority is to.strengthen or establish a mechanism for regular reporting on environment to national parliamentary and planning processes. Awareness raising among the local business and civil society communities through education or media outfits is necessary. Education targeting national administrations would help build an equitable and gender-balanced workforce able to effectively diffuse environmental policy across all economic and societal sectors. Better monitoring and data management systems combined with continuous building of analytical capacity are necessary to support the assessment and research that underpins policy-making.

Enhance international/regional cooperation on climate, air quality and other environmental issues. Countries in the region are parties to many MEAs at the global and regional levels, but implementation has been insufficient as many countries lack implementation capacity. An urgent need is to strengthen capacity to effectively implement the obligations under these MEAs, including the development and enforcement of national legislation and regulations. In that regard, national implementation of the ASEAN Agreement on Transboundary Haze Pollution is a priority. Regional cooperation on disaster management, e-waste management and illegal wildlife trade are also priorities. Elements of a regional support system are in place to support disaster response and emergency relief efforts, but need reinforcing with the expected increase in disasters and extreme climate events. Implementation of the SDGs will require international cooperation mechanisms to support knowledge sharing, technology transfer and technology financing.

Introduction

Welcome to the GEO-6 regional assessment for Asia and the Pacific, through which the UNEP Secretariat and authors provide an objective evaluation and analysis of the state, trends and outlooks of the environment in the region in order to support environmental decision making. In this assessment, the judgement of experts is applied to existing knowledge to provide scientifically credible answers to policy-relevant questions[1]. These questions include, but are not limited to:

- What is happening to the environment in Asia and the Pacific and why?
- What are the consequences for the environment and the human population of Asia and the Pacific?
- What is being done and how effective is it?
- What are the prospects for the environment in the future?
- What action could be taken to achieve a more sustainable future?

The decision to undertake regional assessments was taken at the Global Intergovernmental and Multi-stakeholder Consultation in Berlin, 21–23 October 2014. Participants requested that the sixth edition of the global *Global Environment Outlook* (GEO-6) assessment should "*build on regional assessments*" which would be conducted in a similar fashion to the global GEO process[2].

The mandate for the meeting was provided by Member States attending the first meeting of the United Nations Environment Assembly (UNEA 1)in Nairobi from 23–27 June 2014. In their statement Member States requested:

> *"the Executive Director, within the programme of work and budget, to undertake the preparation of the sixth Global Environment Outlook (GEO-6), supported by UNEP Live, with the scope, objectives and procedures of GEO-6 to be defined by a transparent global intergovernmental and multi-stakeholder consultation informed by document UNEP/EA.1/INF/14, resulting in a scientifically credible, peer-reviewed GEO-6 and its accompanying summary for policy makers, to be endorsed by the United Nations Environment Assembly no later than 2018".*

In addition, Member States also requested:

> *"the Executive Director to consult with all United Nations Environment Programme regions regarding their priorities to be taken up in the global assessment"*[3].

Following from this request, the regional priorities for Asia and the Pacific were established through a Regional Environmental Information Network (REIN) conference, held from 27–28 April 2015 in Bangkok. These regional priorities have been used to guide the analysis conducted in this assessment.

1 UNEP 2015, *An Introduction to Environmental Assessment*, United Nations Environment Programme in collaboration with the UNEP World Conservation Monitoring Centre, 2015, Cambridge and Nairobi, http://apps.unep.org/publications/index.php?option=com_pub&task=download&file=011945_en

2 UNEP/IGMS.2 Rev.2, *Statement by the Global Intergovernmental and Multi-Stakeholder Consultation on the Sixth Global Environment Outlook*, Berlin, 21–23 October 2014, http://uneplive.unep.org/community/file/view/5731/geo-6-outcome-document .

3 UNEP/EA.1/10, *Proceedings of the United Nations Environment Assembly of the United Nations Environment Programme at its first session*, Nairobi, 23-27 June, 2014, Resolution 1/4 paragraphs 8 and 9, http://www.unep.org/unea1/UNEA_Proceedings.asp .

◄ Credit: Shutterstock/ Sakarin Sawasdinaka

The regional assessment is structured in four main chapters that:

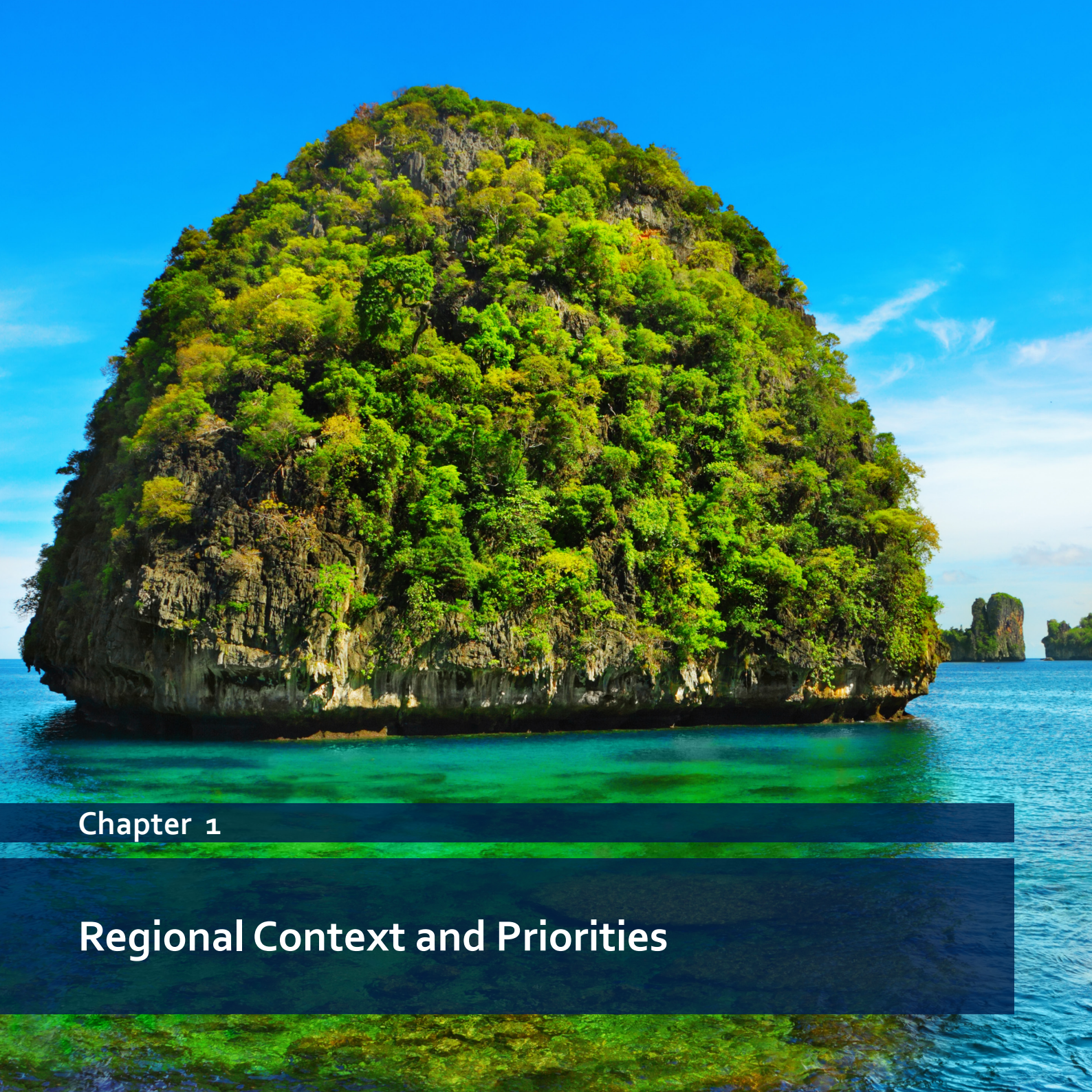
- reviews the regional priorities established at the REIN conference and explain why each priority is of importance to the region;
- establishes the state of the region's environment for six key themes, air, land, biota, freshwater, coasts and oceans, and wastes, and analyses the key trends for each;
- assesses policy responses to these environmental issues;
- reviews the main trends that will affect the region's environment in the future and analyses the action needed for it to achieve a more sustainable future.

There are five GEO-6 sub-regions in Asia and the Pacific, consisting of a total of 41 countries as follows:

- Australia and New Zealand;
- Northeast Asia: China, DPR Korea, Japan, Mongolia and Republic of Korea;
- South Asia: Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka;
- Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Timor-Leste, Thailand and Viet Nam;
- The Pacific: Cooks Islands, Fed. States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.

The data underpinning the assessement can be found in UNEP Live (uneplive.unep.org). The full assessment is available through UNEP Live as a pdf and as an eBook.

Credit: Shutterstock /Pcruciatti ▶



Chapter 1

Regional Context and Priorities

The sixth *Global Environment Outlook* (GEO-6) regional assessment for Asia and the Pacific process began with the inaugural meeting of the Asia and the Pacific Regional Environmental Information Network (REIN) Conference held from 27–28 April 2015 in Bangkok, Thailand. It was attended by 90 participants, including representatives of the governments of Bangladesh, Bhutan, China, Indonesia, Islamic Republic of Iran, Lao PDR, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Republic of Korea, Singapore, Sri Lanka, Timor Leste, Tonga and Viet Nam; regional partners; and GEO experts nominated by governments and partner institutions to support the assessment.

Participants at the REIN conference recognized extensive and accelerating environmental degradation in the region and its impact on human well-being, and agreed on a set of critical trends to be considered in developing this regional assessment:

- accelerating environmental degradation;
- increasing vulnerability to the impacts of natural hazards and extreme events;
- increasing inefficiency in the use of resources;
- increasing environmentally-related health risks;
- changing demography, lifestyles and access to basic services;
- widening of gaps in policies and legislation and their implementation.

The First Forum of Ministers and Environment Authorities of Asia Pacific, held in Bangkok shortly after the REIN (19–20 May 2015), decided on environmental priority action for the region[4] largely mirroring these critical trends which are analyzed in this chapter.

1.1 Changing demographic patterns

1.1.1 Asia and the Pacific population dynamics

A key driver of environmental degradation is rapid population growth. Asia and the Pacific's huge population drives significant environmental challenges. The region's population, about 60 per cent of the world's total, reached

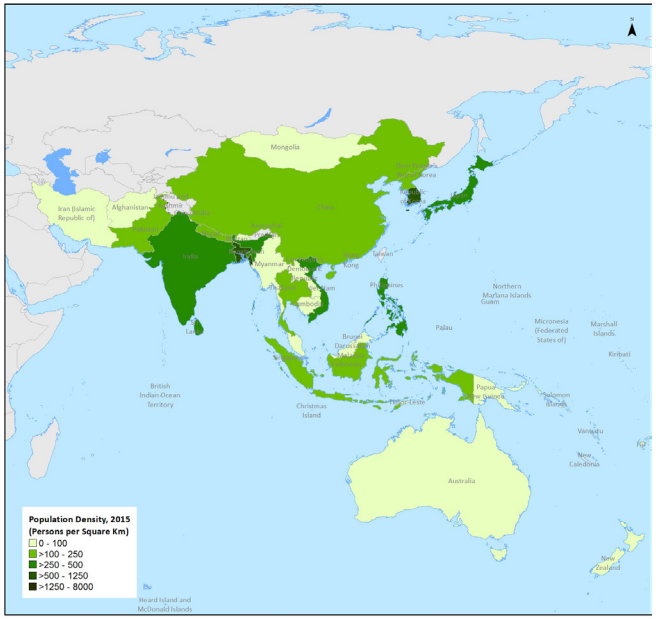
Key Messages

- Population dynamics drive environmental challenges and must be addressed in the 2030 regional sustainable development agenda.
- Population growth, economic development and inequality drive migration patterns in Asia and the Pacific, with local and global environmental consequences.
- Low fertility and an aging population can burden the environment through increased consumption and dependent elders.
- Changes in lifestyles will increase the demand for material consumption, drive land-use change and greenhouse gas emissions.
- Inequality and poverty further contribute to environmental degradation and pose unequal risks to the poor and women.

4 Enhance resilience; decarbonize the economy; decouple economic growth from resource use and pollution: value and secure the sustainable provision of ecosystem services; manage chemicals and waste: address air quality; develop integrated approaches to environment and health: and use the Sustainable Development Goals (SDGs) to scale up environmental action.

◄ Credit: Adisa

Figure 1.1.1: Asia and the Pacific population density, 2015



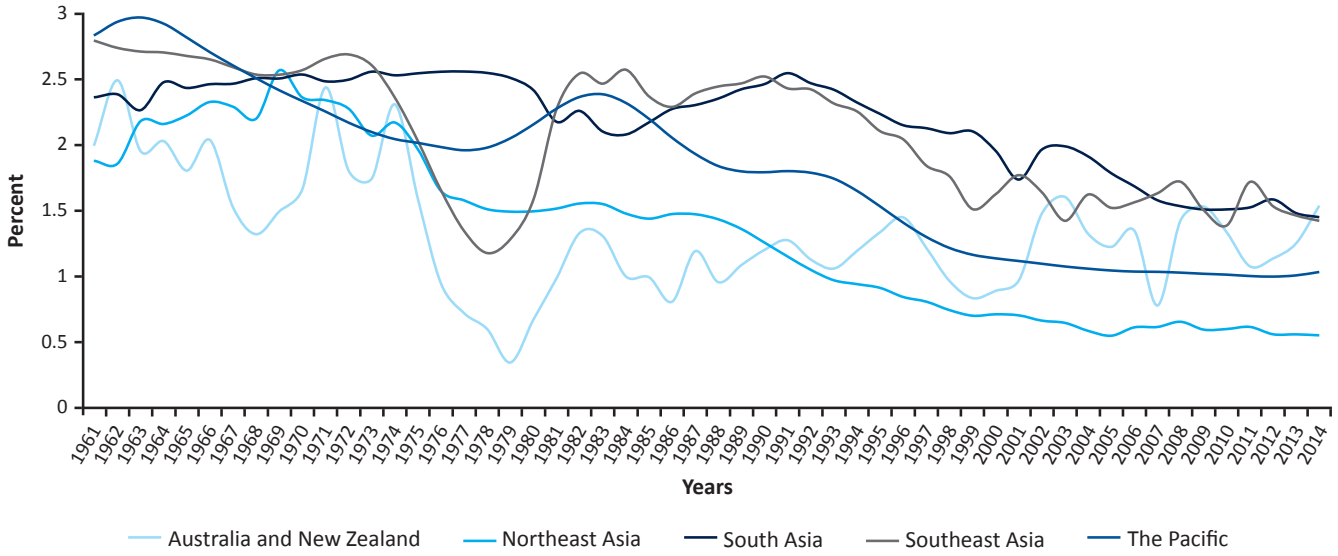
Source: UNDESA 2015

around 4 billion people in 2012 (Seetharam 2012), of which China with 1.36 billion and India with 1.25 billion people account for more than half of the total population of the region. The region's 2014 mid-year population stands at 4.367 billion (**Figure 1.1.1**), and it is projected to rise to 5.08 billion by 2050 (UNESCAP 2014).

The overall growth rate for Asia and the Pacific, 0.98 per cent per year, for 2010–2015 remains lower than the global rate of 1.14 per cent, and is likely to fall to 0.01 per cent by 2045–2050 (**Figure 1.1.2**). China's population is expected to shrink from 2031 onwards and Japan's current population of 127 million is likely to drop to about 107 million by 2040. The world's highest sex-ratio imbalance in favour of males also occurs in the region (UNESCAP 2014).

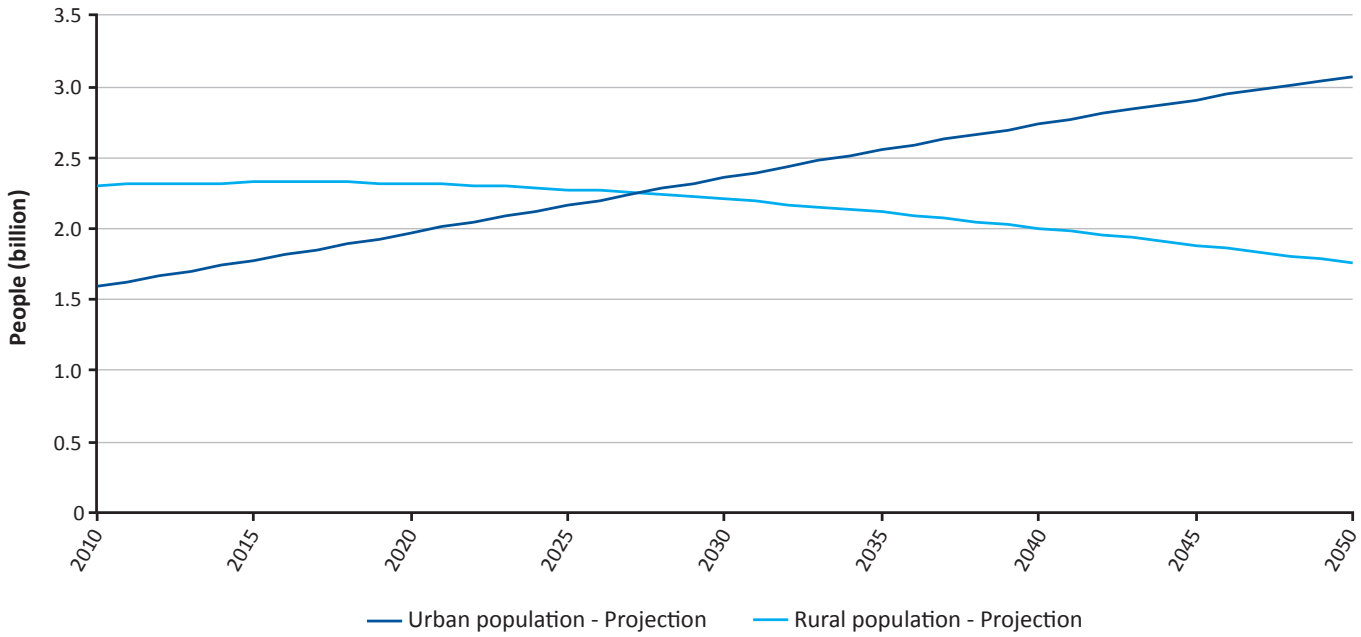
By 2014, around 42 per cent of the region's population was urban and 68 per cent rural, but by 2050 the urban population is projected to increase to about 63 per cent of the total (UNDESA 2015) (**Figure 1.1.3**).

Figure 1.1.2: Annual population growth rate in Asia and the Pacific's sub-regions, 1961–2014



Source: World Bank 2015

Figure 1.1.3: Asia and the Pacific rural and urban population projection, 2010–2050



Source:UNDESA 2015

There is, however, a significant difference in the growth of the urban population among the sub-regions, with Australia and New Zealand showing the least, growing at the rate of 1.16 per cent per year; while South Asia shows the largest, 2.66 per cent per year.

Out of 28 mega-cities with more than 10 million people in the world, 15 are in Asia and the Pacific – Tokyo (37.8 million), Delhi (25 million) and Shanghai (23 million) are the three most populous cities in the world (UNDESA 2014). The demographic transition to urban dwellers and environmental links with urbanisation will largely determine the sustainable development pathways of the region during the next 25 years and beyond.

Changing migration patterns in Asia and the Pacific

Population growth, economic development and inequality drive migration patterns in the region, with local and global environmental consequences. Additionally, climate change and extreme events have displaced millions of people each year over the past decade (Section 1.3).

Asia and the Pacific host more than 30 million migrant workers, amongst whom, in contrast with the past, women make up about half of the total (UNDESA 2013). Main source countries are Bangladesh, Cambodia, China, India, Indonesia, Lao PDR, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka and Viet Nam (Castles and Miller 2009).

The regional population movements have local and global environmental consequences:

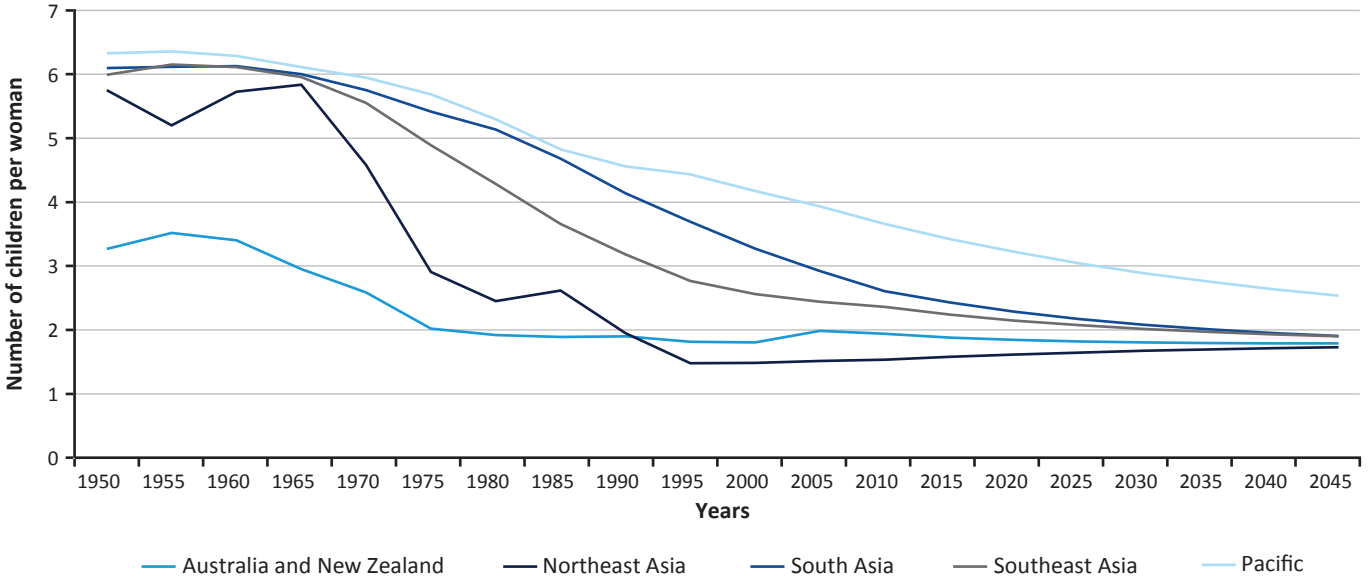
- "Rural-rural migration produces direct household impacts on natural resources, often through agricultural expansion to critical and vulnerable ecosystems.
- "Rural-urban migration and associated livelihood changes are often accompanied by changing patterns of consumption, energy use, and increased pressures on water supply and waste management, which can deteriorate urban environments and intensify land pressures in productive rural areas.
- "International migration, with remittances sent home, can have a direct impact through land-use investment or an indirect impact through increased meat, dairy and material consumption" (UNEP 2012).

Asia and the Pacific is ageing and fertility rates are rapidly declining

The region faces a transition from high fertility and mortality rates to low ones, with consequent environmental impacts. Fertility in the region as a whole has fallen to 2.1 births per woman in 2010–2015 (**Figure 1.1.4**). This lower fertility, together with increased life expectancy, is leading to a rapidly ageing population.

The total fertility rate (TFR), the average number of children born to a woman over her lifetime, in many Asia and the Pacific countries is expected to fall below the replacement rate of two by 2045–2050. This has already happened in China, Hong Kong SAR of China, Japan, Republic of Korea, Singapore and Thailand (World Bank 2015).

Figure 1.1.4: Fertility rate in Asia and the Pacific's sub-regions, 1950–2050



Source: World Bank 2015

Infant mortality rates fell in Asia and the Pacific by 52 per cent between 1990 and 2012, and this trend is expected to continue until 2040. South Asia, with a rate of 42 deaths per 1 000 live births in 2012, has the highest infant mortality in the region.

Alongside more than 1 billion young people representing more than half of global youth (UNFPA 2014),the population aged 65 and over is projected to increase from about 312 million in 2015 to more than 834 million in 2050. Indeed, older people are expected to represent about 20 per cent of the population by 2050. Life expectancy at birth was about 71 years in 2010–2015, and is projected to rise to 76 years by 2045–2050 (UNDESA 2015), alongside which the crude death rate, deaths per 1 000 of the population, for Asia and the Pacific was about 7.6 in 2012, lower than the world average of around 7.8.

Low fertility societies and those with large numbers of older people tend to raise their environmental footprint as a result of increased consumption. Such societies also tend to have fewer fiscal resources that can be allocated to environmental remediation and investment in green technology.

Lifestyles are changing in Asia and the Pacific

To sustain progress in human development (**Figure 1.1.6**) more attention needs to be paid to the impact of human beings and their lifestyle on the environment. The region's overall goal is high human development and a low ecological footprint per person, and it is the more developed and urbanized countries in the region that increase material consumption, drive land-use change and raise greenhouse gas emissions.

Asia and the Pacific's economic development is coupled to unsustainable consumption patterns and waste production. Intensive human activities and energy consumption in urban areas lead to the generation of increasing amounts of pollution and waste, with multiple adverse impacts on urban environments.

There have been significant changes in employment in Asia and the Pacific. Agriculture employment is decreasing, while industrial and services employment is increasing. With growing industrial activities and consumerist lifestyles, the large amounts of industrial, solid and hazardous waste generated degrade the region's environment.

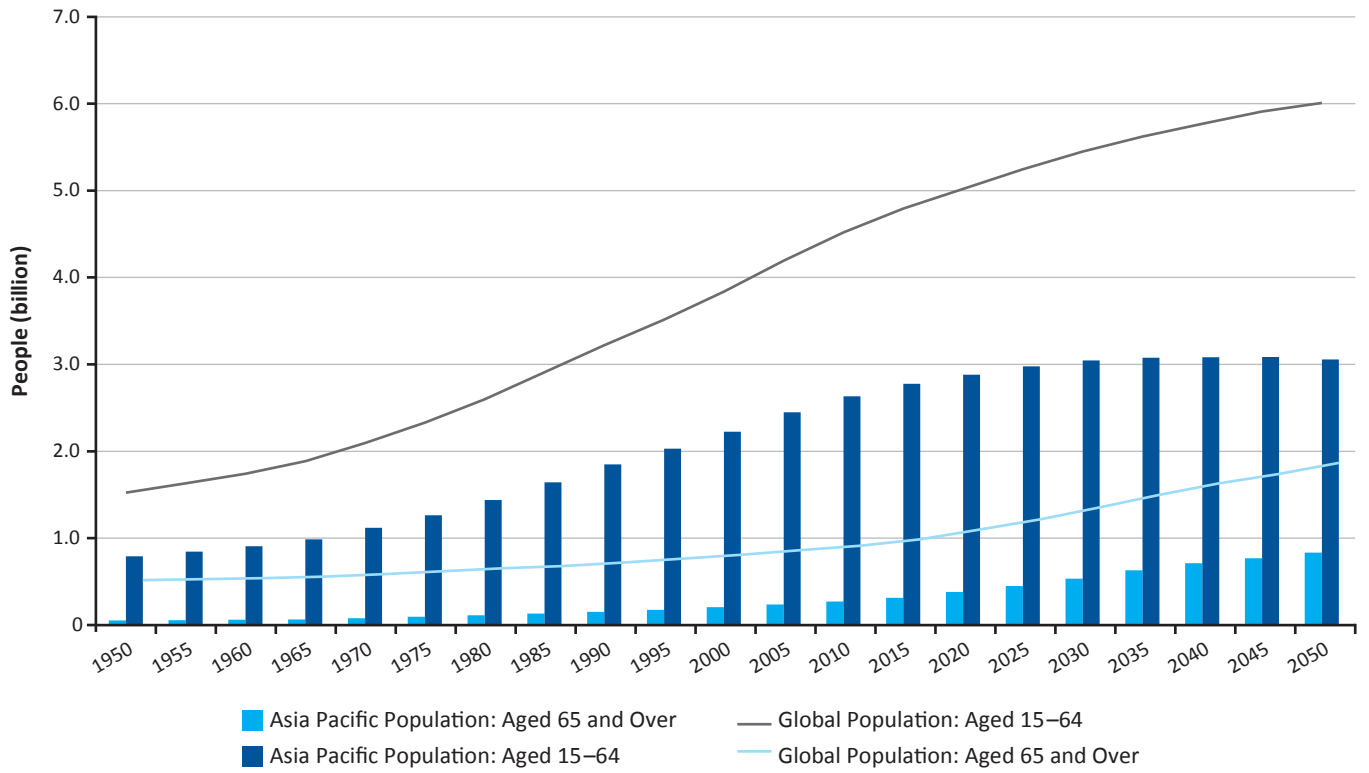
New households in urban settings add pressure on the environment through increased consumption. Regional cities account for 67 per cent of all energy use and emit 80 per cent of all greenhouse gases (IEA 2014). In terms of transport, the increase in the number of private vehicles has resulted in higher fossil fuel consumption, causing more air pollution.

In Asia and the Pacific, obesity and under-nutrition coexist, mainly due to wide socioeconomic disparities. Malaysia has the highest prevalence of obesity in Southeast Asia (14 per cent of the population), followed by Thailand with 8.8 per cent, while more than 50 per cent of the population is overweight in at least 10 Southwest Pacific Island countries (FAO 2015). Viet Nam (1.7 per cent) and India (1.9 per cent) have the lowest obesity rates in the region (WHO 2013).

Food supplies have grown faster than the population over recent decades, leading to increased food availability per person in most sub-regions. FAO estimates that "*the average dietary energy supply adequacy increased by about 20 per cent in Eastern Asia and Southeast Asia. Because of this growth, only one country in the region, the Democratic People's Republic of Korea, now has total food supplies inadequate to meet people's average dietary needs"* (FAO 2015).

In common with global trends, average food consumption per person per day has grown in Asia and the Pacific and is expected to continue to rise. Average consumption per person in Eastern Asia was 12 812 kilojoules (kJ) per day in 2015 and is expected to rise to 13 356 kJ per day in 2030, while that of Southern Asia is projected to reach 12 142 kJ by 2030 (FAO 2015). But food safety and security remain as grave challenges in the region.

Figure 1.1.5: Asia Pacific and world's age structure, 1950–2050



Source: UNDESA 2015

Lifestyles are changing in Asia and the Pacific
Credit: Shutterstock/ Ethan Daniels

Credit: SHung Chung Chih

The main factors affecting food safety are the improper use of pesticides, hormones, additives and preservatives in food production and the improper handling of food during storage and consumption especially in poor households. Food security cannot be achieved because many poor people have neither physical nor economic access to sufficient, safe and nutritious food (ADB 2013). While the region has achieved the Millennium Development Goal of halving the proportion of people suffering from hunger by 2015 (MDG-1c), the situation remains uneven at a sub-regional level and *"there are still 490 million people in Asia and the Pacific who suffer from chronic hunger; the region is home to almost 62 per cent of the world's undernourished"* (FAO 2015).

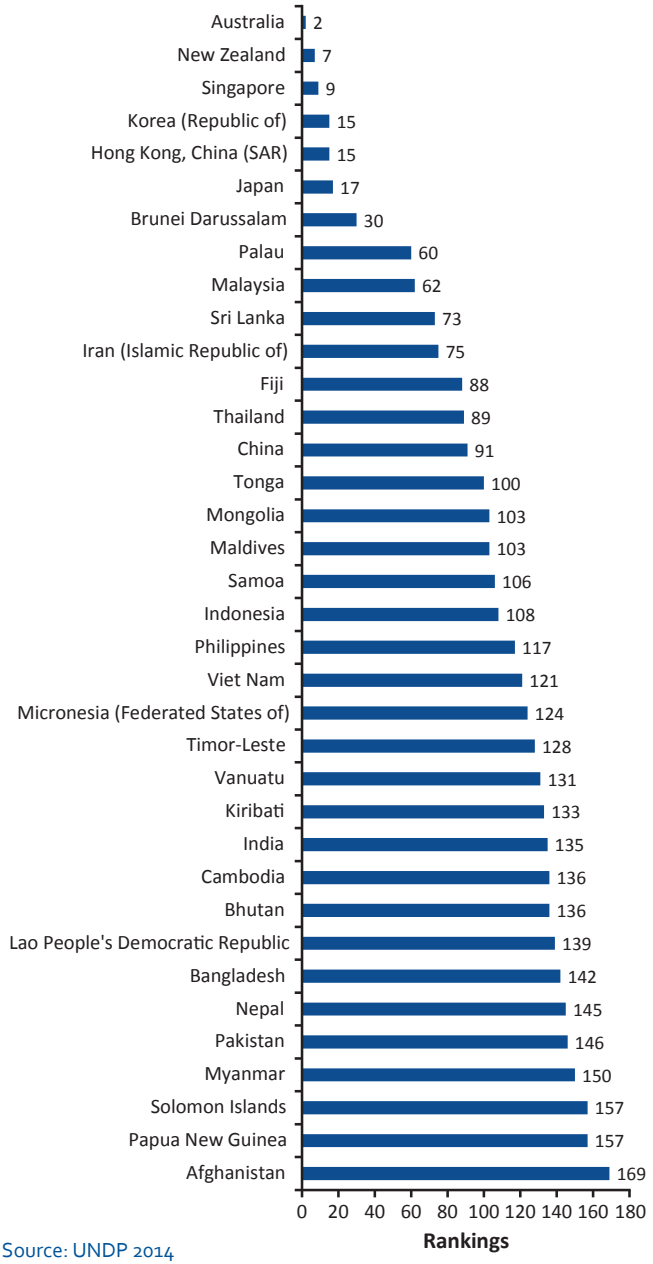
1.1.2 Inequality and access to basic services

It is important to stress the multidimensional relationship between the environment, poverty and inequality (**Figure 1.1.6**). Inequality and poverty contribute to further degradation of the environment and environmental risks pose unequal risks to the poor and women. Tackling extreme poverty and raising average per person income has seen the greatest challenge in the region. *"Across Asia and the Pacific, more than 1 billion people live just above the extreme poverty line, on more than USD1.25 but less than USD2.50 a day"* (UNDP 2014). Those who face multiple deprivations are especially at risk of falling back into poverty if a disaster or crisis should occur. *"South Asia has the largest multi-dimensionally poor population, with more than 800 million poor and over 270 million near-poor – that is more than 71 per cent of its population. The region is home to 56 per cent of the world's poor"* (UNDP 2014).

Developing Asia and the Pacific countries are characterized by a large degree of social and economic inequality. Widening income gaps between the poor and wealthy, in countries, are characterized by an increase in the very top income groups (Kanbur *et al.* 2014).

Since the 1990s, the population-weighted mean Gini index, a measure of income distribution, for Asia and the Pacific rose from 33.5 to 37.5 (UNESCAP 2014). *"Lack of well-paid*

Figure 1.1.6: Human Development Index rankings for Asia and the Pacific countries, 2013



Source: UNDP 2014

Faces of poverty
Credit: Shutterstock/ Zzvet

jobs – especially for youth – is a major challenge in Asia and the Pacific. In many countries of the region, youth unemployment is relatively high: 23 per cent in Iran, 22 per cent in Indonesia, 17 per cent in Sri Lanka, 16 per cent in Philippines and Samoa and 14 per cent in Timor-Leste" (UNDP 2014).

Greater inequality persists amongst women and girls

Despite progress made in addressing gender equality and women's empowerment, many women and girls live in extreme poverty and food insecurity, and face discrimination, violence and lack of access to maternal health services. *"Only 30 per cent of women in Asia and the Pacific are in non-agriculture wage employment, with only 20 per cent in South Asia, the lowest among the world's regions"* (UNESCAP *et al.* 2010). *"Few women own farms despite the fact that 40 per cent of the region's women are employed in agriculture"* (Rodgers and Zveglich 2014).

Poverty amongst women is, as a result, usually higher than amongst men. The 2014 Gender Development Index (GDI), which measures the gender gap in human development in 148 countries, reveals that Afghanistan, where the HDI for females is only 60 per cent of that for males, is the most unequal country. Tackling gender inequality and empowerment of women and girls should be the foundation of current and future sustainable development pathways in the region.

Access to basic services in Asia and the Pacific region is improving

To speed up development and tackle poverty and inequality, efforts should be made to safeguard the environment, improve health and education, and improve access to basic infrastructure, such as electricity, clean drinking water and sanitation (UNESCAP 2015). Governments in the region are committed to the provision of basic social services and social protection to build resilience, especially for the poor and other vulnerable groups.

High disparities in education persist

Although there has been significant progress in improving access to education in Asia and the Pacific, the 2014 Human Development Report reports that illiteracy is still prevalent amongst older people, while younger people have difficulty making the leap from primary to secondary schooling (HDR 2014). Less education means higher unemployment rates and lower-paying jobs, trapping young people in a cycle of poverty (UNFPA 2014; UNESCAP 2015).

Health improvements are patchy

While most countries in Asia and the Pacific have made significant efforts to provide public health services, there are some countries that have not been completely successful in this. In many countries in the region concentration of services in urban areas is a major reason for the lack of progress in the reduction of maternal and infant mortality (UNDESA 2015).

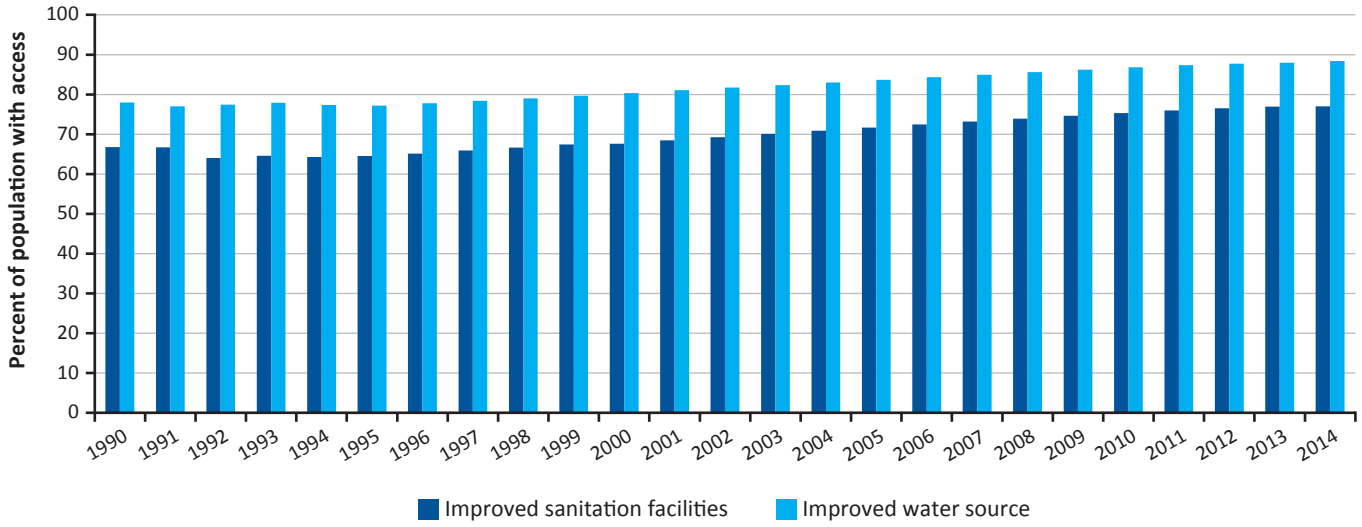
In many cases, people may not be able to afford healthcare services even when they are available –"*out-of-pocket payments in the region range from almost none in Kiribati and Tuvalu to almost 80 per cent in Afghanistan and a number of other countries. In 13 countries in the region, almost 50 per cent of all health expenditures emanate from private households, a major barrier for people to access health-care services*" (UNESCAP 2015).

Access to improved sanitation and water security is poorly developed

Asia and the Pacific made important progress in increasing access to improved drinking water and sanitation between 1992 and 2012 (**Figure 1.1.7**). Despite this, water security and access is under pressure from multiple threats: population growth, urbanization, increasing water pollution, over-abstraction of groundwater, water-related disasters, and climate change. By 2012, 92 per cent of the region's total

Access to water
Credit: Shutterstock/ Pcruciatti

Figure 1.1.7: Asia and the Pacific, access to basic services: improved drinking water and sanitation



Source: World Bank 2015

population had access to drinking water; while only 59 per cent had access to sanitation (UNESCAP 2014; WHO and UNICEF 2014).

Access to energy is lagging in rural areas

Rural populations in many countries still do not have access to basic energy services, "*at least 620 million people lack access to electricity in the region and almost 1.9 billion people still rely on biomass for cooking*" (IEA 2014). The use of biomass is a significant environmental and health concern due to the amount of air pollution it produces when burned indoors, "*more than 1 million premature deaths annually in India and China can be attributed to exposure to household air pollution*" (UNESCAP 2014; WHO and UNICEF 2014). "*Biofuels are produced mainly by China, India, Malaysia, the Philippines and Thailand; while the coal production of China and India accounts for more than half of the global output. However, the use of both commodities poses issues of water stress because their production processes are water-intensive, and the production of biofuels increases the demand for arable land, thus leading to deforestation*" (WWAP 2014).

1.2 Increasing use of natural resources and declining resource productivity

1.2.1 Resource efficiency plays an important role for sustainable development in the region

Resource efficiency means using natural resources in a sustainable manner and minimizing impacts on the environment. Resource efficiency promotes production using fewer natural resources. From a life cycle and value chain perspective, resource efficiency also means reducing the total environmental impact of the consumption and production of goods and services, from raw material extraction to final use and disposal (UNEP 2010).

Over the past 45 years (1970–2015) the Asia and the Pacific region has experienced rapid economic growth, leading to higher incomes, poverty reduction and the emergence of a rapidly-expanding middle class. Consumption behaviour has changed and domestic consumption has started to increase alongside export industry growth.

Key Messages

Consumption of natural resources has been growing rapidly in Asia and the Pacific leading to increasing pressures and impacts on the local environment. Resource efficiency is improving in many countries but not in the region as a whole because of a shift in economic activity from resource-efficient to less resource-efficient countries.

- The region's material consumption has increased sharply over the past four decades, accounting for more than 50 per cent of world consumption while material productivity has not improved and is double the world average.
- Energy provision continues to rely on fossil fuels and the share of renewable energy remains small despite very significant investment in renewable-energy infrastructure.
- The region accounts for more than 50 per cent of the world's water use, and although water intensity has decreased sharply, it is still very high - more than double of the world average.

Decoupling economic growth from resource consumption has been achieved in some countries but not the region as a whole. To meet the Sustainable Development Goals (SDGs), Asia and the Pacific will need to greatly improve resource efficiency and enabling policies will be required to facilitate sustainable consumption and production.

Together with population growth, industrialization and urbanization have led to a sharp increase in natural resource use in the region, which is both unsustainable and inefficient, and results in pollution, declining biodiversity and natural resource depletion (UNEP 2015).

1.2.2 Material consumption increasing and productivity not improving

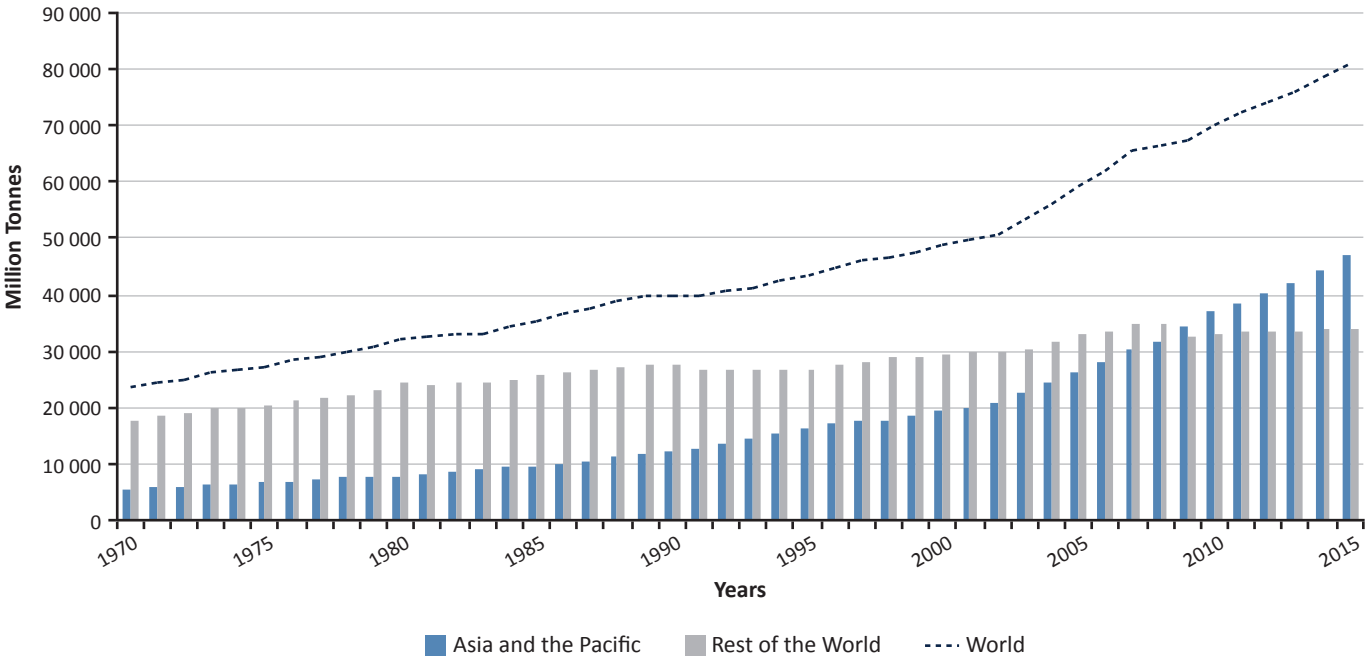
The region's material consumption has increased sharply over the past four decades, accounting for more than 50 per cent of world consumption in 2015. Material productivity has not improved and is still very high, double the world average.

The use of materials in the region – biomass, fossil fuels, metal ores and non-metallic minerals – increased from 26.3 billion tonnes in 2005 to 46.4 billion tonnes in 2015, an annual rate of growth of 6.1 per cent, which is higher than the economic and population growth rates –4.9 and 0.9 per cent respectively.

Domestic material consumption per person increased from 2.9 tonnes in 1970 to 11.9 tonnes in 2015 (**Figure 1.2.1**), with a high growth rate at 5.2 per cent per annum, and has now surpassed the global average of 11.2 tonnes.

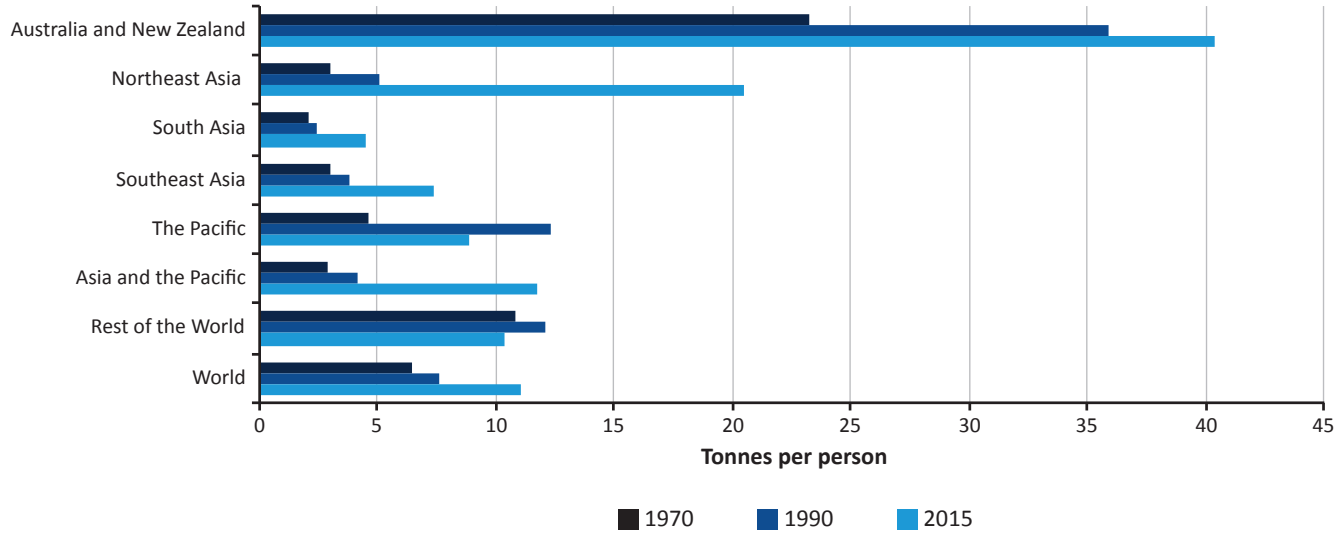
Material use in the region continues to be dominated by the demands of Northeast Asia, (in particular China and Japan) which use 70 per cent of all materials and have the highest rate of growth. Northeast Asia also has the second highest per person material use at 20.5 tonnes but well below the 40 tonnes per person of Australia and New Zealand (**Figure 1.2.2**).

Figure 1.2.1: Asia and the Pacific and world, domestic material consumption, 1970–2015, million tonnes



Sources: CSIRO 2015; UNEP 2015

Figure 1.2.2: Asia and the Pacific, sub-regions and world, domestic material consumption, tonnes per person, 1970, 1990 and 2015



Sources: CSIRO 2015; UNEP 2015

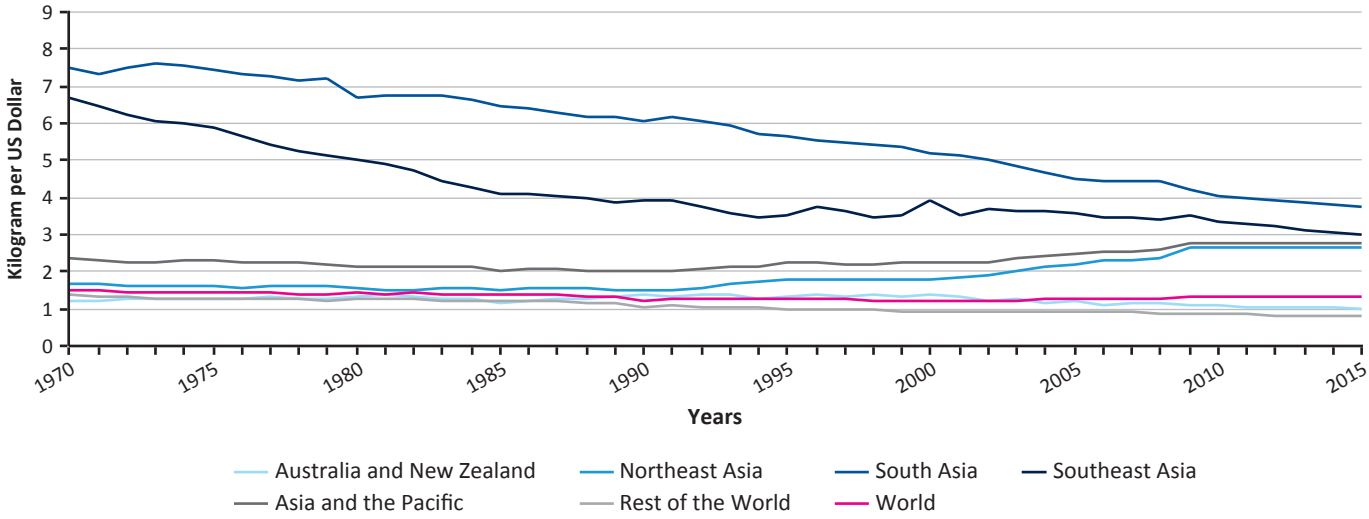
The main driver of accelerating domestic material consumption is the growth of consumption by the expanding middle class and, to a lesser extent, population growth.

The material intensity of many developing countries in the region has increased significantly over the past four decades (**Figure 1.2.3**). In 2015, on average, 1.35 kilograms of materials were needed globally to produce UD1 of economic output but 2.75 kilograms were required in Asia and the Pacific, just more than double the global average and four times the rest of the world average (**Figure 1.2.4**). The environmental impact has increased, in part due to the shift in economic activity from very resource-efficient economies such as Japan and the Republic of Korea to the less resource-efficient economies of China, India and Southeast Asia.

Asia and the Pacific region is rich in rare earth metals (REMs), and consumption of REMs for high-tech applications is increasing rapidly, particularly for new and emerging clean-energy technologies.

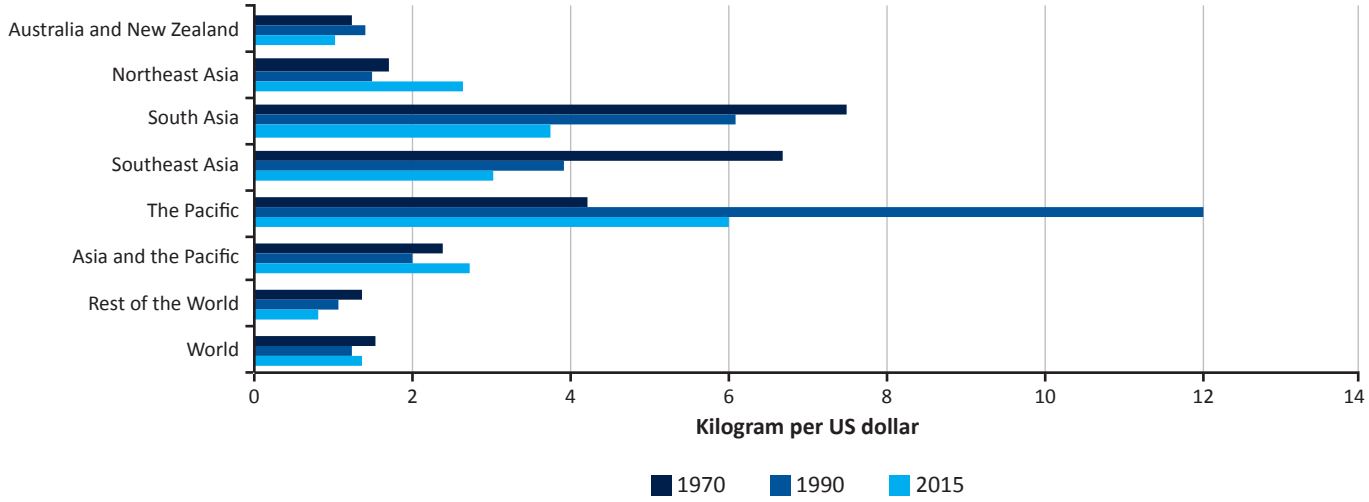
REMs are a group of 17 chemical elements – 15 lanthanide elements (lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium), yttrium and scandium. They are sometimes referred to as rare earth oxides because many of them are typically sold as oxide compounds (King 2015). Demand for REMs in the region and globally has grown rapidly in recent decades because of increasing applications in

Figure 1.2.3: Asia and the Pacific, sub-regions and world, material intensity of the economy, kilogram per USD, 1970–2015



Source: CSIRO 2015; UNEP 2015

Figure 1.2.4: Asia and the Pacific, sub-regions and world, material intensity of economy, kilogram per USD, 1970, 1990 and 2015



Sources: CSIRO 2015; UNEP 2015

industry for permanent magnets, metal alloys and catalysts, electronics and renewable-energy infrastructure. The region has the highest share of global demand for REMs and this is projected to grow at an average annual rate of 9.1 per cent from 2013, mainly due to rapidly increasing demand in China, which currently accounts for about 60 per cent of global consumption. On the supply side, almost 50 per cent of reserves are in China (King 2015).

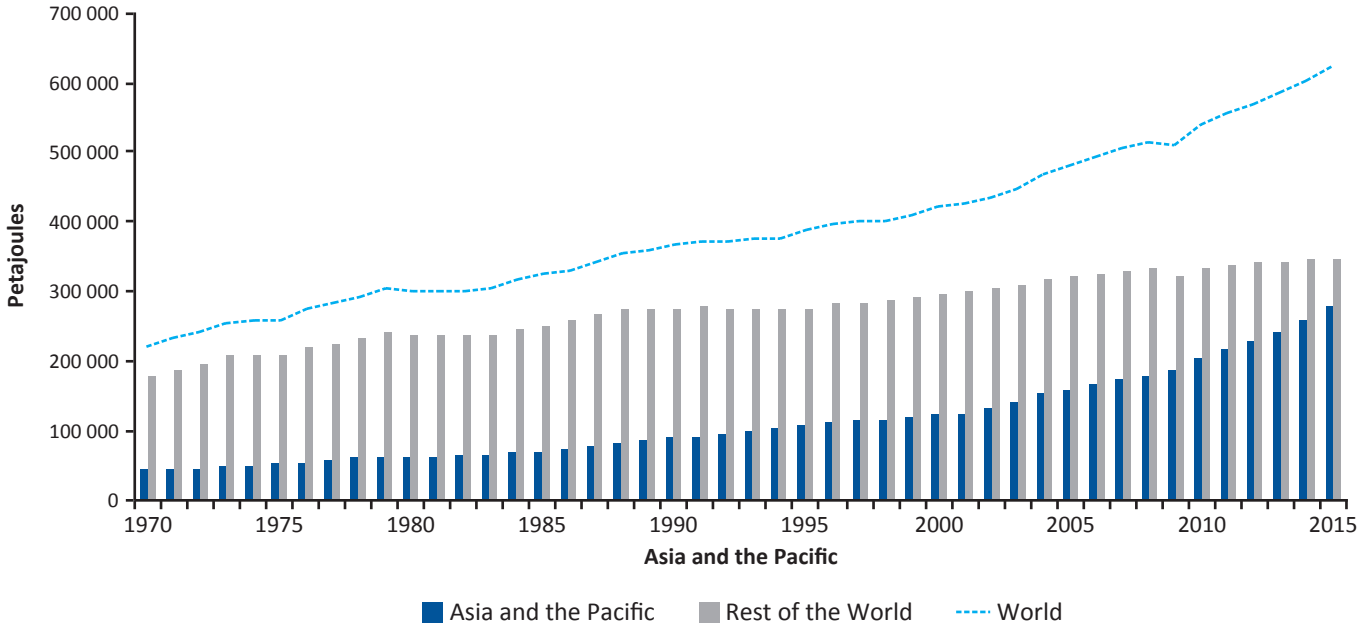
While the global economy is not running out of natural resources, the affordability and timely availability of strategic materials has been decreasing sharply since the turn of the century and economies are now more vulnerable to reduced security of supply. Increasing resource use will affect the environment, climate and human health negatively.

1.2.3 Energy supply, intensity and sustainability under pressure

The region's total primary energy supply (TPES) has increased more than fourfold over the 1970–2010, period and accounted for 45 per cent of the world's TPES in 2015. Energy intensity in the region's developing countries has improved rapidly but is still more than double the world average.

The demand for electricity, gas and transport fuel in the region also increased more than fourfold between 1970 and 2015 (UNEP 2015). Energy use has grown by 5.7 per cent per year on average, from about 43 000 petajoules in 1975 to around 277 000 petajoules in 2015 (**Figure 1.2.5**), and is

Figure 1.2.5: Asia and the Pacific and world, total primary energy supply, petajoules, 1970–2015



Sources: CSIRO 2015; UNEP 2015

largely dependent on non-renewable energy sources, mainly coal, for example in China and India. Per person energy use varies across sub-regions and the regional differences in 2015 are stark: 222 gigajoules per person per year in Australia and New Zealand, 124 in Northeast Asia but only 44.5 in Southeast Asia and 26.6 in South Asia. This reflects the prevalence of hard and low-paid physical labour in South and Southeast Asia, as well as a low material standard of living (**Figure 1.2.6**).

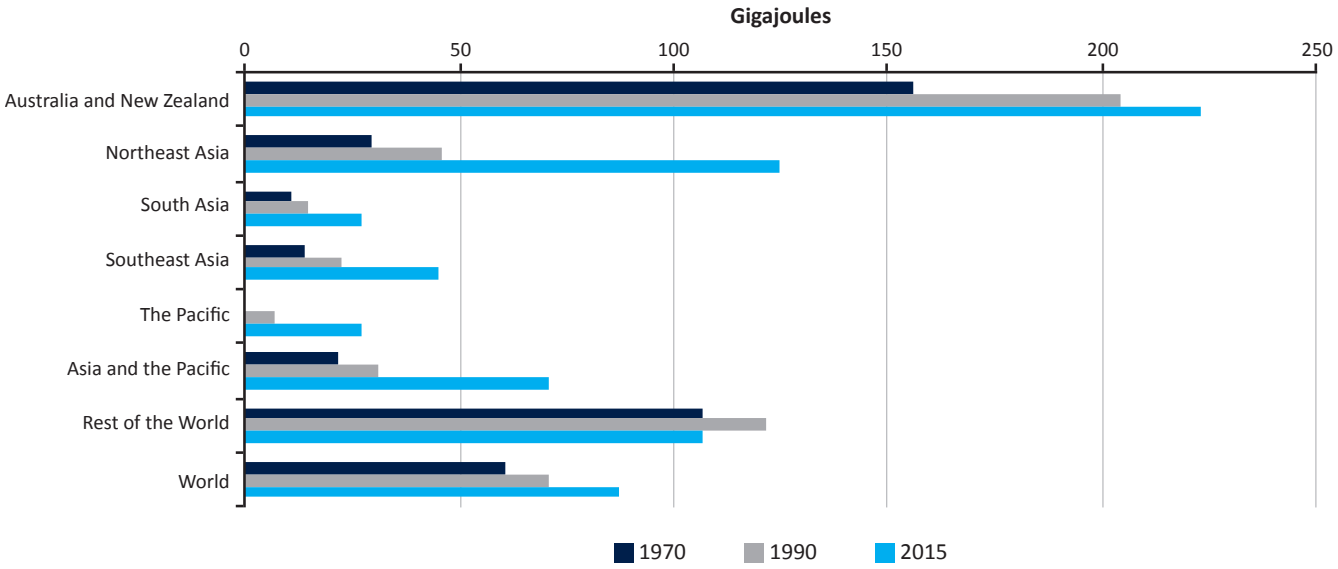
Due to the shift of production from Japan to China and other emerging economies, and increased energy use in these countries, the energy intensity of the whole region has remained stagnant over the past four decades (**Figure 1.2.7** and **Figure 1.2.8**).

The energy intensity in South and Southeast Asia has improved markedly in recent decades, but is still more than double the world average in 2015. Energy intensity in Northeast Asia combined has increased since 2000, caused by the great acceleration of China's energy use and a shift of production from efficient Japan to less efficient China. Only Australia and New Zealand have an energy intensity lower than the world average.

Renewable energy in the region has been growing rapidly, and accounted for 40 per cent of the installed capacity of the world in 2014. Renewable energy supplies, however, are not keeping up with fast-rising energy demand.

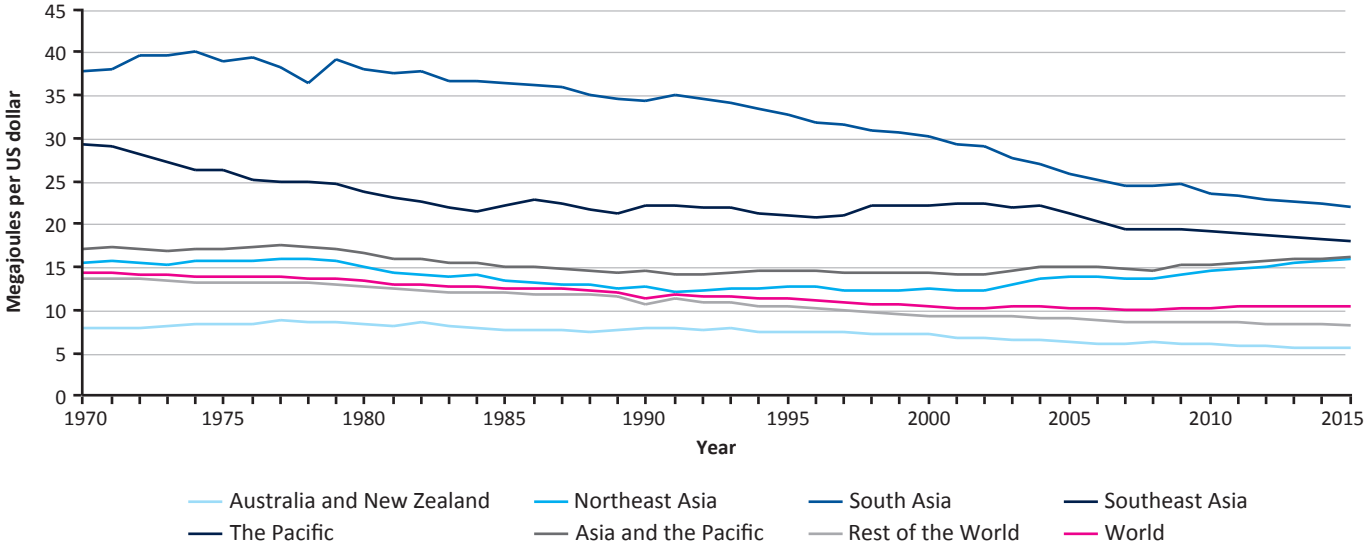
Since 2000, the region has increased its installed capacity of renewable energy, accounting for 40 per cent of global total of 1 839 terawatt (10^{12} watts) in 2014 (IRENA 2015). The region's installed capacity grew by an average of 9–12 per cent per year between 2006 and 2014 compared to the global average of 5–6 per cent. China accounted for 30 per

Figure 1.2.6: Asia and the Pacific, sub-regions and world, total primary energy supply per person in Asia and the Pacific, its sub-regions and globally, gigajoules per person, 1970, 1990 and 2015



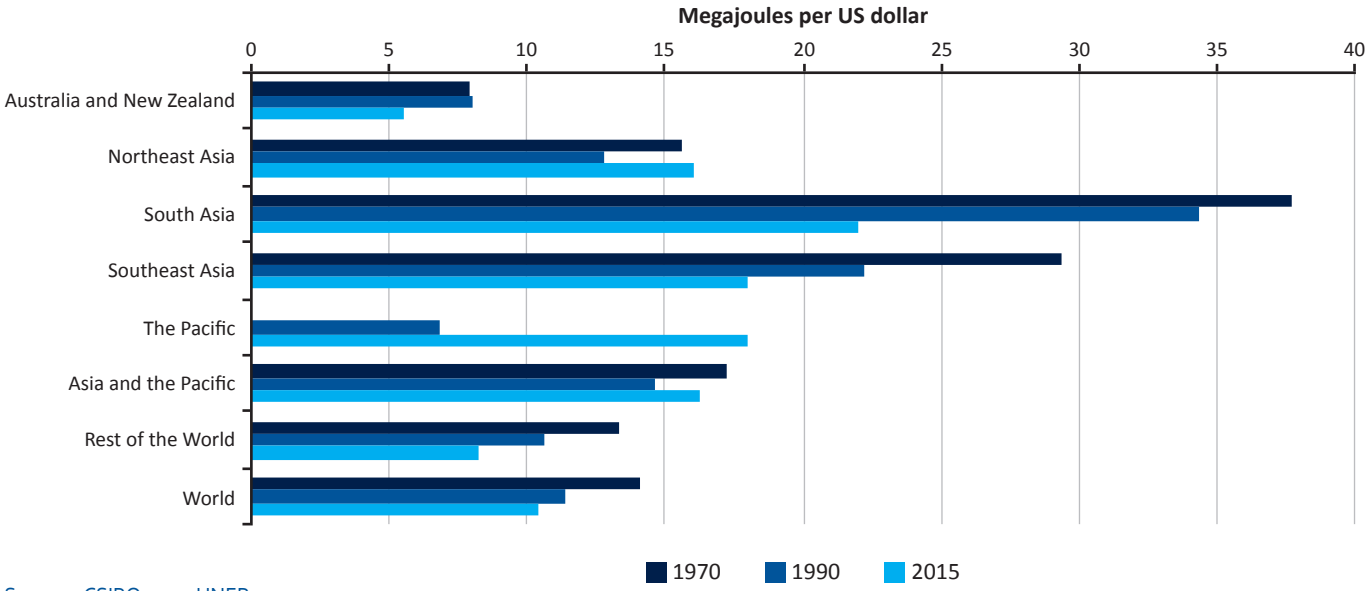
Sources: CSIRO 2015; UNEP 2015

Figure 1.2.7: Asia and the Pacific, sub-regions and world, energy intensity, megajoules per USD, 1970–2015



Sources: CSIRO 2015; UNEP 2015

Figure 1.2.8: Asia and the Pacific, sub-regions and world, energy intensity, megajoules per USD, 1970, 1990 and 2015



Sources: CSIRO 2015; UNEP 2015

cent of the world's renewable energy investment in 2014 (Frankfurt School-UNEP 2015).

The traditional biofuel sector of biomass, timber and waste still accounts for the largest share of renewable energy in Australia, China, India, Indonesia, and Japan. In 2013, solar, wind and geothermal contributed 1.2 per cent of China's energy supply, 1 per cent in Australia, 0.9 per cent in Japan and 0.5 per cent in India. The best example of the use of renewable energy is currently Indonesia, which produced 7.6 per cent of its energy supply from geothermal sources in 2013 (Table 1.2.1).

China and Japan have contributed most to the significant increase in solar photovoltaics (PV) in the region since 2012 (Juan 2014). Japan introduced an electricity feed-in tariff scheme in July 2012 that incentivized large investment in solar PV (Japan, METI 2011).

China also increased its installed capacity of wind power generation to 115 000 megawatt (10^6 watts) in 2014 from 352 in 2000 (REEEP 2009). Wind power capacity increased dramatically after the government announced its medium- and long-term Renewable Energy Development Plan in 2007

Table 1.2.1: China, India, Indonesia, Australia and Japan, renewable energy supply and share of renewable energy in TPES, petajoules (10^{15} joules) and per cent

		1970	1990	2013
China	Hydro	108 (0.7 %)	456 (1.3 %)	3 274 (2.6 %)
	Geothermal	-	-	189 (0.1 %)
	Solar/wind/other	-	-	1 342 (1.1 %)
	Biofuels and waste	6 458 (39.4 %)	8 391 (23.0 %)	9 030 (7.1 %)
India	Hydro	101 (1.6 %)	258 (2.0 %)	510 (1.6 %)
	Geothermal	-	-	-
	Solar/wind/other	-	-	152 (0.5 %)
	Biofuels and waste	4 010 (63.0 %)	5 588 (43.5 %)	7 891 (24.3 %)
Indonesia	Hydro	3 (0.2 %)	21 (0.5 %)	61 (0.7 %)
	Geothermal	-	81 (2.0 %)	678 (7.6 %)
	Solar/wind/other	-	-	-
	Biofuels and waste	1 102 (75.1 %)	1 821 (44.1 %)	2 298 (25.7 %)
Australia	Hydro	32 (1.5 %)	51 (1.4 %)	65 (1.2 %)
	Geothermal	-	-	-
	Solar/wind/other	-	3 (0.1 %)	53 (1.0 %)
	Biofuels and waste	148 (7.0 %)	166 (4.6 %)	212 (3.9 %)
Japan	Hydro	271 (2.5 %)	322 (1.7 %)	281 (1.5 %)
	Geothermal	-	66 (0.4 %)	101 (0.5 %)
	Solar/wind/other	-	49 (0.3 %)	83 (0.4 %)
	Biofuels and waste	-	206 (1.1 %)	466 (2.5 %)

Source: IEA 2015

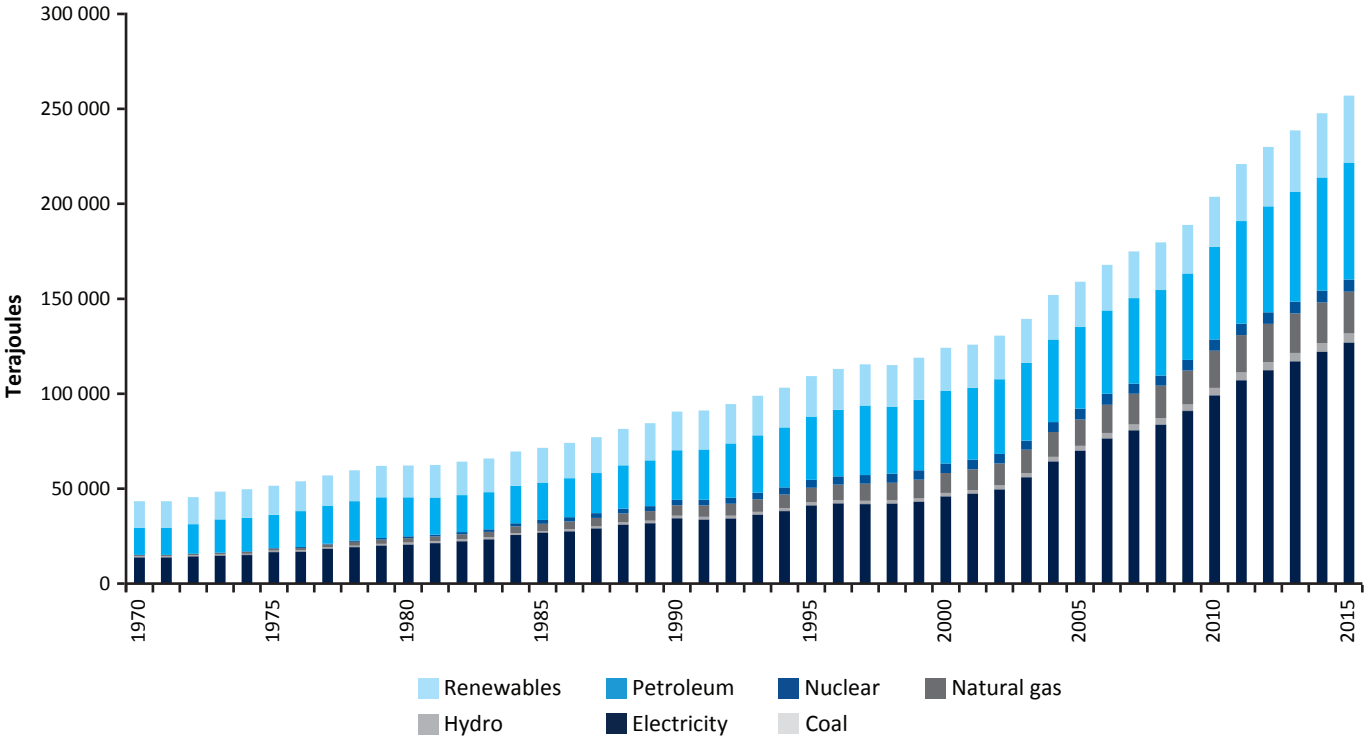
that set a target to increase installed wind power capacity to 30 gigawatt (10^9 watts) by 2020. This target was achieved by 2010, ten years ahead of the plan (IEA 2011).

Despite the positive impact of reduced greenhouse gas emissions, renewable energy generation infrastructure may result in other environmental challenges such as an increased demand for metals for new installations, increased water use, use of hazardous chemicals, land-use change and habitat loss (SVTC 2014). As a result, reducing the use of toxic chemicals in solar PV systems, the establishment of responsible recycling systems and the protection of workers should become priorities.

Despite rapid development, however, renewable energy supply in the region has not kept up with the fast-rising demand for energy demand. The share of renewable energy in the TPES has decreased sharply over the past four decades. In 1970, one third of the energy in the region came from burning biomass but in 2015 the share of all renewable energy had decreased to 14 per cent (**Figure 1.2.10**).

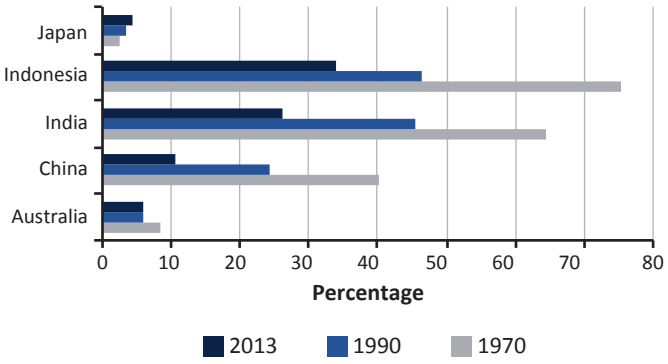
Coal has become the most-used energy carrier, up from 32 per cent in 1970 to 49 per cent of all energy supplied in 2015. The surge in coal demand, an average of 5 per cent a year, has been surpassed by natural gas, for which demand grew by an average of 8.8 per cent a year and nuclear power, which

Figure 1.2.9: Asia and the Pacific, total primary energy supply by energy carriers, Terajoules (10^{12} joules), 1970–2010



Source: CSIRO 2015; UNEP 2015

Figure 1.2.10: Australia, China, India, Indonesia, and Japan, share of renewable energy (TPES), per cent, 1970, 1990, 2015



Sources: CSIRO 2015; UNEP 2015

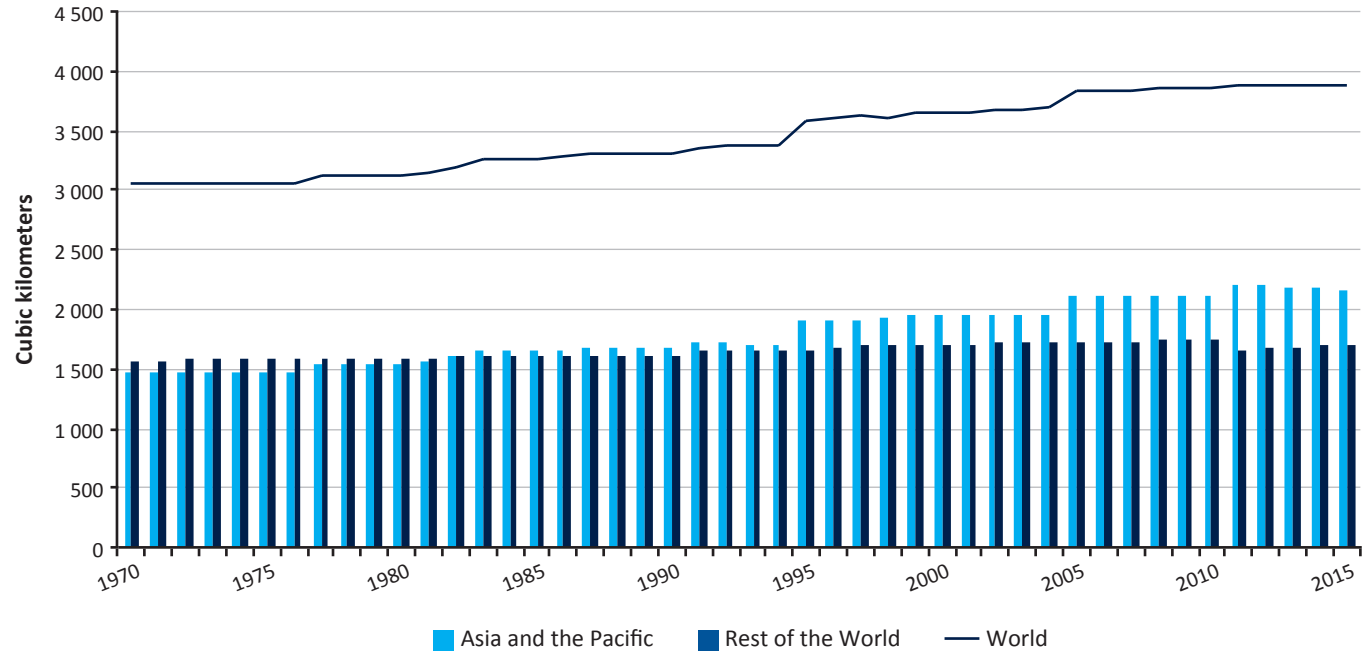
grew by an average of 9.6 per cent a year between 1970 and 2015 (**Figure 1.2.9**).

1.2.4 Water use is increasing and intensity remains high

Asia and the Pacific accounts for more than 50 per cent of the world's water use, and it is increasing. Water intensity in the region's developing countries has decreased sharply but is still very high and, for the region as a whole, it is more than double the world average.

Water use in the region grew from around 1.5 cubic kilometres in 1970 to 2.1 cubic kilometres in 2015 (**Figure 1.2.11**). Total water withdrawals for the region as a whole grew very slowly, at an annual rate of 0.6 per cent per year for 1970 –2010 (UNEP 2015).

Figure 1.2.11: Asia and the Pacific and world, water use, cubic kilometres, 1970–2015

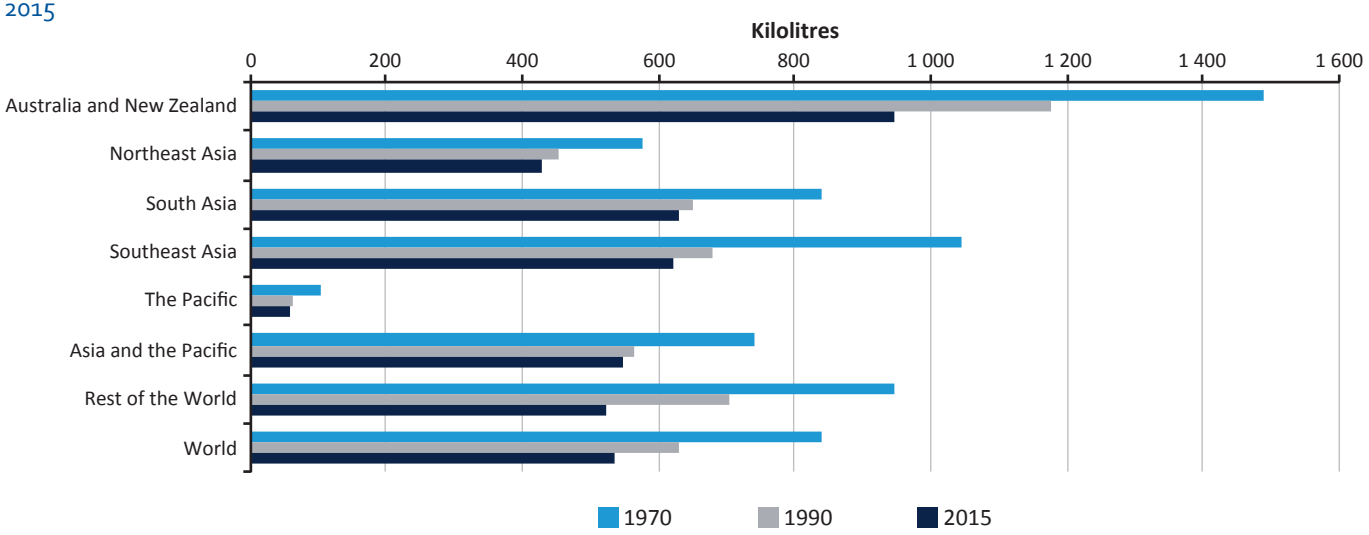


Source: CSIRO 2015; UNEP 2015

The per person use of water fell in all sub-regions, especially between 1970 and 1990, as a result of improved agricultural practices and industrialization (**Figure 1.2.12**). The Pacific and Northeast Asia have the lowest per person water use in the region and Australia and New Zealand have the highest.

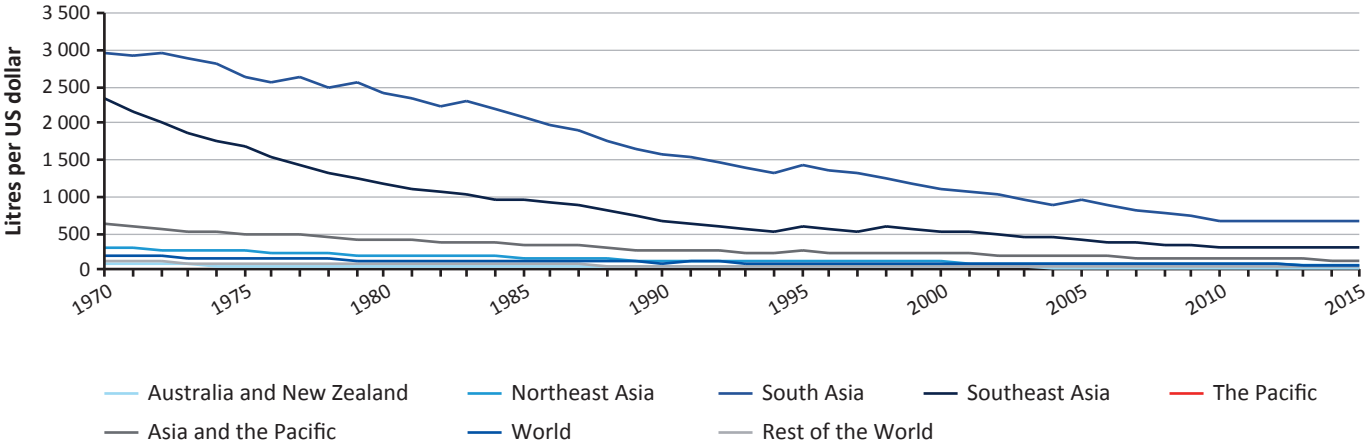
Water intensity has decreased rapidly in developing countries in the region, with a sharp decrease of an average of 4.4 per cent per annum in Southeast Asia, 3.4 per cent in Northeast Asia and 3.3 per cent in South Asia compared to the rest of the world average of 2.4 per cent per year.

Figure 1.2.12: Asia and the Pacific, its sub-regions and world, water use per person, cubic metres per person, 1970, 1990 and 2015



Sources: CSIRO 2015; UNEP 2015

Figure 1.2.13: Asia Pacific, its sub-regions and world, water intensity of the economy, litres per US dollar of GDP, 1970–2015



Sources: CSIRO 2015; UNEP 2015

Impressive improvements in water efficiency have reduced water use per US dollar of gross domestic product (GDP) by 90 per cent in developing countries in the region. However, water intensity in Asia and the Pacific region was almost double the world average in 2015 (**Figure 1.2.13**).

This high water intensity has been recorded mainly in South and Southeast Asian sub-regions, where economies are dominated by agriculture, which requires higher volumes of water (**Figure 1.2.14**).

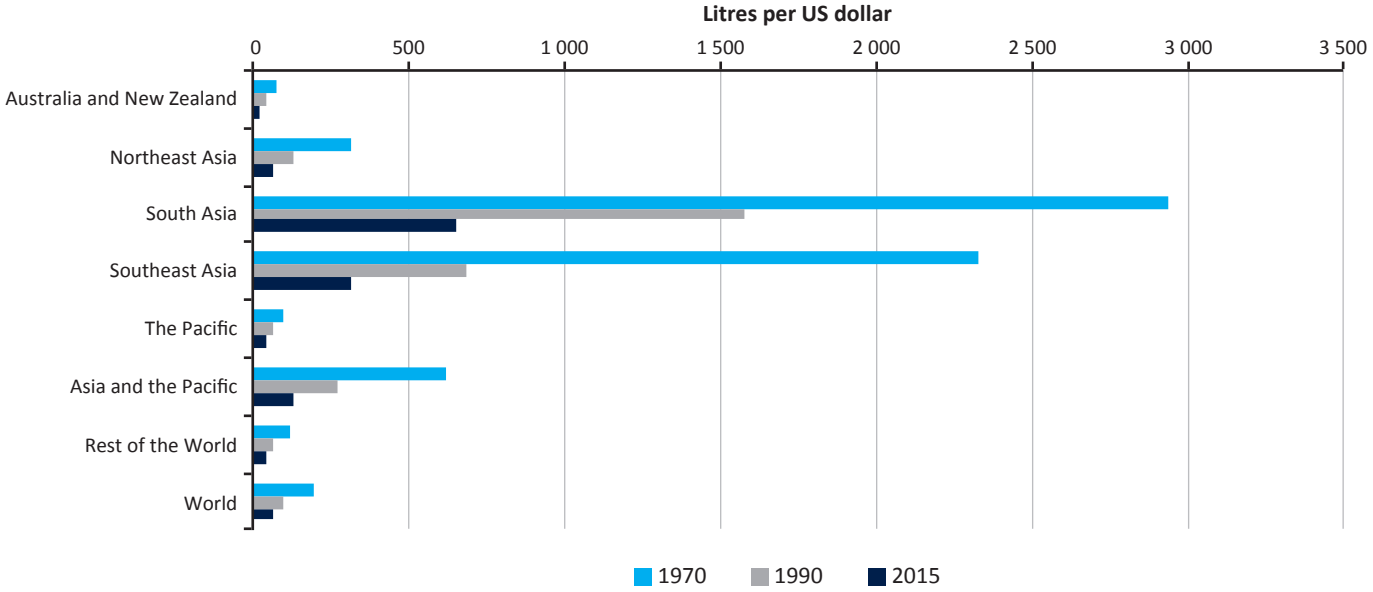
1.2.5 Economic growth is decoupling from resource consumption

Some Asia and the Pacific countries have been largely successful in decoupling economic growth from resource consumption: GDP continues to grow while resource use has increased at a slower rate or decreased. The region as a whole, however, has not achieved decoupling.

Decoupling aims to achieve more with less. There is ample research available indicating that decarbonization of the energy system and dematerialization of the economy can occur with negligible impacts on economic growth and employment (Schandl *et al.* 2015). There are, however, different ways to decouple including through structural change and increasing the share of national income in service sectors which have a lower material intensity, decoupling through externalizing material and energy intensive production to third countries, and decoupling through policy efforts.

Although individual countries have achieved decoupling, this has not led to increased material and energy productivity for the region as a whole. The main reason is that production has shifted from resource-efficient economies such as Japan to less resource-efficient ones including China, which needs five times as many resources per unit of GDP as the Japanese economy. In 1970, 65 per cent of the GDP of the region was

Figure 1.2.14: Asia and the Pacific, its sub-regions and world, water intensity of the economy, litres per USD of GDP, 1970, 1990 and 2015



Sources: CSIRO 2015; UNEP 2015

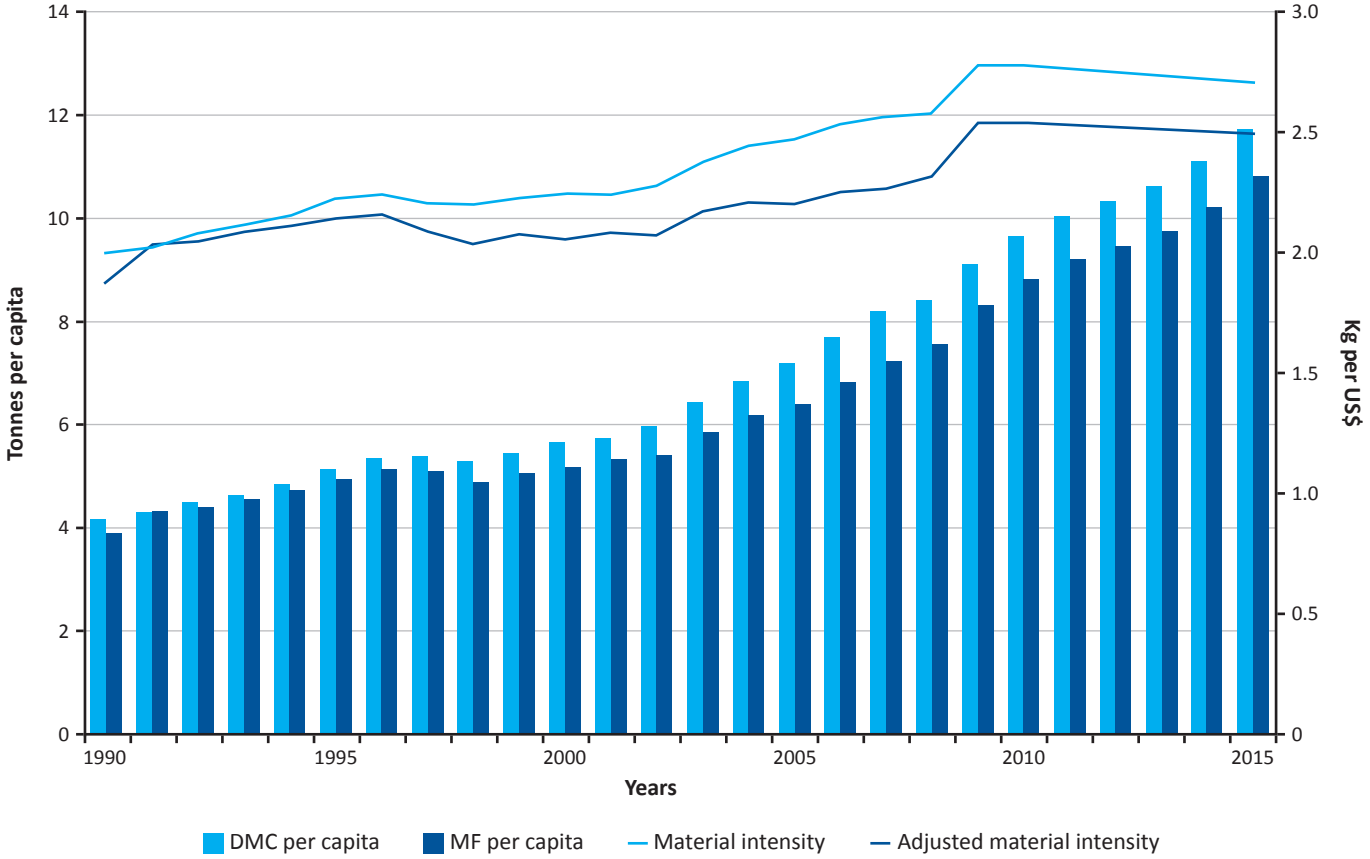
produced by Japan and only 6 per cent by China, but by 2013, Japan's share had fallen to 31 per cent of overall GDP of Asia and the Pacific while China's had risen to 34 per cent (Schandl *et al.* 2015).

Importantly, a considerable share of the materials, energy and water used in the region is for consumption outside the region. The material, energy and water footprints of the whole region are lower than actual material, energy and water consumption, because of products exported to other regions of the world

As a result, the region's economy is slightly more material efficient when the indicators are corrected for material use for consumption outside the region (**Figure 1.2.15**).

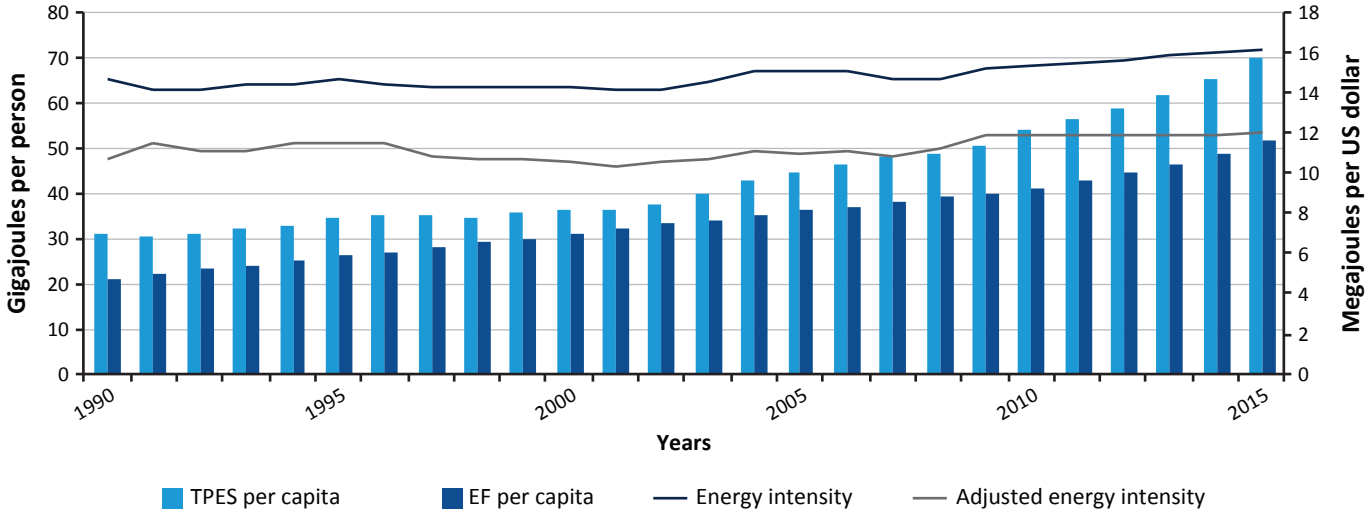
Asia and the Pacific's energy footprint is considerably lower compared to its energy use (TPES), highlighting the extent

Figure 1.2.15: Asia and the Pacific, per person domestic material consumption (DMC), material footprint (MF) per person and material efficiency of the economy, tonnes per person and kilograms per USD, 1970–2015



Source: CSIRO 2015; UNEP 2015

Figure 1.2.16: Asia and the Pacific, per person total primary energy supply (TPES), energy footprint (EF) per person, and energy efficiency, gigajoules (GJ) per person and megajoules (MJ) per USD 1970–2015



Sources: CSIRO 2015; UNEP 2015

to which energy is used in the export manufacturing (**Figure 1.2.16**). There is a similar effect for energy intensity, but stronger than that seen for material intensity.

1.3 Increasing vulnerability to the impacts of natural hazards and extreme events

1.3.1 Disasters caused by natural hazards in Asia and the Pacific

Asia and the Pacific has the highest number of reported disasters of any region in the world – approximately 41 per cent of all natural disasters reported over the last two decades occurred in this region (UNESCAP 2015; UNESCAP 2014) and 1 625 disaster events reported in the region in 2005–2014 (UNESCAP 2015). In 2015, Asia and the Pacific continued to be the world's most disaster prone region. During that year, 160 disasters were reported in the region, accounting for 47 per cent of the world's 344 disasters (UNESCAP 2016).

Asia and the Pacific's sub-regions are affected by different disaster and climate risks. Between 1992 and 2011, South Asia, Eastern China and Southeast Asia were affected by major floods that caused considerable human and economic losses (UNEP 2013a). Southeast Asia, mainly Indonesia and the Philippines, was most affected by disasters with 527 events and 354 293 deaths reported between 2004 and 2013 (UNESCAP 2014). In the same period, China reported 285 events. Many countries are located along the Pacific Ring of Fire, where about 75 per cent of the world's seismic energy is released, and have experienced several large earthquakes during the past two decades (UNEP 2013a). The Indian and Pacific Ocean coastlines, including the east coasts of Northeast Asia, South Asia and Southeast Asia are exposed to tropical cyclones, and were affected by a number of severe storms causing heavy rains and flooding between 1992 and 2011 (UNEP 2013a).

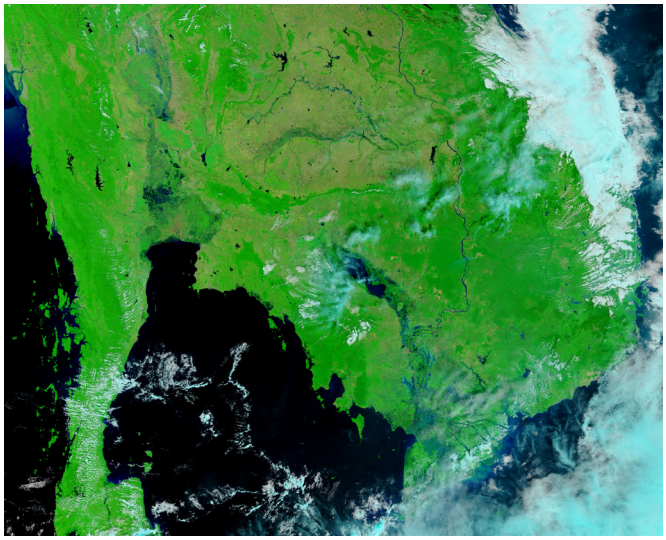
Key Messages

Asia and the Pacific has the most reported disasters caused by natural hazards of any region in the world. The frequency, magnitude, and impacts of disasters in the region is increasing with disaster risk concentrated in urban areas.

- Disaster risk is expected to increase further due to climate change and poorly or unplanned socio-economic development in locations exposed to a range of hazards.
- The worst impacts of climate change are projected to occur in the Pacific and South and Southeast Asia. Some islands could become uninhabitable in the future and others may lose some parts of their territories due to sea level rise.

There are national frameworks and roadmaps for disaster risk reduction in many countries. The causes of social vulnerability and the drivers of disaster risk are often not sufficiently addressed by disaster risk reduction strategies and development planning.

Figure 1.3.1: Flood waters inundated the provinces of Phra Naknon Si Ayutthaya and Bangkok, Thailand, December 2011 (NASA)



Source: NASA Earth Observatory 2011

According to the World Risk Index (ADW 2012), eight of the 15 countries with the highest risk worldwide are island states, with Tonga and Vanuatu having the highest risk. Extreme events that have occurred in Asia and the Pacific in the past few years include the Great East Japan earthquake and tsunami in 2011, the Bangkok floods in 2011 (**Figure 1.3.1**), Tropical Cyclone Evan in Samoa 2012, Typhoon Hayan in the Philippines in 2013, floods in India in 2011 (**Figure 1.3.2**) and Pakistan in 2013 and 2014, Tropical

Figure 1.3.2: River floods in the Indian state of Bihar, October 2011 (NASA)

Source: NASA Earth Observatory 2011

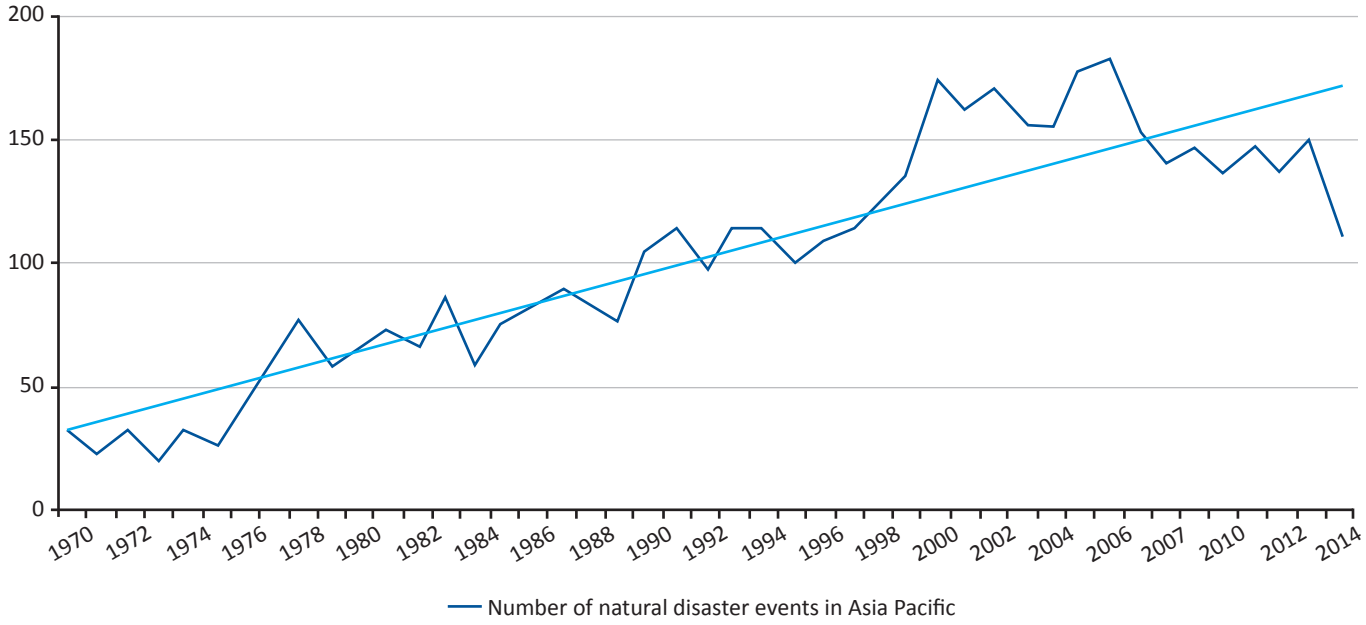
Cyclone Pam and Typhoon Maysak in Kiribati, the Federated States of Micronesia, Tuvalu, the Solomon Islands and Vanuatu in 2015, the Nepal earthquake in 2015 and the heat wave in India in 2015.

Data compiled by the Emergency Events Database (EMDAT) show a sharp rise in the number of reported disasters in Asia and the Pacific since 1960, but a tailing-off since 2000 (**Figure 1.3.3**).

Many risks of climate change are concentrated in urban areas and affect people, assets, economies, and ecosystems (IPCC 2014b). The risks include heat stress, extreme precipitation, inland and coastal flooding, landslides, air pollution, drought and water scarcity. A lack of essential infrastructure and services, poor-quality housing and living in exposed areas increase risk. Sea-level rise is expected to lead to increasingly adverse impacts such as submergence, coastal flooding and erosion in coastal and low-lying areas.

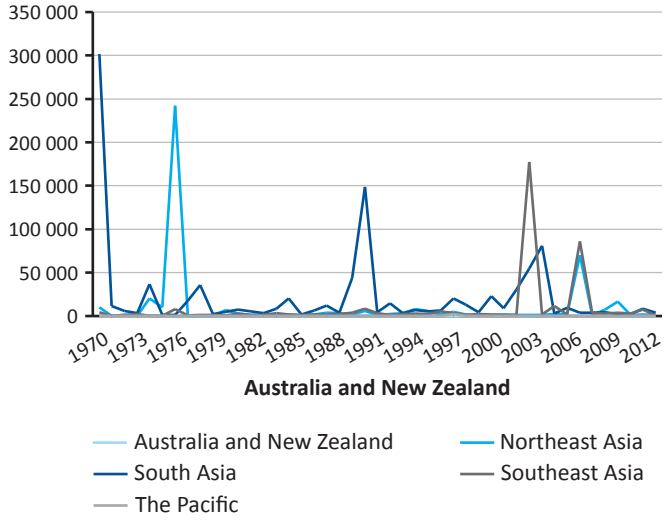
Extreme events are increasingly affecting small island developing states (UNDESA 2010). Disasters and associated impacts vary significantly across sub-regions. While disaster intensity and loss of life are higher in Southeast Asia and South Asia, the highest property losses occur in Oceania and Australia and New Zealand (**Figure 1.3.4**).

Figure 1.3.3: Natural disaster events in Asia Pacific, 1970–2014



Source: EM-DAT 2015

Figure 1.3.4: Deaths caused by natural disasters in Asia and the Pacific by UNEP Sub-region, 1970-2014



Source: EM-DAT 2015

1.3.2 Causes of vulnerability and drivers of increasing risk

Because of the geographical, environmental, climatological, social, economic and political diversity of the Asia and the Pacific region, vulnerabilities, hazard types and characteristics, and hazard impacts vary greatly across the region. Certain socio-ecological systems, such as mountains, coastal areas and small islands, are particularly vulnerable because of their geographic and environmental characteristics (Leal Filho 2014). At the same time, socio-economic characteristics such as politics and governance, economic development status, and development choices also determine levels of vulnerability and resilience.

The Intergovernmental Panel on Climate Change (IPCC 2014c) places medium confidence on the attribution to climate change of increases in the frequency or intensity of ecosystem disturbances such as droughts, wind-storms, fires and pest outbreaks. The character and severity of impacts from climate change and extreme events depend not only on climate-related hazards but also on exposure and vulnerability of human and natural systems (IPCC 2014a).

Poor and marginalized people, those living in high-risk areas, women, the young, old and the disabled tend to be more at risk and more vulnerable to hazards for different reasons. These include dependence on natural resources to sustain livelihoods, reduced mobility and/or mental, physical or cognitive abilities, lack of access to different types of resources such as hazard information, communication and other technologies and infrastructure, political power and representation, and financial means to cope with and recover from hazard events (**Table 1.3.2**).

Table 1.3.1: Disaster occurrence and damage in Asia and the Pacific Region due to droughts, floods, landslides, earthquakes, wildfires, and storms, 1970- August 2015

	Parameters	Pacific Islands	Southeast Asia	South Asia	Northeast Asia	Australia & New Zealand
1	Deaths (% of total population)	0.02	0.09	0.08	0.04	0.005
2	Total damage (USD billion)	75.31	118.87	152.97	923.06	72.68
3	Damage (USD per person per year)	59.22	5.79	2.77	15.03	75.88
4	Intensity (number of events per 1 000 square kilometres	0.06	0.29	0.30	0.10	0.03

Source: EM-DAT 2015

Table 1.3.2: Parameters determining risk and vulnerability to disasters in different geographical settings

S. No	Parameter	Islands	Coasts	High Lands	Mountains
1	Exposure	→	→	↓	↑
2	Susceptibiity	↑	→	→	↑
3	Coping Capacity	↓	→	→	↓
4	Adaptative Capacity	↓	→	→	↓
5	Predictabilty	→	→	→	↓
6	Technical Application	↓	↑	→	↓
7	Communication	↓	↑	↑	↓
8	Transboundary Impact	↓	→	→	↑

Note:(Arrows: vertical – high, horizontal – medium, down – low)
Source: EM-DAT 2015

An important driver of risk and the socio-economic impacts of disasters in Asia and the Pacific is hazard exposure (**Figure 1.3.5, Figure 1.3.6, Figure 1.3.7, Figure 1.3.8, Figure 1.3.9**). This is increasing because of population growth unplanned urbanization and high population density (IPCC 2012). Because of their isolation, low elevation, concentration of people living along coasts, and the lower response and recovery capacity after disasters, Pacific Island Countries

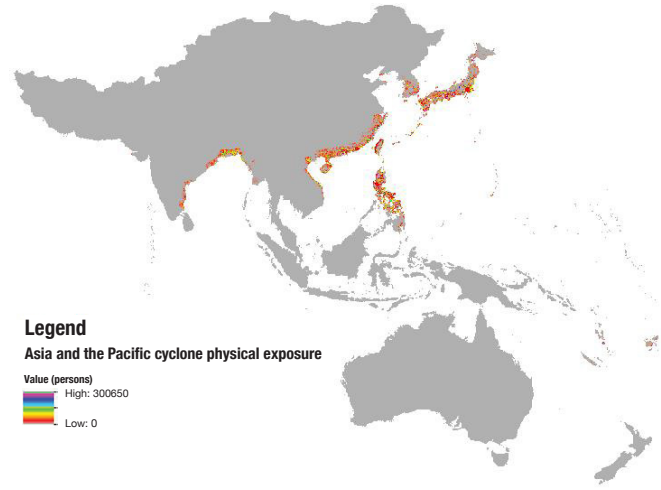
Figure 1.3.5: Development in China's Pearl River Delta (Zhu San Jiao), 1988–2014

Source: NASA Earth Observatory 2011

Figure 1.3.6:Economic exposure to tropical cyclones in Asia and the Pacific

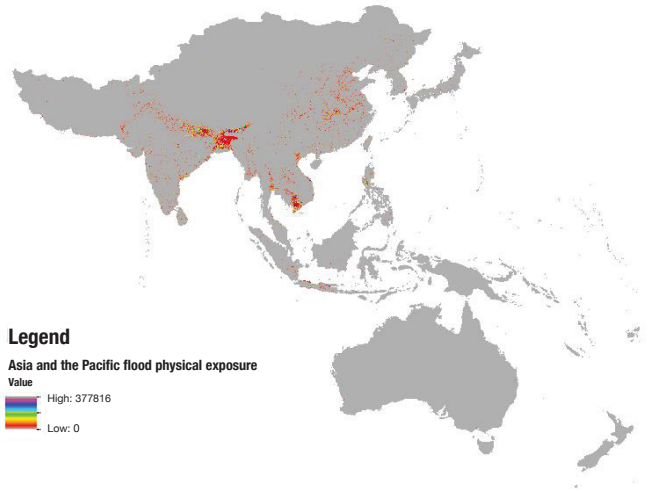
Source: UNEP 2013b

Figure 1.3.7: Physical exposure to tropical cyclones in Asia and the Pacific



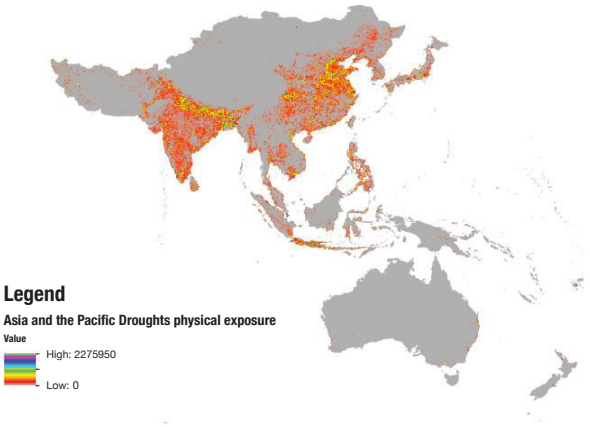
Source: UNEP 2013b

Figure 1.3.8: Physical exposure to floods in Asia and the Pacific



Source: UNEP 2013b

Figure 1.3.9: Physical exposure to drought in Asia Pacific



Source: UNEP 2013b

and Territories (PICTs) are particularly vulnerable to climate change (SPREP 2012).

ESCAP (2014) estimates that the average number of people exposed to annual floods increased from 30 million to 64 million, and the population living in areas affected by cyclones from 72 million to 121 million between 1970 and 2010. While the overall percentage of the urban population living in slums has decreased, the absolute number increased from 410 million in 1990 to 470 million in 2000.

The worst impacts of climate change are projected to occur in the Pacific and South and Southeast Asia. In 2011, six of the ten countries most vulnerable to climate change worldwide were in Asia and the Pacific (UNEP 2013a). Focusing on the population at risk from sea level rise by 2050, seven of the ten most vulnerable countries worldwide are in the region (UNEP 2013a). Nearly 40 million people in India (1st) will be at risk, more than 25 million in Bangladesh (2nd), more than 20 million in China (3rd) and Indonesia (4th), nearly 15 million in the Philippines (5th), and nearly 10 million in Viet Nam (7th) and Japan (8th). Other Asian countries in the top 20 include Republic of Korea (12th), Myanmar (13th), Malaysia (16th) and Thailand (20th).

1.3.3 Impacts of disasters across Asia and the Pacific

Disasters caused by natural hazards kill and affect millions of people, undermine human security, physical and mental health and well-being, cause displacement, and lead to damage to and losses of ecosystems, property, infrastructure, and places of cultural and recreational significance, as well as putting livelihoods and economies at risk (UNEP 2013b; IPCC 2012). Between 2005 and 2014, more than 1.4 billion people were affected by disasters in Asia Pacific, 80 per cent of the number of people affected by disasters globally (UNESCAP 2015). In 2015, 59.3 million people were affected by disasters in the region (not including slow-onset disasters such as droughts, heat waves, and forest fires (UNESCAP 2016).

Table 1.3.3: Key regional risks from climate change

Sub-region	Key risks	Drivers
Asia	Increased riverine, coastal and urban flooding leading to widespread damage to infrastructure, livelihoods and settlements (medium confidence)	Extreme precipitation, damaging cyclones, sea-level rise
	Increased risk of heat-related mortality (high confidence)	Warming trend, extreme temperature
	Increased risk of drought-related water and food shortages causing malnutrition (high confidence)	Warming trend, drying trend, extreme temperature
Australia & New Zealand	Significant change in coral reef systems' community composition and structure in Australia (high confidence)	Damaging cyclones, sea-level rise, ocean acidification
	Increased frequency and intensity of flood damage to infrastructure and settlements in Australia and New Zealand (high confidence)	Extreme precipitation
	Increasing risks to coastal infrastructure and low-lying ecosystems in Australia and New Zealand, with widespread damage towards the upper end of projected sea-level-rise ranges (high confidence)	Damaging cyclones, sea-level rise
The Pacific	Loss of livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (high confidence)	Drying trend, extreme precipitation, damaging cyclones, sea-level rise, ocean acidification
	The interaction of rising global mean sea level in the 21st century with high-water-level events will threaten low-lying coastal areas (high confidence)	Damaging cyclones, sea-level rise

Source: IPCC 2014a

The number of recorded deaths from disasters increased from just over 200 000 between 1994 and 2003 to almost 750 000 between 2004 and 2013, largely in Asia (UNESCAP 2014). 16,000 fatalities were recorded in 2015 (UNESCAP 2016). Direct and insured losses from weather- and climate-related hazards have increased substantially in recent decades, both globally and regionally. However, UNEP (2011) notes that relative risk, measured as a proportion of the population or GDP, is stable, and may even be declining for mortality.

Disasters caused by natural hazards are one of the most important causes of forced displacement. A 2011 report (IDMC and NRC 2011) estimated that in 2010, 90 per cent of disaster displacement within countries was attributed to climate-related hazards. During 2010–2011, more than 42 million people were displaced in Asia and the Pacific as a result of extreme weather events.

Climate-induced migration has become a focus because Asia and the Pacific is the most disaster-affected region, the most populous region and, a region in which mass movements of people are driven by growing inequalities and regional economic integration, and where climate change is expected to have significant impacts (ADB 2012). In small island developing states, population displacement is increasing, particularly in low-lying islands, because of environmental degradation, climate change and sea-level rise. Some islands could become uninhabitable in the future and others may lose their entire territories due to sea level rise (UNEP 2014).

Economic damage caused by disasters in Asia and the Pacific increased from USD52 billion in the 1970s to more than USD 523 billion in 2005–2014, which is 45 per cent of the global total (UNESCAP 2015). Reported economic damage incurred in 2015 (not including damage from slow-onset disasters) was more than USD 45.1 billion (UNESCAP 2016).

Earthquake events have caused the largest number of deaths and economic losses, followed by storms and floods. The 2015 Nepal earthquake killed more than 8 000 people, 22 000 were injured, more than 100 000 displaced, and about 500 000 houses were destroyed and 300 000 damaged. In small exposed countries, particularly small island developing states, the impacts of climate change and sea-level rise on the environment and socio-economic development of the country are disproportionately greater (UNEP 2014; SPREP 2012), with losses exceeding 1-8 per cent of GDP, averaged over the period 1970– 2010 (IPCC 2012).

1.4 Environmentally-related health risks

1.4.1 Introduction: health has social and environmental determinants

Human health is determined by socio-economic and environmental (including ecological) factors. Some definitions of the environment include social dimensions, but this section avoids discussion of social health influences such as discrimination based on gender, status, religion, culture, ethnicity and other descriptors. Literacy, nutrition, female empowerment and health systems are also not discussed, nor are cultural attitudes that influence such health-risking behaviour, such as smoking, lack of exercise, diet, alcohol consumption and violence. This section focuses on health effects arising from alterations in the physical environment, such as pollution and ecosystem and climate change.

Key Messages

Demographic factors, including ageing and population density, influences human health, including the total burden of disease, both quantitatively and qualitatively. The impact from environmental determinants of human health include food security and nutrition, access to clean water, sanitation and reduced air pollution.

- Life expectancy is increasing in the Asia and the Pacific and the regional population is aging.
- Water and sanitation contribute to poor hygiene and disease risk throughout the region. Contamination of water sources by human and industrial wastes is a major problem in South and Southeast Asia. Ground water contamination from sea level rise is especially problematic for island nations in the region with limited fresh water supplies.
- Food contamination by pesticides and other toxins affects rural poor and vulnerable populations. Poor animal husbandry has caused regional outbreaks of zoonoses diseases such as SARS, Avian influenza.
- Air pollution from biomass and coal burning attributes to premature deaths throughout the region especially among the rural poor women and vulnerable populations. Transboundary smoke and haze is a leading regional air quality issue.

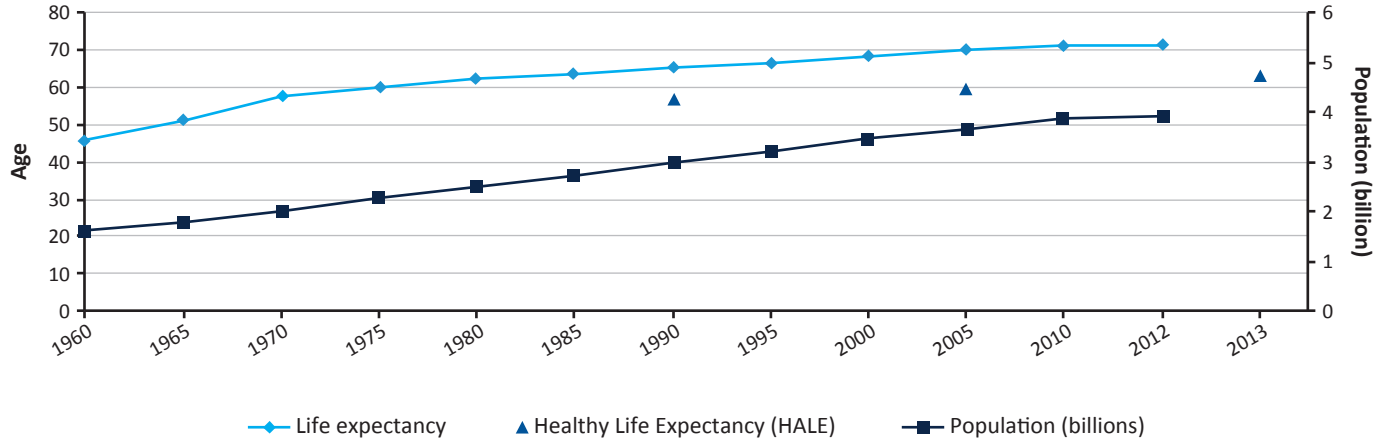
Climate change and resource depletion are emerging issues that when coupled with urbanization lead to increases in environmentally-related health risks throughout the region. The appearances of new diseases or the manifestation of known disease in a new form (like zika), or in new areas (malaria, Japanese encephalitis) can cause severe economic harm and have the capacity to reverse recent regional progress.

Demographic factors, including ageing and population density, also influence health, including the total burden of disease, both quantitatively and qualitatively (Campbell et al. 2007). In Asia and the Pacific, in recent decades, the net impact of development on health has been strongly positive (**Figure 1.4.1**). Although the burden of non-communicable diseases (NCDs), including cardiovascular impairment, arthritis, cancer, diabetes and dementia, has increased in Asia and the Pacific, it not entirely clear whether this is true after age standardization[5]. In particular, age-standardized mortality of most NCDs has declined, perhaps because of better childhood nutrition and reduced smoking. Important exceptions may be lung cancer in Chinese men and all cancers in South Asia. Importantly, novel entities, such as synthetic organic pollutants, radioactive materials, nanomaterials, and micro-plastics[6], and behaviour including a reduction of weight-bearing exercise especially in childhood, could undermine future population health.

Environmental determinants of health include food, nutrition, water, air, infrastructure, climate, ecosystems and other natural resources. Access to green and blue space – views of water in urban settings– has been suggested as benefitting mental health, after adjustment for socio-economic status. However, high quality evidence for this in Asia and the Pacific is lacking.

Industrial wastes and synthetic and naturally occurring pollutants harm human health, by contaminating air, soil, food, freshwater and oceans. Some pollutants, heavy metals and organochlorines for example, bio-accumulate in food chains, including fish and marine mammals, others disrupt endocrine systems or are carcinogens. Important contaminants include arsenic in groundwater from geologic sources, mercury in fish from coal burning, and particulate air pollution from the burning of biomass and coal. Greenhouse gases, including from fossil fuel combustion, deforestation

Figure 1.4.1: Asia Pacific, population and life expectancy, 1960–2012



Sources: World Bank, HALE Collaborators 2015; GBD 2013 DALYs.

5 Age standardization is a technique used for comparing populations when their age profiles are quite different.

6 http://www.anthropocene.info/pb2.php.

and excessive meat consumption, are also a central health issue (Watts *et al.* 2015; Whitmee *et al.* 2015).

1.4.2 Water and food pollution in Asia and the Pacific

Inadequate sanitation, together with a paucity of treated water, contributes to poor hygiene and water-borne illnesses (World Bank 2013). Drinking water contaminated by human faeces is estimated to be used by about 30 per cent of the population of South and Southeast Asia (Bain *et al.* 2014). Many Pacific countries face problems of contaminated and limited drinking water, due to their small area, increasing populations and sea-level rise. Freshwater stress is also increasing in many parts of Asia, and can worsen water-washed diseases, such as scabies and trachoma, the incidence of which can be reduced by ample supplies of clean water for washing.

Much groundwater is contaminated by arsenic in geologically vulnerable areas, including much of Bangladesh and parts of China, India and Myanmar. Groundwater can also be contaminated by human and industrial waste – a study in China found significant antibiotic contamination in 58 river basins (Zhang *et al.* 2015), a potential cause of anti-microbial resistance

Food can also be inadvertently contaminated by pesticides, aflatoxins or microbial toxins, or deliberately, such as by melamine sometimes added to food products to defraud consumers (Guan *et al.* 2009).

Population size and life expectancy increased considerably between 1960 and 2012 in Asia and the Pacific. Health adjusted life expectancy (1990–2013) also improved.

1.4.3 Air pollution, chronic disease and ageing

Air pollution, a leading global environmental health risk factors (Smith *et al.* 2014) is particularly important in Asia and the Pacific, especially in China, India and Southeast Asia. It has two major sources, in households from the burning of coal and biomass for cooking and heating; and in the ambient environment from fossil fuel combustion mostly for transport and electricity generation. Of 7 million premature deaths attributed globally to air pollution in 2012, about 53 per cent has been attributed to outdoor (ambient) air pollution (Lelieveld *et al.* 2015) (**Table 1.4.1**).

The 2015 El Niño greatly worsened the effects of the seasonal fires most of which are deliberately set each year to clear forests for agriculture in large parts of Kalimantan, Sumatra and elsewhere in Indonesia, and cause haze that extends to Brunei, Malaysia and Singapore. These fires have probably caused tens of thousands of foetal deaths, as well as suffering to other vulnerable populations in Southeast Asia (Jayachandran 2009).

Although the total burden of most non-communicable diseases has increased in Asia and the Pacific, the rate and severity of most conditions has declined, once ageing is accounted for (Beaglehole, *et al.* 2011). This is probably mainly because of improved childhood nutrition. There are possible exceptions: mortality from lung cancer among men has been reported to be increasing in China, potencially because of air pollution and smoking (Chen *et al.* 2015; Mandel *et al.* 2015).

This success should, however, not be cause for complacency. It is likely that future population health could be substantially improved through reduced environmental and other risks, especially air pollution and smoking. The replacement of the burning of coal and biomass with cleaner fuels that do not pollute the atmosphere would also slow climate change and thus benefit health in other ways – such win-wins are often called co-benefits. Similarly, better organized cities, with good public transport systems, would improve air quality, slow climate change and might also bring other health benefits, such from walking (active transport) and greater social interaction. Obesity and diabetes remain key threats in many Pacific islands, even though they, too, continue to experience rising life expectancy.

Table 1.4.1: Illustrative examples of environmental health issues affecting air, land, water, ecosystems and the ocean in Asia and the Pacific

Media: major causes/mechanisms	Asia and the Pacific example(s)	Manifestations
Air: inhalation of smoke, particulate matter and ground-level ozone exposure from the combustion of fossil fuel, (especially) coal for electricity and heating and biomass for cooking; from forest fires and deliberate burning of vegetation for land clearance; ground level ozone and nitrous oxide also from motor vehicles; toxic waste from industrial accidents and petroleum by-products	About 70 per cent of the global burden of disease (air pollution) occurs in Asia and the Pacific (http://www.healthdata.org/gbd/data-visualizations); Bhopal methyl methyl isocyanate poisoning (India 1984); (Sharma 2005); Yokkaichi (Japan, 1960s); Tianjin explosion (China 2015) (Chan et al. 2015), Indonesian fires, especially in Kalimantan and Sumatra, worse during El Niño years (e.g. 1978, 2015) (Marlier et al. 2015)	Lung and cardiovascular disease, including stroke; lung cancer; death, neurological and other consequences, including asthma and chronic lung disease
Ecosystems: synanthropy, loss of habitat by deforestation and other factors can stress bats which are viral reservoirs, possibly enhancing spillover; irrigation and intensive crop and animal raising	Malaria; Japanese encephalitis (Nepal, Sri Lanka), SARS (Chinese origin), Hendra virus (Australia), avian influenza, Nipah virus (Malaysia and Singapore 1998) (McMichael et al. 2013)	
Land: soil contamination by faeces with parasites, industrial waste	Bursting of tailings dam with coal-ash flood, Viet Nam (2015); chromium pollution China (Gao and Xia 2011)	Cancer, unknown
Fresh water: Contamination by human and animal faeces, salt, pesticides, industrial waste and antibiotics, naturally-occurring arsenic and in some places excess fluoride	Faecally contaminated water remains a major problem in South Asia, parts of China and on some Pacific islands	Gastroenteritis, diarrhoea, cholera, schistosomiasis, stunting due to repeated diarrhoea with inadequate nutrition, skin changes, cancer (arsenic),
Ocean: Mercury from coal burning and industry, bioaccumulation of heavy metals and endocrine disruptors in fish and marine mammals	Minimata (Japan, 1950s-1960s), contamination of fish and marine mammals by mercury and some persistent pollutants (Karagas et al. 2012)	Neurological syndrome, birth defects

1.4.4 Agricultural intensification and ecosystem change

Increasing livestock intensification allows more efficient resource use to produce food. Its drawbacks, however, include poorer animal welfare, antibiotic resistance from excessive antibiotic use, and infectious diseases, some of which spill into human populations. The nutritional quality of meat is lower, both fattier and less nutrient-dense than from animals raised extensively. Zoonoses, diseases that can be transmitted from animals to humans, from livestock include severe acute respiratory syndrome (SARS), probably from farmed raccoon dogs (*Nyctereutes procyonoides*) and civets, and highly pathogenic avian influenza, from poultry (McMichael *et al.* 2013). Indeed, some zoonoses have at times caused severe economic harm. Intensively raised crops can also be associated with human health concerns, including vector-borne diseases such as malaria and Japanese encephalitis. With adequate public health measures, however, these vector-borne disease risks can be reduced.

Ecosystems have been altered for millennia in Asia and the Pacific, with a net increase in provisioning ecosystem services from, for example, farmland, aquaculture and plantations, but with declines in regulating and cultural ecosystem services from, for example, intact forests that reduce erosion, or associated declines in biodiversity that many humans value (Millennium Ecosystem Assessment, 2005). Some important diseases have emerged from ecosystem change, including HIV/AIDS. Examples in Asia and the Pacific include Hendra virus in Australia, from bats *via* horses to people, and Nipah virus, from bats to people, sometimes *via* pigs.

1.4.5 Climate change and health

There is increasing recognition that global health is endangered by climate change, especially if the average global temperature rises more than 2 ºC degrees above pre-industrial levels (Watts *et al.* 2015; Butler 2014). Early concerns about climate change and health focused on heat stress and changes in the range of vector-borne diseases, especially malaria. Concerns about the relationship between climate change and more indirect health effects, including through food production, conflict and migration, are, however, becoming more prominent (King *et al.* 2015; Butler 2014). There is also growing recognition that heat stress, exacerbated by the urban heat island effect, harms occupational productivity and can increase the risk of injuries (King *et al.* 2015). The elderly, the poor and those with mental illness and chronic disease, especially cardiac ones and dementia, are also at risk from excessive heat, especially at night and if persisting for several days (Oudin Åström *et al.* 2011). Disasters, exacerbated by sea-level rise, also harm health and are climate change related. Many cities and regions in Asia and the Pacific are vulnerable to natural disasters, with many informal settlements located in fragile environmental areas on shorelines and major river basins.

Although disputed by some, it is highly likely that climate change, together with other aspects of environmental change, is making diseases such as malaria, dengue, chikungunya and Zika harder to manage (**Box 1.4.1**). Flooding, which can also be worsened by climate change (with other anthropogenic factors), increases the risk of leptospirosis, a rodent-carried disease that can be acquired by walking through flood water that is prevalent in the Philippines and parts of Thailand. Ciguatera fish poisoning, which occurs in the Pacific, has been linked with higher ocean temperatures and with storms (Barrett 2014). Climate change may also alter the frequency and intensity of the El Niño-Southern Oscillation, with consequences including intensified droughts and floods, worse fires in Southeast Asia

Box 1.4.1: Dengue in Japan and Singapore

Japan and Singapore are both highly developed, densely populated nations. Even so, neither is free of dengue fever. In 2014 an outbreak of locally transmitted dengue fever occurred in Tokyo, the first in Japan for at least 70 years (Kutsuna et al. 2015). Climate change is expanding the range of dengue transmission further north in Japan, by creating suitable temperatures for the mosquito vector. Nevertheless, the temperate climate in Japan, which means that there are long periods each year when no dengue transmission is possible, combined with the advanced state of public health, means that dengue is unlikely to become more than a nuisance, even if future autochthonous outbreaks occur. In Singapore, however, disease transmission is possible all year round. Despite intensive efforts that have successfully kept mosquito populations fairly low, complete eradication of the vector has proved impossible, and dengue cases continue to occur. Although the disease is now less common in children (Ooi et al. 2006), it is possible, as with many other viral infections, that a later age of acquisition could actually be more problematic.

(Marlier *et al.* 2013, Miriam *et al.* 2015), and a weakened Indian monsoon, adding to the stress on farming communities and leading to food price increases.

1.4.6 Integrated environmental health risks

While greater understanding of the links between the environment and health has emerged in the last five centuries, McMichael (1993) proposed a new category of environmental risk; those that undermine civilisation's life support mechanisms. This concept is fundamentally different from that of traditional environmental health concerns, including many that are newly emerging. The difference between the two lies chiefly in their scale and the long causal chain between exposure and effect. For example, Zika virus is a viral vector-borne disease recently recognized as emerging in the Pacific, and likely causing microcephaly and perhaps other birth defects. However, even Zika lacks the causal potential to undermine civilisation and thus ruin population health. In contrast, climate change, biodiversity loss beyond critical thresholds, not yet determined, and the over-exploitation of natural resources, unless substituted, do have this capacity (McMichael and Butler 2011, Whitmee *et al.* 2015).

1.5 Widening of gaps between policy and implementation

This section discusses the divergence of policies created but often poorly implemented to address environmental issues in the Asia and the Pacific region. The income disparity between countries in the Asia and the Pacific region partly, but imperfectly, explains the differences in each nation's capacity to cope effectively with environmental challenges. Despite these problems, environmental policy in the region does have some bright spots, mostly because social demand is increasing for robust measures to address growing environmental challenges.

Key Messages

The region has seen increasing policy intervention to cope with existing environmental issues, improve ecosystem quality and achieve sustainable development. Drafting of laws and regulations, applying market-based instruments and the use of voluntary approaches, has generally contributed to environmental improvement. But there is a widening gap between policy and implementation, due to ineffective policy implementation, a poor scientific base for policy formulation and emerging environmental issues.

- Uneven policy development to address regional issues such as climate change and air quality due to different policy priorities.
- Changing consumption patterns and skyrocketing energy consumption have led to poor performance on environmental issues.
- The use of multilateral agreements and treaties has great potential throughout the region but enforcement and implementation are uneven.
- Resources and capacity are inadequate to finance and support policy formulation and execution.

Building stronger institutions and governance are especially important, including mainstreaming the environment in other policy areas, adopting integrated policy approaches, collaborative governance with greater public participation in decision making and strengthening the judicial system for better enforcement.

1.5.1 Policy development

Overview of environmental performance

Environmental performance refers to the general outcome of policies applied to the real world. In order to assess the environmental performance of policies adopted, the Environmental Performance Index (EPI) (Malaysia, NRE and Universiti Teknologi Malaysia 2015) and the Environmental Democracy Index have been developed and applied (WRI2015).

According to the 2014 EPI, the Asia and the Pacific region is one of the poorest-performing on environmental stewardship metrics, with only the sub-Saharan African region performing worse on average (Hsu *et al.* 2014). The low overall EPI performance of Asia and the Pacific countries clearly reflects a measurable gap between environmental protection goals and aspirations, and the effectiveness of policies in the region.

Because of the differences between nations in levels of economic development, performance and environmental issues of concern, it is difficult, if not impossible, to generalize policy implementation gaps and problems in the huge Asia and the Pacific region. Some countries, including Australia, Japan and New Zealand have had long trajectories and histories of environmental management. Others, notably the emerging economies, focused first on economic development and only began to implement environmental policies following the landmark 1972 Stockholm Conference on the Human Environment, and effective implementation remains a challenge.

Uneven policy development

Nations in the Asia and the Pacific region have developed environmental legislation and policies to cope with intensifying environmental hazards emerging in the course of development and responding to multilateral environment agreements and assessments. Due to resource constraints and pressures, policy priorities differ significantly between the region's developed and developing countries. Developed nations, such as Australia and Japan for example, currently focus on greenhouse gas mitigation while developing countries give more attention to local pollution problems that were addressed in developed countries several decades ago. The types of policy instruments and the advancement of environmental measures are likewise uneven between countries in the Asia and the Pacific region.

China and India have experienced the most rapid environmental policy development over the past several decades. Part of this has been out of necessity: breakneck economic growth, changing consumption patterns and skyrocketing energy consumption have ensured China and India's place at the bottom of almost every indicator of environmental performance (Hsu *et al.* 2014). China has rapidly enacted a broad portfolio of policies in response to its mounting environmental problems. The 12th Five Year Plan (2011–2015), the main policy blueprint to guide social and economic development in China, is considered its greenest to date (Seligsohn and Hsu 2011).

India has a long history of environment legislation including the Indian Forest Act, 1927; the Water (Prevention and Control of Pollution) Act, 1974; the Air (Prevention and Control of Pollution), 1981; the Environment (Protection) Act, 1986; and the Biological Diversity Act, 2002. The National Environment Policy, 2006 seeks to build on the earlier policies on environmental conservation. In 2010, the National Green Tribunal was established under the 2010 National Green Tribunal Act for effective and expeditious disposal of cases relating to environmental protection and the conservation of forests and other natural resources.

1.5.2 Addressing policy ineffectiveness

More and more policies have been drafted in recent years, yet the gap between the demand for policy and implementation is widening. Environmental issues are more pressing than ever and there has been a corresponding increase in multilateral environmental agreements, factors that have expanded the demand for effective policy intervention in the Asia and the Pacific region.

Not all policies have realised their full potential

Many environmental policies in Asia and the Pacific nations have yet to realize their full potential. Malaysia, for instance, has a suite of environmental laws, but these have not yet been properly implemented due to a lack of institutional coordination, weak enforcement and entrenched attitudes (Mohammad *et al.* 2011). Many factors influence policy formulation and enforcement. Institutional structure and coordination is crucial for effective implementation of environmental laws.

Governments and policy experts advocate integrated and comprehensive approaches to policy creation, as unscientific policy design often leads to ineffective implementation. Balancing the complexity of environmental issues with political interests makes many environmental policies less effective than they should be. Developing countries tend to use resource-intensive growth strategies that produce copious amounts of pollution before turning to more sustainable pathways (Berkhout *et al.* 2010). There are science and policy gaps in ecosystem management in the Asia and the Pacific nations, as well as inadequate capacity and a general lack of strategies for community participation (Avishik *et al.* 2012).

Institutional barriers are a common factor that results in ineffective policy. Almost every country in the region has an official environmental institution in place but the nations exhibit large differences in capacity for policy creation and execution. Environmental responsibilities are often fragmented into several governmental departments, and this can undermine an integrated approach to environmental issues (Zhang 2008). Furthermore, developing countries tend to have new environmental institutions, often with the most junior or inexperienced minister in charge.

Lack of resources is another common factor contributing to ineffective policies. Resource support comes in many forms, including human resources, facilities and equipment, and money to fund policy formulation and execution. In the newly-established environmental institutions of developing countries, human resources, facilities and equipment are often in short supply. Outsourcing environmental policy studies and formation is common among these institutions.

As environmental hazards increase in severity and become part of public consciousness, more investment in the environmental sector is being mobilized, and government support for environmental policies is on the rise. The Government of China, for example, has set aside special funds for pollution control with a portion devoted to policy formulation and execution. A National Special Programme for Water Pollution Control was initiated as part of China's 11th Five-Year Plan period 2006–2010, an initiative that will extend until at least 2020. It is promising that international institutions, including UNEP, the World Bank and the Asian Development Bank, have played key supporting roles in capacity building for environmental policy formation in developing Asia and the Pacific nations.

Policy assessment and evaluation is a crucial step to determine the effect of a policy intervention, but governments tend to pay more attention to policy formulation, which is a troubling trend. Assessment and evaluation are difficult and complex processes, which require comprehensive methods and experienced, trained personnel to perform properly. One positive sign that countries in the Asia and the Pacific region are paying more attention to the importance of performance evaluation and measurement is the development of sub-national Environmental Performance Indexes (EPIs) to improve tracking of policy implementation. Malaysia, for example, has developed two iterations of a state-level EPI. China and Viet Nam both completed feasibility assessments to identify gaps in existing measurement frameworks, monitoring systems and policies at the sub-national level (Zomer and Hsu 2015). In 2012, India's Planning Commission released its first national Indian EPI, a multi-indicator, state-by-state assessment of environmental quality and policy. The Indian EPI tracks performance in five categories, using 16 indicators. The most significant result of India's EPI is that official governmental channels are now collecting and analysing data about the environment on a national scale.

Need to address policy ineffectiveness

The Asia and the Pacific region boasts many environmental laws, plans, regulations and policies, and the region's countries are members of a wide variety of multilateral environmental agreements and other environmental cooperation mechanisms. The effectiveness of these measures, however, is highly variable. There have been some beneficial outcomes and one can identify a set of good practice cases, but on the whole these best intentions have been insufficient to reverse the trend of increasing environmental degradation.

Some policies need to be made stronger, others are robust on paper but not effectively implemented, and still others are contradictory. Transformative change would require a strengthening of policies, policy coherence and a corresponding bolstering of their implementation. Regulation is needed to shift major investment away from unsustainable infrastructure and transport to cleaner modes of production, development and design, based on life-cycle approaches.

In the absence of regulation, market or incentive-based approaches that can send the right signal to both private and public actors are needed. China, for example, is using multiple approaches to strengthen environmental regulation and management. Starting in 2013, China launched seven provincial and regional emission-trading pilot programmes, with an eventual goal of scaling these up to the national level by 2016–2017 (IETA and CDC 2015). Combined with these market-based approaches, in 2014 China reformed its National Environmental Protection Law for the first time since 1973 to increase penalties for non-compliant enterprises, strengthen environmental courts and provide a greater voice to civil society organizations (Wubbeke 2014).

Many environmental problems are difficult to solve because they involve public goods, such as air, and externalities including pollution. Governments can also make environmental challenges more intractable through insufficient monitoring, ineffective institutions, lack of funding, diminished capacity, and the belief that environmental concerns are too costly and that economic development is a separate, higher priority. These problems may be compounded with the next round of global environment and sustainability targets, the SDGs, which set 17 new goals and 169 targets for all countries to achieve by 2030.

1.5.3 New policy options

Policies for new challenges

The fact that new environmental issues emerge over time and that priorities attached to these burgeoning challenges shift requires policies to be evaluated dynamically rather than only at a particular moment. This suggests a need for novel approaches to cope with new environmental problems. New policies aimed at delivering the SDGs will help sharpen the focus of policies and mobilize resources to address challenges and drivers systematically and holistically.

China, for example, has undergone five stages of policy development since the 1970s. China's policy priorities have shifted from end-of-pipe to whole-process management, from point-source to integrated control of point and non-point sources, from focusing only on pollution control to attaching equal priority to pollution and ecological conservation, and from concentration-based to total load-based regulation of key pollutants (Wang 2010). As the government has become more concerned about tackling environmental problems and pursuing sustainable development, China has become more open to committing to further pledges at the international level. In November 2014, the United States of America (USA) and China agreed to a landmark climate pledge that committed China to a peak emissions year prior to 2030 (The White House 2014). Public health concerns as a result of record levels of air pollution from high coal consumption were major drivers of the Chinese government's climate policies (Liu *et al.* 2015).

More scientific and actionable options

Sound scientific and actionable solutions are needed not only for emerging environmental issues but also to address shortcomings in existing environmental policies. The Asia and the Pacific region needs a wide range of potential solutions to tackle emerging environmental problems, including environmental institutional reform, stronger enforcement, the use of market-based instruments and increased public involvement. All these measures are required in some proportion to build an effective environmental policy platform.

Easily readable, internet-accessible, public-friendly measures for environmental management are welcomed by the general public in developing countries. Environmental information disclosure tools have a role to play in environmental improvement. In Indonesia, for example, where the negative trend of environmental quality has been experienced for many years, an Environmental Quality Index (EQI) has been developed. And in 2015, India launched the National Air Quality Index to monitor the quality of air and to raise public awareness to protect the environment.

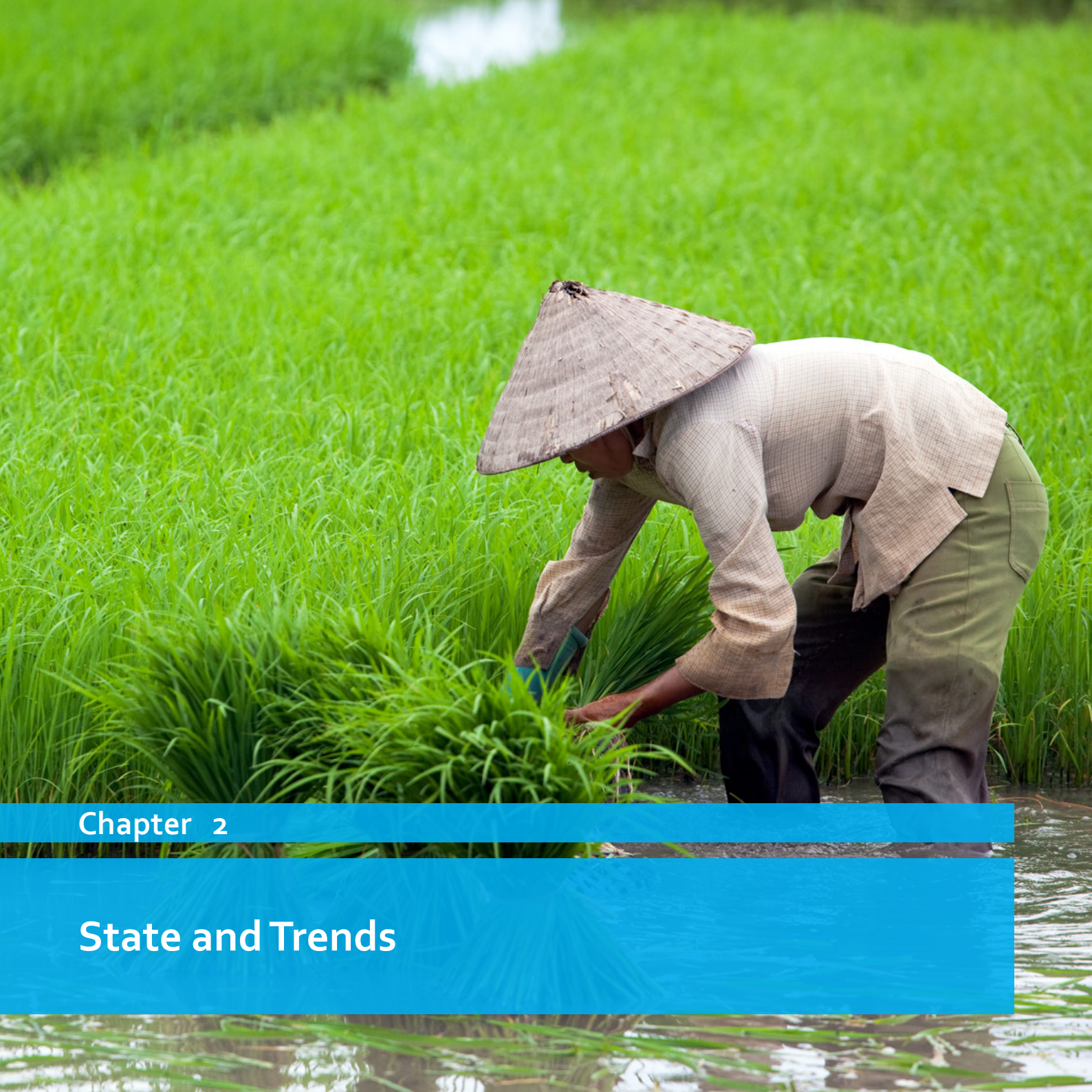
Building stronger institutions and governance are especially important, including mainstreaming the environment in other policy areas, adopting integrated policy approaches, collaborative governance with greater public participation in decision making and strengthening the judicial system for better enforcement. Nations without strong environmental institutions need to mobilize manpower and resources to establish a robust environmental sector. Countries with established environmental institutions need to develop their policies as environmental challenges and national priorities shift over time.

Nations must also work to mainstream environmental protection into macro-economic decision making, a well-established concept that remains difficult to put into action. Mainstreaming would conserve more resources than end-of-pipe approaches, solving environmental problems before they occur while promoting economic development. Government departments responsible for economic development should be educated and armed with adequate environmental knowledge and awareness.

Governments should invest in environmental protection from the perspectives of SDGs implementation and monitoring, natural capital enhancement and governance innovation. Growing environmental challenges require greater funding as well as innovative financing mechanisms and new fiscal instruments. Strengthened capacity-building and education are essential components of robust environmental management plans. Enhanced regional cooperation is necessary to manage trans-boundary issues, especially those related to major ecosystems. Strategic environmental assessments would improve these cooperative efforts, but the cost of conducting such assessments can be high.

Policy assessment and evaluation should improve over time. Strengthening these processes ensures rational and scientific policy creation and implementation. Governments should first institute a broad strategy to develop a greater understanding of the costs of pollution and benefits of a healthy environment. This approach should be supported by environmental information and data that are open to the public, as well as an effective science-policy interface and yardsticks based on novel concepts such as natural capital, environmental accounting and cost-benefit analysis. These are only the initial actions that nations in the Asia and the Pacific region should take to tackle the world's growing environmental challenges.

See references for Chapter 1



Chapter 2

State and Trends

All of the GEO-6 regional assessments follow the traditional Drivers, Pressures, State, Impacts and Response (DPSIR) assessment framework; however, each integrated environmental assessment considers the elements of this framework in a regional context. For Asia and the Pacific drivers of environmental change primarily include economic development and population growth. As highlighted in the regional priorities, however, another significant driver is unsustainable consumption and production, which affects such sectors as energy and mining as well as both commercial and personal consumption.

This section considers the drivers and the pressures they exert on the environment by analysing recent trends in the state of the environment as well as the impacts of environmental change on human health. The analysis is conducted through six environmental themes, namely:

- air, including common and toxic air pollutants as well as greenhouse gas emissions;
- land, including fragmentation and degradation;
- biota, including both plant and animal diversity;
- water, including both quantity and quality of freshwater;
- coasts and oceans, including coastal zones and marine pollutions;
- waste, including chemical, industrial and municipal waste.

2.1 Atmosphere – air and climate

2.1.1 Introduction

Air pollution and climate change are closely linked. The main sources of carbon dioxide emissions, such as transport and the extraction and burning of fossil fuels, are major sources of air pollution as well as key drivers of climate change. Air pollutants have a dual impact on climate change: some cause warming, others have a cooling effect. Short-lived climate pollutants (SLCP) such as ground-level ozone, methane and black carbon are among the top contributors to global warming, and act in a shorter time frame than other greenhouse gases such as carbon dioxide and nitrous oxide. Indoor Air Quality and Toxic air pollutant are the issues that need high attention in the Asia and the Pacific region, due to the link to gender imbalanced exposures, and continuing risk and lack of monitoring, as well as related regulations.

2.1.2 Drivers

The main causes of air pollution include transport, domestic combustion of biomass both outdoors and indoors, industrial processes, electricity generation, heating, and the use of some products such as paints and solvents. Air pollution may also be caused by natural sources such as volcanic eruptions, dust storms and emissions of volatile organic compounds from vegetation.

The main drivers of air quality degradation in Asia and the Pacific are related to population and economic trends, transport, energy and agricultural demand and household consumption:

- Growing population, higher consumption per person, migration, and urbanization, as well as increases in the number of middle-income families, energy intensity and waste generation. A growing population leads to higher emissions if efforts have not been made to reduce emission levels per person.

- Economic activities, global market-driven production and intensified industrialization lead to unsustainable consumption with increasingly unhealthy, polluting and carbon-intensive lifestyle choices.

- Land transport has increased mobility but insufficient or ineffective public transport systems, and many poorly maintained old vehicles and a lack of integrated inspection, result in increasing vehicle exhaust emissions – gases and particulate matter (PM) from buses, private cars, trucks and motorcycles.

- Increasing air traffic and mobility due to rising incomes and the emergence of budget airlines in Asia and the Pacific. These contribute to higher transboundary emissions.

Key Messages

Air quality degradation and climate change driven by population and economic growth, transport, energy, agricultural demand and household consumption, are key issues in Asia Pacific.

- In Asia and the Pacific, there has been some reduction in emissions of Sulphur dioxide and Nitrogen oxides, but air pollution and Green-house gas emissions are high and continue to increase.
- Short-lived climate pollutants (SLCPs), Persistent Organic Pollutants (POPs), Polycyclic Aromatic Hydrocarbons (PAHs), and heavy metals are of particular concern to human health.
- In South and Southeast Asia, smoke haze pollution is the most important transboundary problem.

The impact of air pollution on human health is of great significance in Asia and the Pacific resulting in heart and chronic respiratory illnesses, cancer, increased morbidity, and premature deaths. In addition, indoor air pollution has been found to have gendered impacts leading to high lung cancer rates for women. Climate change and air pollution cause glacier retreat, contribute to ocean acidification, and increase the risk of vector-borne diseases throughout the region.

◀ Credit: Shutterstock/ Ethan Daniels

- Low fuel quality standards. Fuel qualities/standards in the Asia and the Pacific region remain lower than in other parts of the world, and are poorly regulated in many countries.

Concentrations of greenhouse gases such as carbon dioxide, methane and low-level ozone are increasing (Dlugokencky and Tans 2015; Akimoto *et al.* 2015). Ozone and black carbon are often considered local pollutants, but are also major climate change drivers. Other local air pollutants, such as sulphur dioxide (SO_2) and nitrogen oxides (NOx) can also affect the climate, and many sources of carbon dioxide and local air pollutants are the same, including vehicle exhaust, factory chimneys, energy and heating production.

In recent decades, carbon dioxide emissions have continued to increase, although they slowed in 2014. Carbon dioxide emissions increased in the top four emitting countries/ regions, which are responsible for more than 61 per cent of total global carbon dioxide emissions – China, 30 per cent; the United States, 15 per cent; the European Union, 10 per cent; and India, 6.5 per cent (PBL 2015).

High economic growth rates at aggregate and per person levels in Asia has led to the largest growth in per person emissions, despite the sub-region also having the highest efficiency improvements in emissions per unit of output (Blanco *et al.* 2014). In addition, population in Asia increased from 1.9 billion to 4.4 billion during 1970–2014, while purchasing power parity (PPP) adjusted gross domestic product (GDP) has also showed a six-fold increase over the past four decades in the sub-region. Most of the emission growth is from fossil fuel combustion and industrial processes. Nevertheless, global per person food availability and consumption of animal products also increased, particularly in Asia (FAO 2014b).

Another driver of air pollution is natural disasters, such as droughts, volcanic eruptions and sand storms that cause damage, especially in dry and desert regions every year. Sand and dust storms have resulted in significant financial damage and loss of lives in many Asia and the Pacific countries, including Australia and New Zealand. Larger storms are generated when long-term droughts occur, completely drying the soil surface and then wind velocities rise.

2.1.3 Pressures

Transboundary smoke-haze pollution caused by improper land-use practice

Transboundary smoke-haze events in Southeast Asia, caused mainly by extensive vegetation clearing, such as the uncontrolled biomass and peat burning in Borneo, Sumatra and Cambodia, Myanmar, Thailand and Vietnam, are of major concern both regionally and globally due to their wide-ranging economic, climatic, ecological and public health effects (Pentamwa and Kim Oanh 2008; Heil and Goldammer 2001). The 1997–1998 wildfires in Indonesia, for example, resulted in economic losses of more than USD9 billion, of which almost USD150 million was for additional health costs, while losses in tourism amounted to more than USD100 million (Bappenas 1999). The region's economic cost during the latest Southeast Asian wildfires in 2015, another El Niño year, was estimated to exceed USD16 billion (World Bank 2015).

Overuse of water contributing to desertification and leading to sandstorms

Dust storms are a recurring phenomenon in Northeast (Northern China, Korea. Mongolia) and South Asia (Iran). Such storms are a particular problem in the eastern provinces of Iran, which are most affected by water shortages and frequent droughts (Rashki *et al.* 2015).

Northeast Asian dust events normally occur in spring (March through May). Most particles of Asian dust are in the respirable range of particulate matter, up to 2.5 micrometres in size ($PM_{2.5}$), and consist of soil or mineral particles coming mainly from severe dust storms in arid and semi-arid regions. A system to predict dust events is being developed in China, the Republic of Korea, Japan and other countries under the framework of the World Meteorological Organization (WMO 2016)

Improper waste disposal, leading to open burning and landfill fires

Uncontrolled dumping is still the main waste disposal method in the region (Section 2.6). A study in 2010 by the National Environmental Engineering Research Institute in India found that, in Mumbai, about 2 per cent of total municipal solid waste generated is openly burned on the streets, while 10 per cent is deliberately burnt in landfills, or ignited by landfill fires. These contribute not only to the atmospheric release of particulate matter, including black carbon, but also dioxins and furans which are considered persistent organic pollutants (POPs) with carcinogenic effects (NSWAI 2015).

2.1.4 State

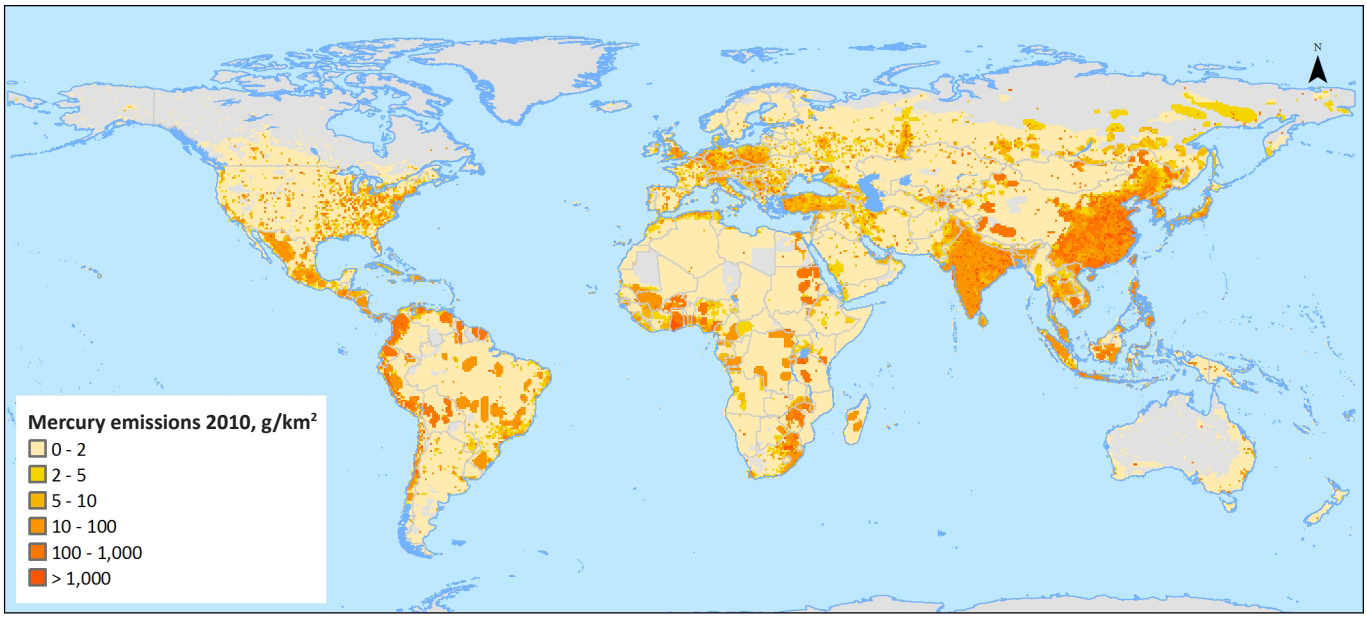
Short-lived climate pollutants

The World Health Organization (WHO) (2015) highlighted the urgent need to reduce emissions of black carbon, ozone and methane, the SLCPs that globally contribute to the more than 7 million premature deaths annually, while for the low- and middle-income countries in Western Pacific 102 deaths, and for Southeast Asia 51 deaths per 100,000 people were attributable to air pollution (WHO 2012). Traditional brick kilns and coke ovens are identified as the major sources, particularly in Asia, associated with adverse respiratory symptoms in Kathmandu, Nepal (Joshi and Dudani 2008), and, in Dhaka, Bangladesh, responsible for about 750 premature deaths each year (World Bank 2011).

Indoor air quality

Epidemiological studies of lung cancer in people who have never smoked have shown that the incidence of lung cancer in women in Asia is particularly high (Bruce *et al.* 2015). The impact of particulate matter on human health is attributed to exposure to environmental tobacco smoke, combustion products from indoor heating and cooking fuel, and cooking-oil fumes (Lan *et al.* 2012).

Figure 2.1.1: Global distribution of anthropogenic mercury emissions to the air, 2010



Source: UNEP 2013

Toxic air pollutants

These include mercury, POPs, lead, heavy metals, asbestos and carcinogenic hydrocarbons (benzene, Toluene, 1,3 Butadiene and polycyclic aromatic hydrocarbons). Asia was found to contribute almost half the anthropogenic emissions of mercury released globally to the atmosphere in 2010. Coordination and global cooperation in the monitoring, data sharing and model development are required to assess the future trends of atmospheric mercury (Ebinghaus *et al.* 2010).

Persistent organic pollutants have been of major concern in the Asia and the Pacific region. They have been extensively used in agricultural or industrial activities to support Asia's huge population and economy as well as to control malaria and pests, particularly in tropical areas. In addition, the unintentional production of POPs in chemical reactions or incineration, high temperature processes in industries and waste treatment has contaminated the environment and human beings. Since the Stockholm Convention on Persistent Organic Pollutants came into force in 2004, monitoring has been conducted in the Pacific, Northeast and Southeast Asia, but similar data are lacking for South Asia including Afghanistan (UNEP-Stockholm Convention 2015).

Currently Asia is the largest user of asbestos in the world, accounting for two-thirds of global consumption – more than 1 million tonnes per year. Despite the well-known detrimental effects of asbestos on the respiratory system, its use has continued in some countries. Asia's proportion of global asbestos use rose from 14 per cent in 1920–1970 to 64 per cent in 2000–2007. In 2011, almost 20 per cent of all asbestos production was in China, while most use was in China, India and Indonesia (Leong *et al.* 2015). So far, only Japan and the Republic of Korea are signatories to International Labour Organization's (ILO) Asbestos Convention (1986)

that commits to protect workers from potentially harmful occupational asbestos exposure (Le *et al.* 2011).

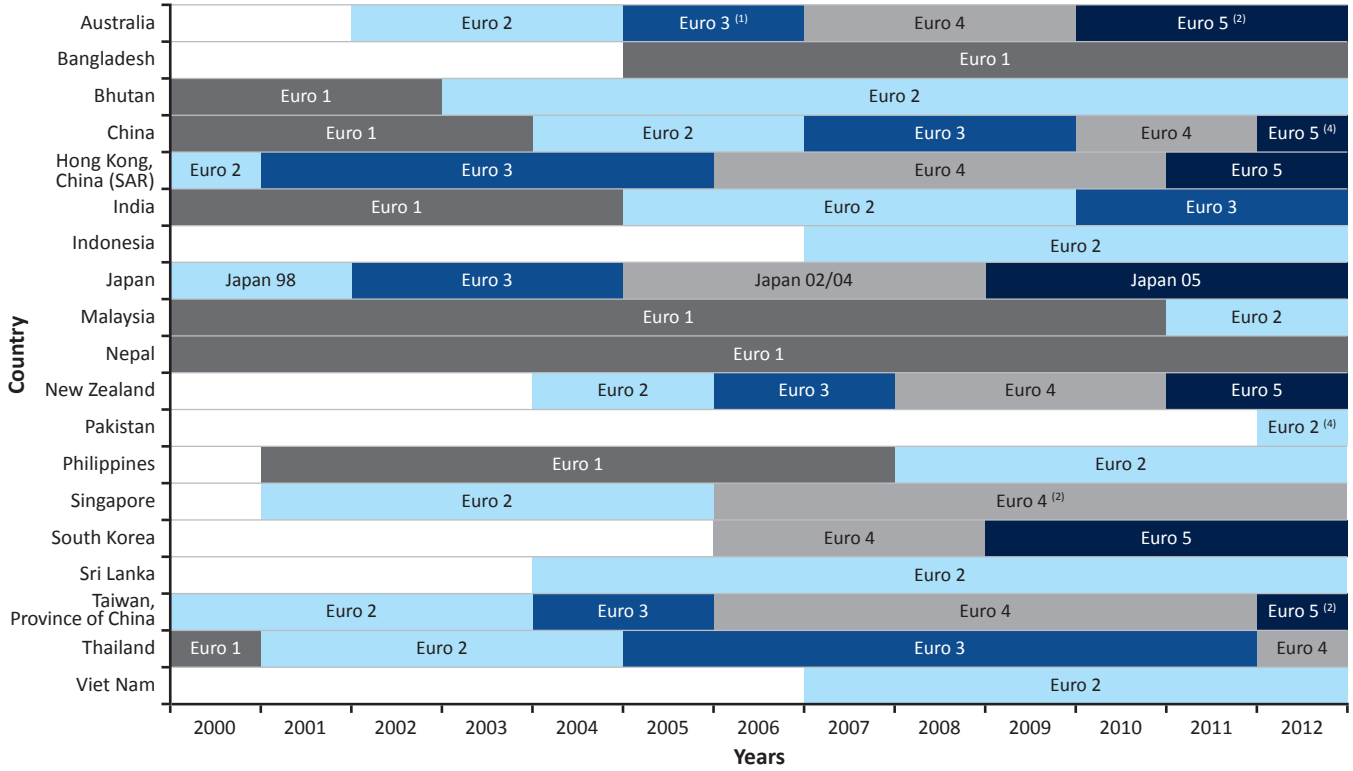
Regarding toxic air pollutants, there have generally been higher toxicity-equivalent concentrations (TEQs) due to polycyclic aromatic hydrocarbons (PAHs) in Asia and the Pacific than in Europe (**Table 2.1.1**). Estimates of the risk of exposure to these substances in Australia, China, India, Japan, Malaysia and Thailand have given rise to concerns over adverse human health impacts in the region (Pongpiachan *et al.* 2015).

Table 2.1.1: Toxicity equivalent concentrations in Asia and the Pacific and Europe

TEQ [ng/m^3]	Asia and the Pacific		Europe	
	Average	Standard deviation	Average	Standard deviation
Gas phase	4.51	5.48	2.54	5.54
$PM_{2.5}$	6.67	5.36	2.44	2.18
PM_{10}	3.67	3.10	6.65	13.07
Total Suspended Particulates	13.80	26.01	4.83	6.36

Source: Pongpiachan *et al.* 2015

Figure 2.1.2: Timeline of fuel quality standard evolution in Asia and the Pacific



(1) Gasoline vehicles only

(2) Diesel vehicles only

(3) Diesel vehicles only, gasoline and CNG vehicles at Euro 2

(4) Delayed

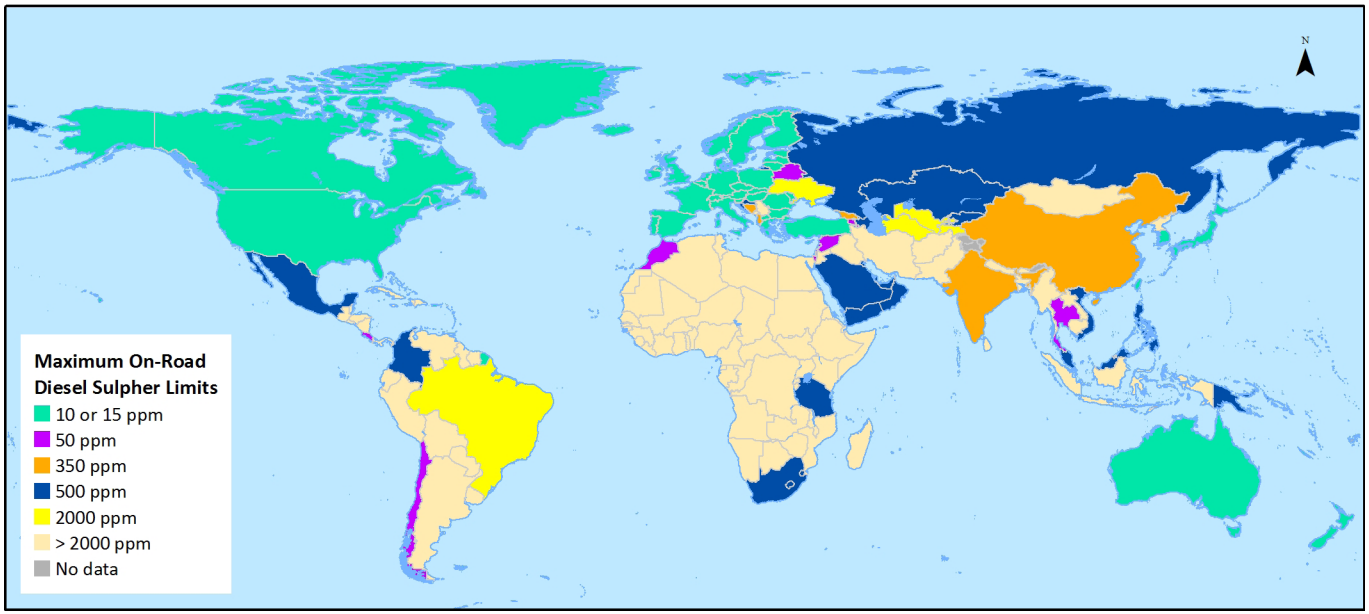
Source: Hart Energy 2016

Improved fuel quality, vehicle standards and fuel economy provide co-benefits by reducing both greenhouse gases and air pollution. These benefits come from not only gasoline and diesel, but also the alternative fuels, such as biofuels, liquid petroleum gas (LPG), compressed natural gas (CNG) and hydrogen fuel. Biofuels are not necessarily more eco-friendly, especially if they were derived unsustainably, for example through cultivating land cleared by burning. There is a need for more stringent standards and enforcement pertaining to biofuels in the region, and the evolution of standards has had different adoption timelines among the Asia and the Pacific countries (**Figure 2.1.2**).

Over the past decade, Asia and the Pacific has made progress in phasing-out leaded gasoline. By January 2016, all countries in Asia and the Pacific have made unleaded gasoline available (UNEP 2016). However, the situation for sulphur, in diesel and gasoline, is far more diverse (**Figure 2.1.3, Figure 2.1.4**). Some places, such as Australia, China, Japan and New Zealand have already adopted ultra-low sulphur diesel (50 parts per million (ppm)), while others are still far away from this. Few countries have announced a timeline for reducing sulphur in diesel to 50 ppm or less.

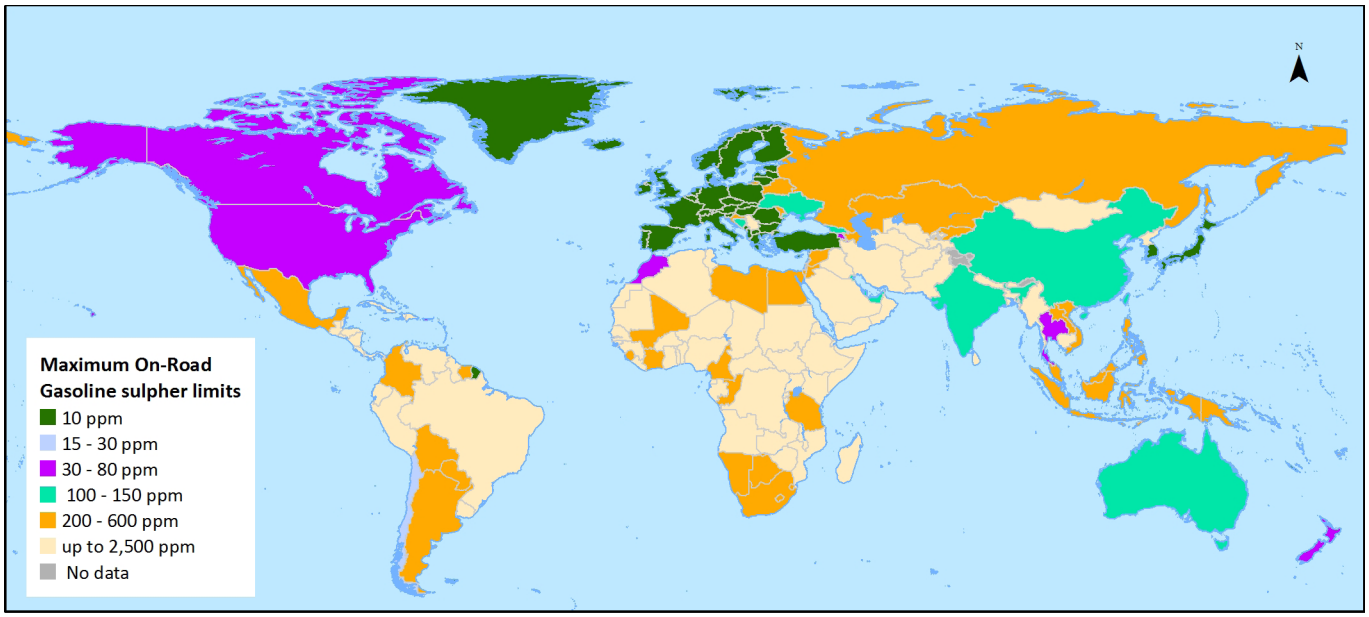
Biofuel trends in Asia and the Pacific have been highly variable, in blend and levels. Ethanol and biodiesel have been produced and is in high demand in Indonesia, while biodiesel is popular in Thailand, and ethanol has been promoted in India. The quality of these fuels needs to be controlled as, although sulphur is not the issue, volatile organic compounds (VOCs), which are ozone precursors, can be a concern. Research on the impact of these alternative fuels on air quality is still underway, despite alternative fuels being key in the Kyoto Protocol's Clean Development Mechanism (CDM).

Figure 2.1.3: Diesel sulphur limits in Asia and the Pacific and globally



Source: Hart Energy 2016

Figure 2.1.4: Gasoline sulphur limits in Asia and the Pacific and globally



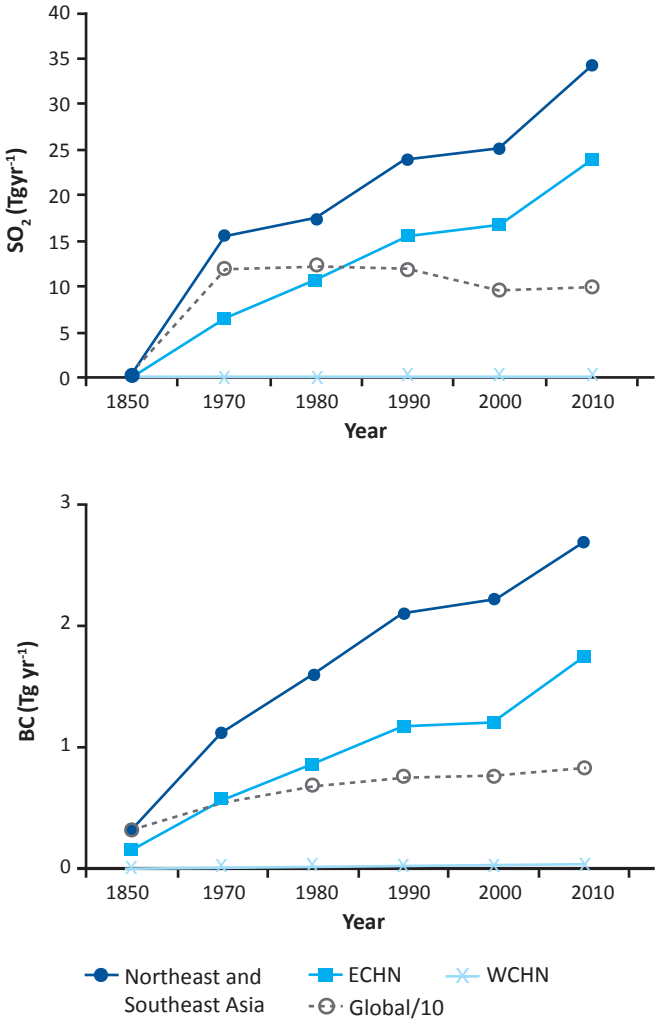
Source: Hart Energy 2016

Ambient air quality assessment relies on monitoring data. There are more than 400 ground-monitoring stations in continental Asia, Australia and New Zealand (World Air Quality 2015). There is, however, a lack of a consistent monitoring framework for the Pacific Islands, and this limits the ability to obtain an accurate and up-to-date state of the atmospheric environment as well as the trends over longer periods of time (SPREP 2012b).

Sulphur dioxide emissions, at least in Northeast and Southeast Asia, have increased continuously from about 0.4 teragrams (10^{12} grams) per year in the pre-industrial period (1850) to about 34.1 teragrams in 2010. Black carbon emissions in East Asia increased continuously during 1850–1980, slowed during 1990–2000 and accelerated again in 2000–2010. Black carbon emission was 0.3 teragrams per year in 1850, increasing to 2.7 teragrams in 2010 (Li *et al.* 2013) (**Figure 2.1.5**).

Satellite aerosol optical depth (AOD) measurements, available from the US National Aeronautics and Space Administration (NASA) satellites since 2000, indicate seasonal trends in particulate matter over the Asia and the Pacific region. The dataset continues to provide the most comprehensive view of atmospheric aerosols, although research is currently underway to improve the algorithms and compare satellite data with ground-based measurements to provide more reliable monitoring, particularly in Asia and the Pacific.

Figure 2.1.5: Emission of sulphur dioxide and black carbon in selected Asian sub-regions, 1850–2010



Notes: Northeast and Southeast Asia (solid dots), eastern China (ECHN, solid squares), western China (WCHN, solid crosses) and global (dash circles) emissions (anthropogenic+biomass burning); global emissions are scaled by 1/10.
Source: Li *et al.* 2013

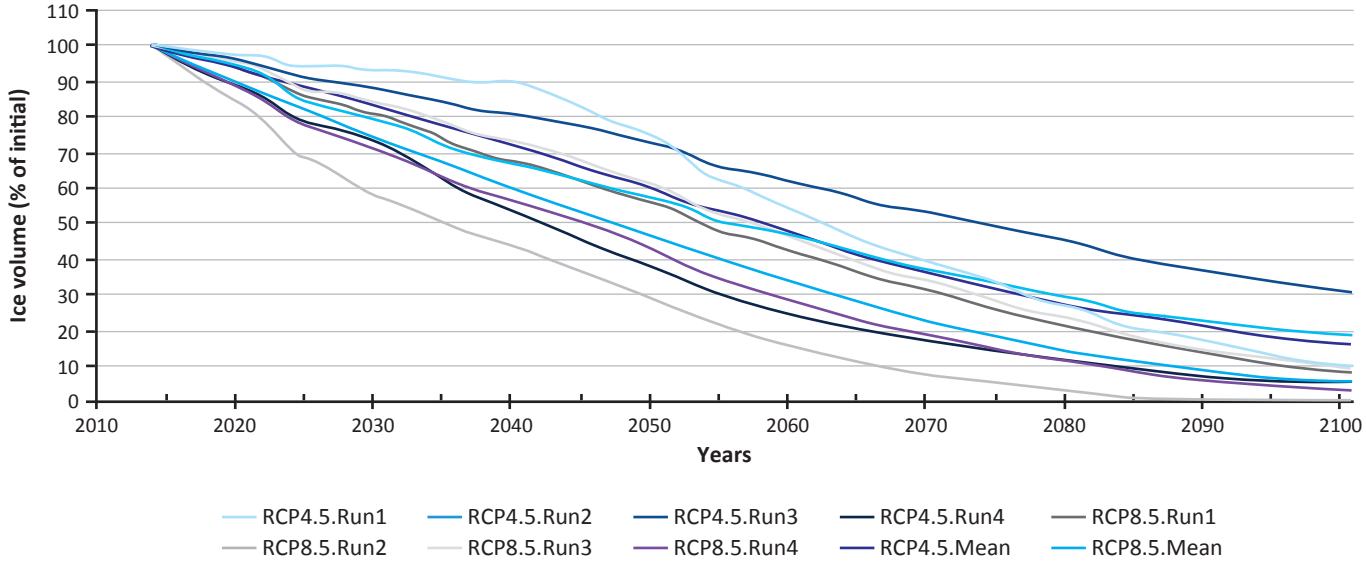
Significantly increasing levels of tropospheric nitrogen dioxide (NO_2) were clearly observed above the eastern regions of China during 1996–2012 through satellite observations retrieved from the Global Ozone Monitoring Experiment (GOME), Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY), and NASA Ozone Monitoring Instrument (OMI) (Lalitaporn *et al.* 2013). However, the sulphur dioxide (SO_2) columns in China have been decreasing since 2008 (Yan *et al.* 2014).

Ozone and black carbon measured at the Nepal Climate Observatory-Pyramid (NCO-P) at 5.1 kilometres above sea level in the Khumbu valley of the Himalayas (Bonasoni *et al.* 2008) were found to have been transported to the site in the pre-monsoon period, according to a back-trajectory analysis, linked to continental outflow from Eurasia with an upper troposphere/lower stratosphere influence. In mid-June, ozone and black carbon were transported to the site from closer anthropogenic sources to the east, near the India-Pakistan border (Dentener *et al.* 2010).

Glaciers in the Everest region of Nepal have been found to be highly sensitive to climate change, particularly due to black carbon, through a glacier mass balance and ice redistribution model study (**Figure 2.1.6**). Modelled glacier area change between 1961 and 2007 is –101.0 ± 11.4 square kilometres, a decrease of approximately 20 per cent from the initial extent. Application of temperature and precipitation anomalies from warm/dry and wet/cold end-members of the CMIP5, RCP4.5 and RCP8.5 ensemble results in sustained mass loss from glaciers, which means that glacier volume in the Everest region may be reduced by between 70 and 99 per cent by 2100 (Shea *et al.* 2015).

The changing pattern and frequency of Asian monsoons is also being watched closely by researchers (NCAR 2015). The Indian summer monsoon is shifting westward, impacting the variability of rainfall and the onset of monsoons in Southeast Asia. This is projected to be delayed for 15 days and will have increasing impacts on financial, infrastructure and food security in the region (Loo *et al.* 2014).

Figure 2.1.6: Sensitivity of modelled glacier volumes to temperature and precipitation anomalies, 2015–2100



Source: Shea et al. 2015

Warming of at least 0.85°C has been reported for the globe (IPCC 2013) since pre-industrial times. Asia and the Pacific has witnessed rapid warming since the 1970s (**Figure 2.1.7**), but there is no clear trend in precipitation anomalies over the region (NOAA 2015).

2.1.5 Ambient air quality

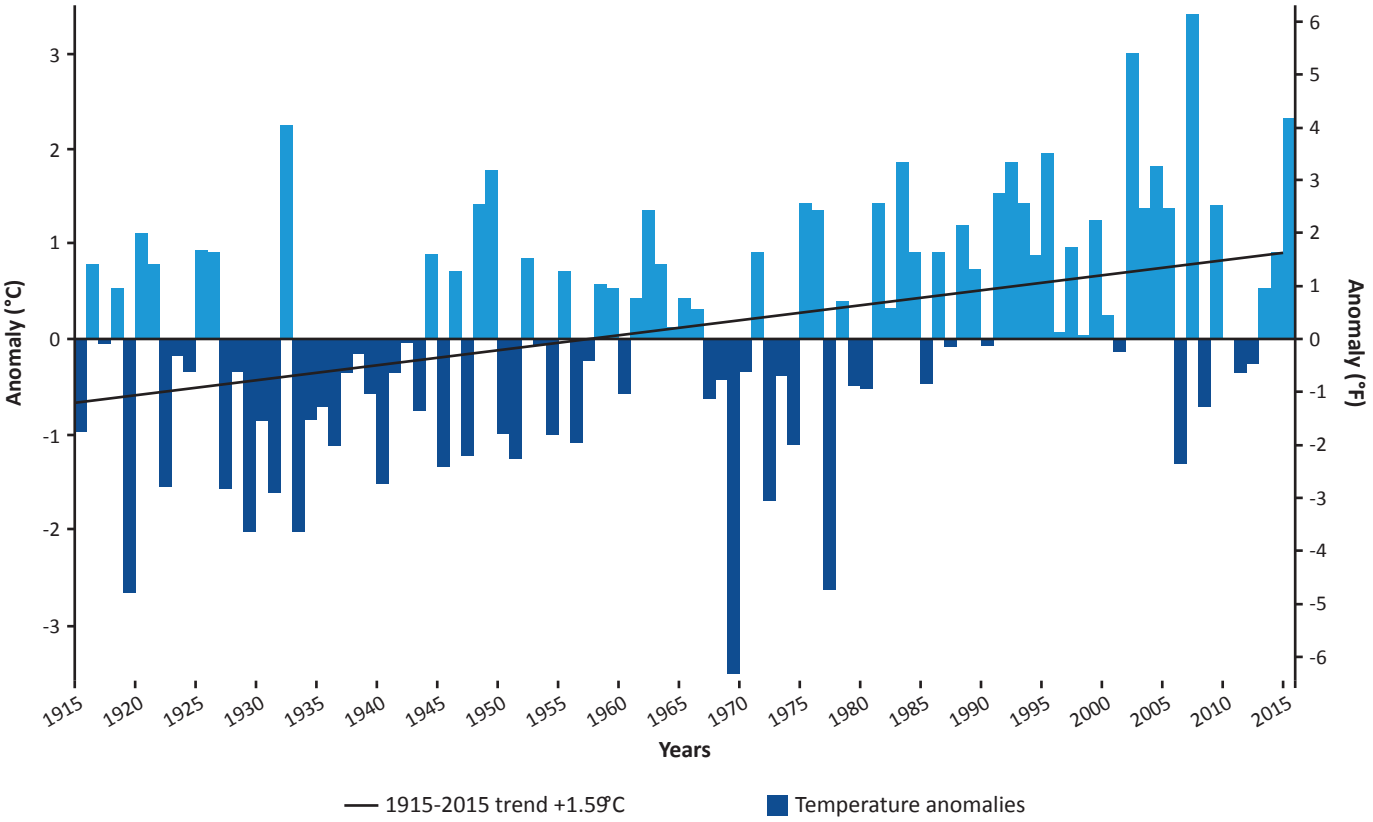
Particulate matter

Particulate matter (PM_{10}) is a major air quality problem in Asian urban areas (CAI-Asia Center 2010). Long-term measurement in China, Japan, Republic of Korea and Thailand in 2000–2013 showed exceedances of the annual WHO air quality guidelines of 20 micrograms per cubic metre (µg/m³) (**Figure 2.1.8**). Measurements in 2013 in Indonesian cities indicated a similar situation, with a 24-hour average of 50 µg/m³. The WHO database also shows that 97 out of 117 cities having annual mean PM_{10} at or above 100µg/m³ are in Asian countries (WHO 2014a), and nine out of 10 megacities with the highest $PM_{2.5}$ are in Asia (**Figure 2.1.9**).

Nitrogen dioxide

Nitrogen dioxide is a signature pollutant of fuel combustion. Measurements over 2000–2013 in some Northeast and Southeast Asian cities showed that in China, Indonesia and Thailand the annual concentration exceeded WHO air quality guidelines. The increasing trend in fuel consumption has been reflected in the long-term measurement of nitrogen dioxide. In Indonesia, there is a significant rising trend of + 0.002 parts per million per year, as monitored by the Meteorology, Climatology and Geophysical Agency (Republic of Indonesia, Ministry of Environment 2014).

Figure 2.1.7: Land temperature anomalies over Asia, 1915–2015



Source: NOAA 2015

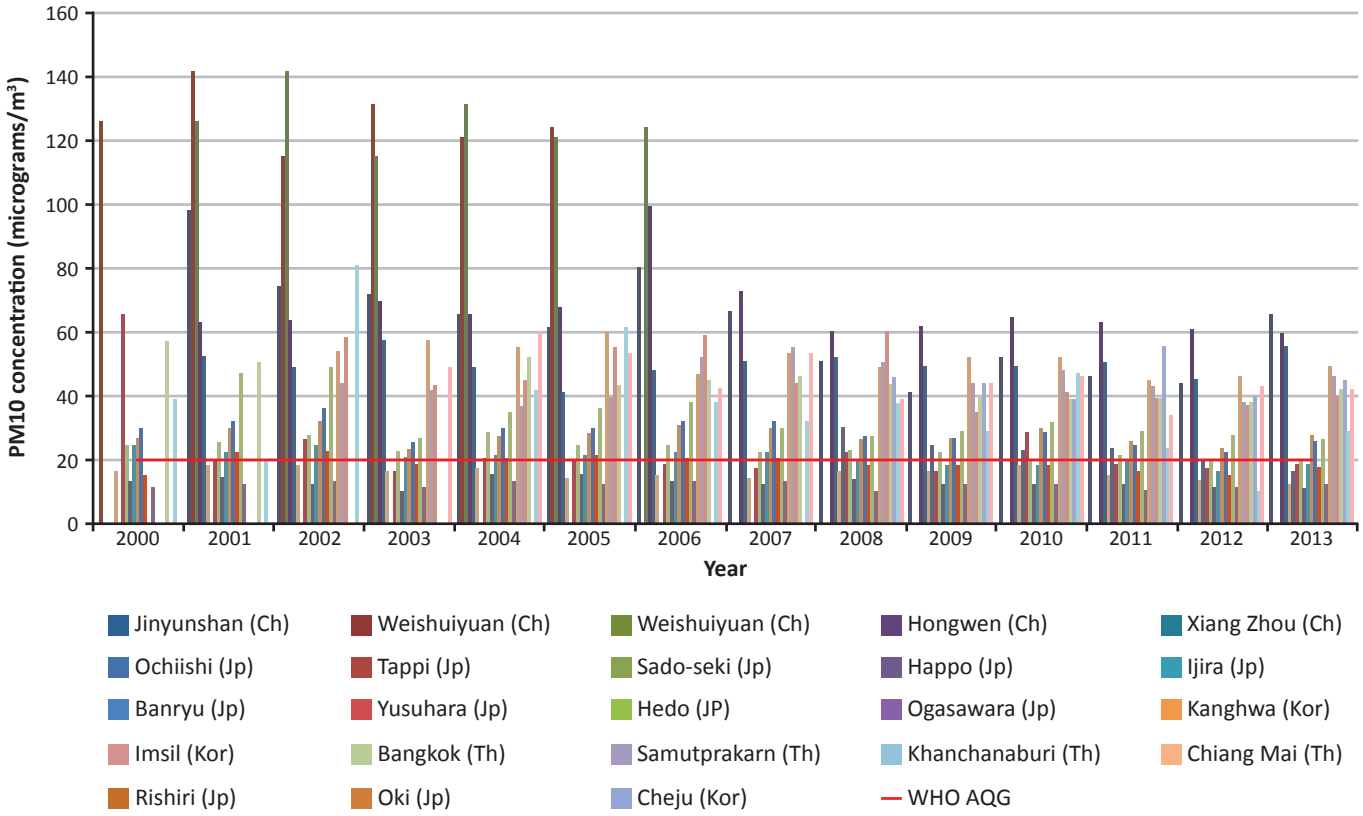
Sulphur dioxide

Sulphur dioxide originates from the sulphur content in fuels such as coal and diesel oil. Its concentration in urban areas is generally low. Data from 1993–2007 showed falling concentrations in Asia, though in some cities concentrations were found to be above WHO air quality guidelines (CAI-Asia Center 2010). Measurements in Jakarta (2003–2013) found a generally low concentration, although a small increase was observed in the annual average (Republic of Indonesia, Ministry of Environment 2014).

Ozone

In Northeast Asia, there is a puzzling increase in annual average ozone in spite of a decrease in its precursors – nitrogen oxides and non-methane hydrocarbon. These levels were observed in China, Japan and the Republic of Korea in 1999–2010 (Akimoto *et al.* 2015) (**Figure 2.1.10**).

Figure 2.1.8: Annual average PM_{10} concentrations in cities of China, Japan, Republic of Korea and Thailand



Source: EANET 2015

2.1.6 Impacts

Human health impacts include increasing climate change-induced diseases, exacerbating vector-borne diseases, heart and respiratory illnesses (chronic), cancer, strokes, increased morbidity, premature deaths and health costs. Chronic exposure to air pollution is an important risk factor for cardiovascular diseases (Yamamoto 2014). The WHO found that the 3.7 million premature deaths globally attributable to outdoor air pollution, 2.67 million, 72 per cent, occur in Asia and the Pacific (WHO 2014). This estimate reflects the very significant role of air pollution in cardiovascular illness and premature deaths.

Recent studies have documented the on-going impacts of climate change on terrestrial ecosystems. Observations suggest that climate change is causing many species, including plants, to shift their geographical ranges, distributions and phenologies at faster rates than previously thought (Staudinger *et al.* 2012; Chen *et al.* 2011).

Figure 2.1.9: Top ranking of $PM_{2.5}$ for cities in Asia

Country	SubRegion	City	Population (millions)	Average annual $PM_{2.5}$ (µg/m³) (WHO)	Rank
India	South Asia	Delhi	25.7	153	1
Pakistan	South Asia	Karachi	19.5	117	5
Bangladesh	South Asia	Dhaka	17.0	86	23
Egypt	Africa	Cairo	18.4	73	34
Pakistan	South Asia	Lahore	11.3	68	43
China	Northeast Asia	Beijing	21.2	56	76
India	South Asia	Mumbai	23.1	45	142
India	South Asia	Bangaluru	10.2	45	148
China	Northeast Asia	Tianjin	10.6	44	169
India	South Asia	Kolkata	16.0	43	186
Brazil	Americas	Rio de Janeiro	14.4	36	259
China	Northeast Asia	Shanghai	24.8	36	261
Turkey	Europe	Istanbul	14.5	32	317
China	Northeast Asia	Guangzhou	12.4	32	331
Iran	South Asia	Tehran	13.4	30	354
China	Northeast Asia	Shenzhen	11.7	26	429
Mexico	Americas	Mexico City	21.6	25	461
South Korea	Northeast Asia	Seoul	25.6	22	523
Philippines	Southeast Asia	Manila	19.7	22	526
Russia	Europe	Moscow	16.5	22	550
Indonesia	Southeast Asia	Jakarta	20.0	21	569
Thailand	Southeast Asia	Bangkok	14.5	20	590
United States	Americas	Los Angeles	17.2	21	605
Brazil	Americas	Sao Paulo	21.2	19	623
Germany	Europe	Rhine-Ruhr	11.3	19	650
France	Europe	Paris	10.7	17	749
Argentina	Americas	Buenos Aires	16.1	16	782
United Kingdom	Europe	London	15.5	16	830
Japan	Northeast Asia	Tokyo	37.8	15	841
United States	Americas	New York City	20.1	14	919
Japan	Northeast Asia	Osaka	20.1	9	1,251

Source: WHO 2014b

Climate change impacts on coastal zones and infrastructure have been recorded in the past 20 years in some Pacific island countries and territories. The islands have been heavily modified and intensively developed, significantly increasing their vulnerability to natural climatic variability, extreme events and global climate change. So far, ocean acidification has not been recorded around Pacific island countries and territories due to a lack of experiments to demonstrate links between ocean acidification and coral destruction or other possible impacts (SPREP 2012b).

Crop productivity is highly sensitive to the distribution of rainfall during the cropping season. Expected intense rainfall during the harvest or post-harvest stage is extremely damaging to crops and hence the livelihoods of farmers. There is also an increased probability of drought, especially over the semi-arid regions of India (IMD 2010).

In central China, trends in mean and extreme values for temperature and precipitation over the Loess Plateau between 1961 and 2011 were found to be statistically

Figure 2.1.10: Trends in atmospheric ozone in Japan, 1990–2010 – TMA is Tokyo Metropolitan Area, NA is Nagoya Area, OKA is Osaka/Kyoto Area and FA is Fukuoka Area

Source: Akimoto 2015

significant in almost all regions. Warming rates increased from the southeast to the northwest of the plateau, while the total amount of precipitation on wet days decreased over a large area, particularly in the southeast region. Overall, when both temperature and precipitation changes were combined, the southwest of the Loess Plateau has undergone the largest degree of climate change (Sun *et al.* 2015).

2.2 Land

2.2.1 Introduction

Land plays an important role in human wellbeing and preserving land resources in their best condition is of paramount importance for the Asia and the Pacific region. Despite several interventions to conserve them, land resources are continuously put under pressure by rapidly

Key Messages

Land use changes in the Asia Pacific region are driven by population increases and changing demographic and economic conditions. However, issues related to access to land resources associated with land tenure and rights to access contributes to growing income and gender inequality throughout the region with serious implications for how land resources are managed.

- The total forest area has shown a continuous increase in Asia since 1990, although there are sub-regional differences. Wetlands are also under pressure, with notable losses in Northeast and Southeast Asia.
- Soil resources are significantly impacted by deforestation, overgrazing, conversion of rangelands and forests to palm oil production and other uses. Soil pollution, soil erosion, desertification, and salinization have impacted the agricultural suitability of land.
- Land degradation has additional implications for water resources in terms of soil water content and groundwater recharge.

Direct impacts of large-scale land-use changes include displacement of indigenous people, loss of biodiversity, reduction in important forest products and increasing gender inequality associated with land tenure and access. Land degradation induced migration is projected to increase in Asia.

emerging social, demographic and economic changes in the region. This section is organized following the drivers, pressures, state and trends, and impacts (DPSI) framework (**Figure 2.2.1**) and responses are dealt in Chapter 3 of this report.

2.2.2 Drivers

Chapter 1 of this report provides a description of drivers acting in the Asia and the Pacific region and several of these affect the land resources. Only significant drivers are listed here in order to avoid repetition.

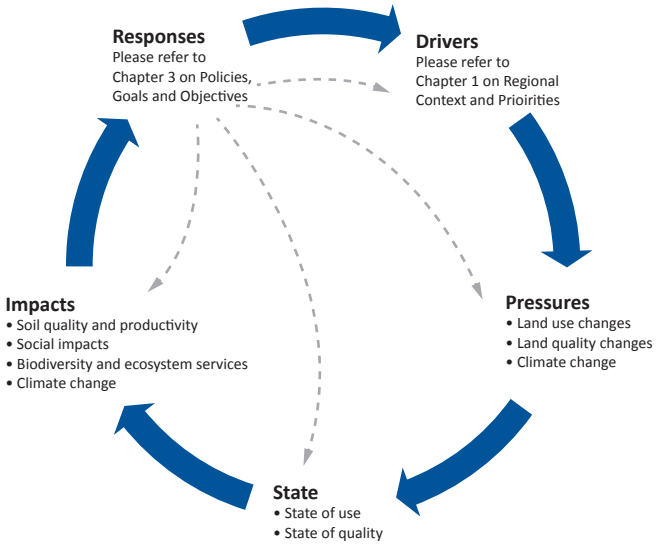
1. Population: the region has witnessed a rapid growth in population in the past several decades. Regional differences include rapid population growth in developing countries and stagnation or decline in developed ones.

2. Globalization and regional integration: Asia and the Pacific has participated actively in globalization, with many manufacturing and service sector activities moving to the rapidly developing Asia, providing immense economic opportunities for millions of people. In addition, regional integration has had a strong beginning in the last decade.

3. Economic growth: countries have introduced policies paving the way for rapid economic development and inclusion of populations in the economic growth of the region. Consequently, there was a significant growth in the proportion of the middle class in most developing Asian countries.

4. Living standards: the region has witnessed poverty reduction, access to healthcare and education, reduction in hunger and malnutrition, better transport and communication facilities and improved access to water and sanitation facilities. Change in people's dietary preferences has influenced the way that food is produced and consumed in the region.

Figure 2.2.1: Asia and the Pacific, summary of drivers, pressures, state and trends, and impacts on land resources



Source: UNEP

2.2.3 Pressures

The growing human needs discussed in Chapter 1 and highlighted in 2.2.2 of this section have exerted pressures on land resources since the needs in the region are being met through unsustainable means. The major pressures on land include residential and commercial development in the form of agriculture, urbanization, aquaculture, energy production, mining, transport and development of biological resource use including species extraction, service corridors, deforestation and related land-use changes, human intrusions and disturbance including for recreation, pollution, geological events, and climate change (Baldwin 2010; Salafsky *et al.* 2008).

Quantifying the human pressure on land is difficult because of the quality and fragmented form of the data, the complexity of interactions between pressures, and the continuous evolution and lack of understanding of manifestations of these pressures under different conditions (Geldmann *et*

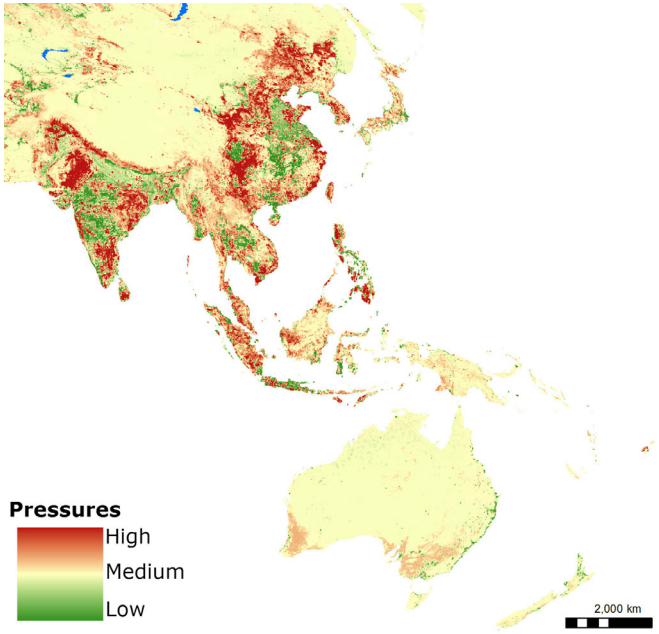
al. 2014; **Figure 2.2.2**). In general, human pressures on land in the region are rising continuously. In terms of sub-regional trends, Southeast Asia followed by Euro-Asia are experiencing the largest increase in human pressures (Geldmann *et al.* 2014), in particular in the protected areas in Southeast Asia. These protected areas are reportedly being affected by multiple pressures including agricultural conversion, urban expansion, invasive species and water related threats (UNEP-WCMC 2014). Table 2.2.1 gives a concise view of the sub-regional diversity in the state and trends associated with land resources.

Need for food

Food production exerts one of the important pressures on land in the region. Asia produced 1.34 billion tonnes of cereal grains in 2013 (FAO 2015c) but food demand by 2030 is projected to rise as a result of population increase, rapid urbanization and increasing incomes (FAO 2009). At the current level of growth in food productivity, the region will probably face food shortages without expanding its agricultural areas or by further vertical intensification, which could exert pressure on land resources. Efforts to meet ever-growing food demand are already exerting pressures on agricultural soils, resulting in erosion, salinization, acidification, compaction and pollution.

Changing dietary patterns has implications for land resources. Asia's growing middle class food preferences have led to diversification of diet from cereals to meat, dairy products, fruits and vegetables (ADB 2013). The livestock population and meat production in Asia increased by 22 per cent and 50 per cent respectively between 2000 and 2013 (FAO 2015). By 2030, global annual consumption of beef and poultry is expected to increase by 25.4 and 60.3 million tonnes respectively compared to 2000, with almost half of the increase occurring in Asia (FAO 2011a) with implications for land for fodder.

Figure 2.2.2: Asia and the Pacific, increase in human pressure on land resources



Source: Geldmann *et al.* 2014

The Asia and the Pacific region has experienced substantial agricultural intensification while expansion of arable land has been minimal. This has been made possible by an increasing use of chemical fertilizers and pesticides in agriculture. By region, Northeast Asia followed by South Asia together are the heaviest users of fertilizers at 445 and 150.38 kilograms per hectare respectively (FAO 2014). Pesticide use, in terms of active ingredients, has decreased in China, India, Japan, the Republic of Korea and Viet Nam but increased in countries such as Australia, New Zealand, Pakistan and Thailand (FAO 2015). These land management trends may have helped the region in limiting the real expansion of agriculture to an extent; however, these trends, especially the over use of chemical fertilizers, may have contributed to a gradual decline in agricultural land quality through soil compaction, pollution, nutrient imbalance, salinity and acidity (Nkonya

Table 2.2.1: Asia and the Pacific, sub-regional coverage of land-related state and trends

Sub-region	Major sub-regional Issues	Trend	Severity of issue	Critical threshold
Northeast Asia				
	Net forest change	&	***	O
	Urbanization	&	****	---
	Land tenure	"	****	---
	Biodiversity and ecosystem services	(	****	---
	Desertification	&	****	X
	Dust storms	&	****	O
	Rangeland degradation	&	****	O
	Area under agriculture	(	**	X
	Agricultural land quality	(	****	X
South Asia				
	Net forest change	"	***	O
	Urbanization	&	***	O
	Biodiversity and ecosystem services	(	****	O
	Desertification	&	***	O
	Dust storms	&	****	O
	Land tenure	S	***	---
	Area under agriculture	(	**	X
	Agricultural land quality	(	****	Y
Southeast Asia				
	Net forest change	(	*****	O
	Urbanization	&	***	O
	Area under agriculture	&	***	O
	Biodiversity and ecosystem services	(	****	O
	Agricultural land quality	(	**	X
The Pacific				
	Net forest change	(	**	O
	Biodiversity and ecosystem services	(	****	O
	Land tenure	"	***	---
	Agricultural Land quality	(	****	X
Australia and New Zealand				
	Net forest change	(	**	X
	Biodiversity and ecosystem services	(	**	X
	Agricultural land quality	(	**	X

Source: UNEP

Note: All trends the above are based on the authors' expert judgement from the trends in the literature reviewed
Trends: & Significantly increasing; (Significantly decreasing; " no significant change; S Trend not clear
Severity: * Not severe; ** Moderately severe; *** Somewhat severe; **** Very severe; ***** Extremely severe
Critical threshold: indicates whether the issue is difficult to return to normalcy without substantial efforts on a priority basis, the level of trend beyond which reverting to previous conditions is difficult with the current level of knowledge and resources to address the issue.
X Not yet; O Yes; --- High potential to become critical if not addressed soon.

et al. 2016). As a result, declining productivity of agricultural land, reported in parts of South Asia, needs to be addressed through sustainable agricultural land management practices (Kumar *et al.* 2008).

Need for fuel

The Asia and the Pacific region is witnessing a rapid growth in demand for fuel, and part of the demand has been met from biomass in rural areas and from biofuels in the transport sector (Elder *et al.* 2008). In 2009, bioenergy accounted for nearly 15 per cent of the total primary energy supply in Asia (FAO 2009). The residential sector, mostly rural, accounts for 88.7 per cent of the biomass consumption for energy purposes, followed by the industrial, commercial and transport sectors. The region has seen a significant expansion of area under oil palm plantations, with largest expansion observed in Indonesia (3.7 times the area in 2014 compared to 2000), Malaysia (1.5 times), Philippines (3.4 times) and Thailand (2.9 times) (FAO 2015). This rapid expansion is putting pressure on some of the fragile forest and peatland ecosystems in oil-palm producing countries (Colchester and Chao 2011).

Income inequalities and land tenure

The region has witnessed growing income inequalities, with implications for land resources. The population-weighted mean Gini coefficient, a measure of inequality of income or wealth, for the entire region rose from 33.5 to 37.5 between the 1990s and the 2000s. Income inequalities are also evident between urban and rural areas, between women and men, and between groups of different caste, ethnicity and language (UNDESA 2014). For example, the women owned far less land than men in South Asia compared to many other parts of the world (FAO 2016) and these differences have significant implications in terms of how the land is managed and who gets benefits with direct impact on women empowerment and gender inequality (FAO 2011a). Income inequality has a significant effect on land tenure and land rights (Kanbur *et al.* 2014), the ownership and access to land has also become concentrated among richer sections of society, with environmental and socio-economic implications and affecting how the land is put to use. Poor development of land tenure and land rights could have a significant impact on who owns the land, how it is used and its productivity (Ghatak and Roy 2007; Lawry *et al.* 2014).

Growing demand for wood products

The region has seen a staggering growth in the demand for wood and forest products, such as paper, furniture, construction materials and services. Asia consumed 440.1 million cubic metres of industrial roundwood in 2013 (FAO 2015c), and demand for wood and related products is projected to rise by 2100 (WWF 2011). To meet the growing need, Asia's industrial roundwood production rose 137 per cent from 2006. This was insufficient, however, to meet demand and the region imported 64.5 million cubic metres of industrial roundwood in 2013. India and China account for about 80 per cent of the global import of tropical hardwoods while also being significant exporters of wood products.

China's rapid economic growth has had profound effects on the forest economies of Asia and the Pacific through demand for raw materials and exports of processed wood products (Katsigris *et al.* 2004). In 2010, 13 million hectares of tropical forests were cut down (FAO 2011a), but, despite a large demand for wood products, most of this was driven by the desire to cultivate commodities such as palm oil and beef production (Boucher *et al.* 2011). The Global Forest Products Model projects demand for different types of wood products through 2060, with increases in demand over 2010 consumption for construction timber, plywood and furniture as well as for paper products such as newsprint, tissues, cardboard and writing paper.

Urbanization

An estimated 120 000 people migrate to cities in Asia and the Pacific every day. The proportion of people living in urban areas is likely to rise to around 3.3 billion people, 63 per cent of the population, by 2050. Along with the land needs of urbanization, urban solid waste disposal through

landfills and the management of industrial hazardous waste have become major concerns (Pariatamby and Tanaka 2013). With the development of large manufacturing zones, the requirement for land for industrial units and associated infrastructure has also increased significantly. Often the expansion is being met by clearing forests or fallow lands in the outer zones of cities. Indeed, the Special Economic Zones (SEZ) and National Manufacturing Zones (NMZ) in several developing countries convert agricultural or forest lands. Land acquisition, sometimes on a large scale and with poor governance, is a growing phenomenon in the region.

Smaller cities, with fewer than 500 000 people, represent just over half the urban population (54.4 per cent) in Asia and the Pacific (UNDESA 2014). As a result, the proportion of land occupied by human settlements in urban areas is 2–3 per cent of the total land area in the region (Collins 2011) with consequences in terms of an increase in mean surface temperatures, soil pollution, deforestation and associated land-use changes including decline in agriculture land. With rapid urbanization and growing consumerism, the region generated 870 million tonnes of municipal solid waste in 2014 (Section 2.6), much of which goes into landfills that occupy a significant amount of land.

Climatic variability and change

Projected climate change in Asia and the Pacific could lead to a shortage of water resources, widespread land degradation and increased desertification. Impacts of climate change in the Asia and the Pacific region include changes in natural vegetation types and associated changes in ecosystems at higher elevations and latitudes (Mendelsohn 2011). Shang and Long (2005) listed climate change-induced glacial retreat among direct causes of grassland degradation, in particular an increase in erosion in high-elevation areas, *Kobresia*-dominated meadows of Tibet, China. Although retreating glaciers will have impacts on hydrology, particularly for downstream water users, it is unclear how the loss of glaciers will affect rangeland conditions. In addition, climate change could cause migration of coastal populations to inland areas, putting pressure on land resources there. In the Pacific islands, emigration could put pressure on land resources in other countries (Wyett 2014).

Overgrazing

Rangelands in Asia and the Pacific include China, India, Mongolia and parts of Australia spanning arid and semi-arid shrublands in southern and western Australia to tropical open woodlands in northern Australia (Smith *et al.* 2007). Development of infrastructure – roads, railways, pipelines and irrigation canals – disrupts movement patterns of livestock and wildlife and exacerbates the fragmentation of habitats. Increased transport facilities have opened new areas to livestock grazing, encroaching on undisturbed refuges in northern Tibet, China. The past century of grazing by sheep and cattle has brought about changes in environments, social systems and policies, spread across a vast geographical area.

Mining

Mining has been increasing in Asia and the Pacific (USGS 2012) with environmental consequences including degradation of land resources – Australia and China are among the world's leading mineral producers (Fong-Sum *et al.* 2014). Australia has large reserves of bauxite, coal, cobalt, copper, diamonds, gold, iron ore, lead, lithium, manganese, mineral sands, tantalum and uranium. China has large reserves including antimony, arsenic, barite, bauxite, coal, fluorite, gold, graphite, iron ore, magnesium, rare earths, strontium, tin, tungsten and zinc. India is also one of the world's significant mineral producers, with large reserves of barite, bauxite, chromium, iron ore, manganese, rare earths and salt. With growing demand for minerals, metals and energy resources, mining is projected to increase with severe environmental consequences for land resources (SNL 2015).

2.2.4 State and trends

Forests

The forests of Asia and the Pacific account for about one-fifth of the world's total and cover around 25 per cent of the land area of the region, or 722 million hectares (Wilkie 2009). **Figure 2.2.3** shows tree cover in the region (DiMiceli *et al*. 2011); forests show varying density, with high densities in Northeast and Southeast Asia. River basins such as the Mekong and Ganges show considerably higher tree-cover density than other parts of the region.

In general, the total forest area has shown a continuous increase in Asia since 1990 (FAO 2015c). Sub-regional trends differ. However it has increased in Northeast and South Asia but declined in Southeast Asia (FAO 2015a). The Northeast Asia sub-region has seen a continuing increase in forest area and carbon stocks. While deforestation continues, albeit at a slower rate, deforestation rates in Southeast Asia are higher than in other sub-regions. South and Southeast Asia showed the highest partial canopy-cover loss, a proxy for forest degradation. Despite the high deforestation rates and declining forest cover, South Asia reports a higher proportion of forest area covered by forest management plans than other areas, which may help to halt the decline in future (FAO 2015b).

Asia has 134 million hectares of privately owned forests and their area is increasing in the region, with Southeast Asia having highest proportion of privately-owned forests (FAO 2015a). Although much of the forest in the region is still publicly owned, the change towards private ownership, especially by individuals, could have serious implications in terms of how forests are sustained and managed in the future. Although significant areas of forests are under indigenous management which helps conserve forests for generations (WHRC and EDF 2015), it is alarming that indigenous people own the least amount of forest among all categories of ownership (FAO 2006), and the area is on the decline (FAO 2015a), with negative consequences on forest conservation.

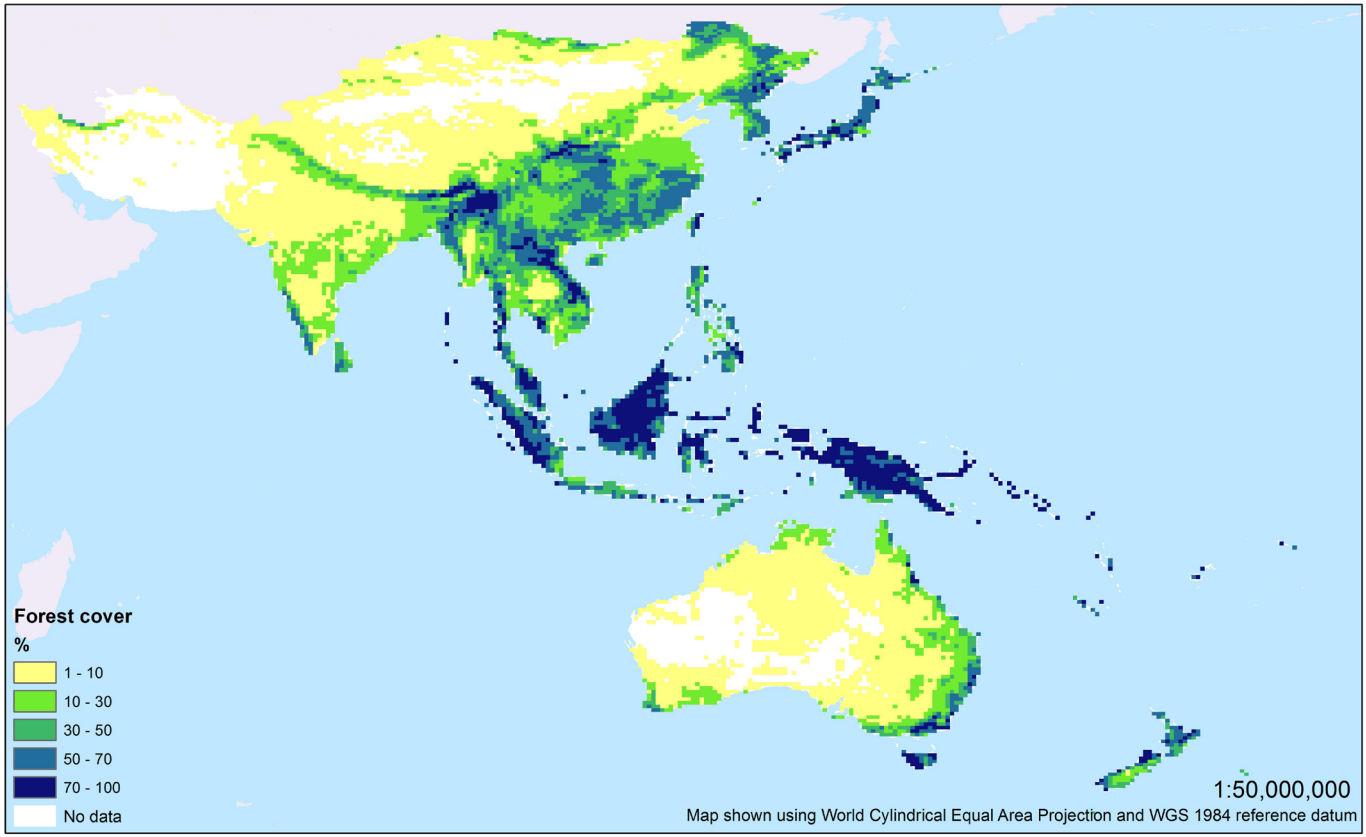
Poor tenure and rights to forest land, especially that of indigenous people, are considered to be one of the important factors contributing to deforestation and forest degradation and restoring tenure and rights to indigenous people is seen as a social, economic and political imperative (Sunderlin *et al.* 2008). Not all ecosystems are equally affected by the increasing population and environmental hazards, the Sundarbans mangrove forests of Bangladesh and India are known to continue to thrive with no major impacts in the past decade (UNEP-Stockholm Convention 2015).

Agricultural land

About 40 per cent of the world's agricultural land is in the Asia and the Pacific region, of which almost 31 per cent is arable, 4 per cent is used for permanent crops, and 65 per cent consists of permanent meadows and pastures. Regional differences exist: Southeast Asia has less farm land than other sub-regions, 20 per cent of the total land area of the sub-region, while Northeast Asia has the largest, more than 60 per cent, although a substantial reduction was observed a decade ago (FAO 2015c).

The region has experienced a significant expansion of agricultural land, from 47 per cent of the region's total land area in 1970 to 53 per cent in 2007 (FAO 2009), an average growth of 0.8 per cent a year compared to 0.1 per cent globally. The change in agricultural land areas has been driven by rapid economic development, technological advances, infrastructure programmes and population growth and mobility in the region (Schandl *et al.* 2009). In the past decade, however, expansion of agricultural land has been negligible (World Bank 2015), and actually decreased in some developed countries – Australia, New Zealand and the Republic of Korea –and in some developing ones – Fiji, Indonesia, Malaysia, Papua New Guinea, Samoa, Vanuatu and Viet Nam. In contrast, it increased in Bangladesh, Bhutan, China, India, Pakistan, Philippines and Thailand (Friedl *et al.* 2010) (**Figure 2.2.4**). Practices such as shifting cultivation continue to impact forest resources in Asia. Land tenure requires urgent attention in the region as little significant improvement has been achieved despite ongoing

Figure 2.2.3: Asia and the Pacific, tree cover, 2010



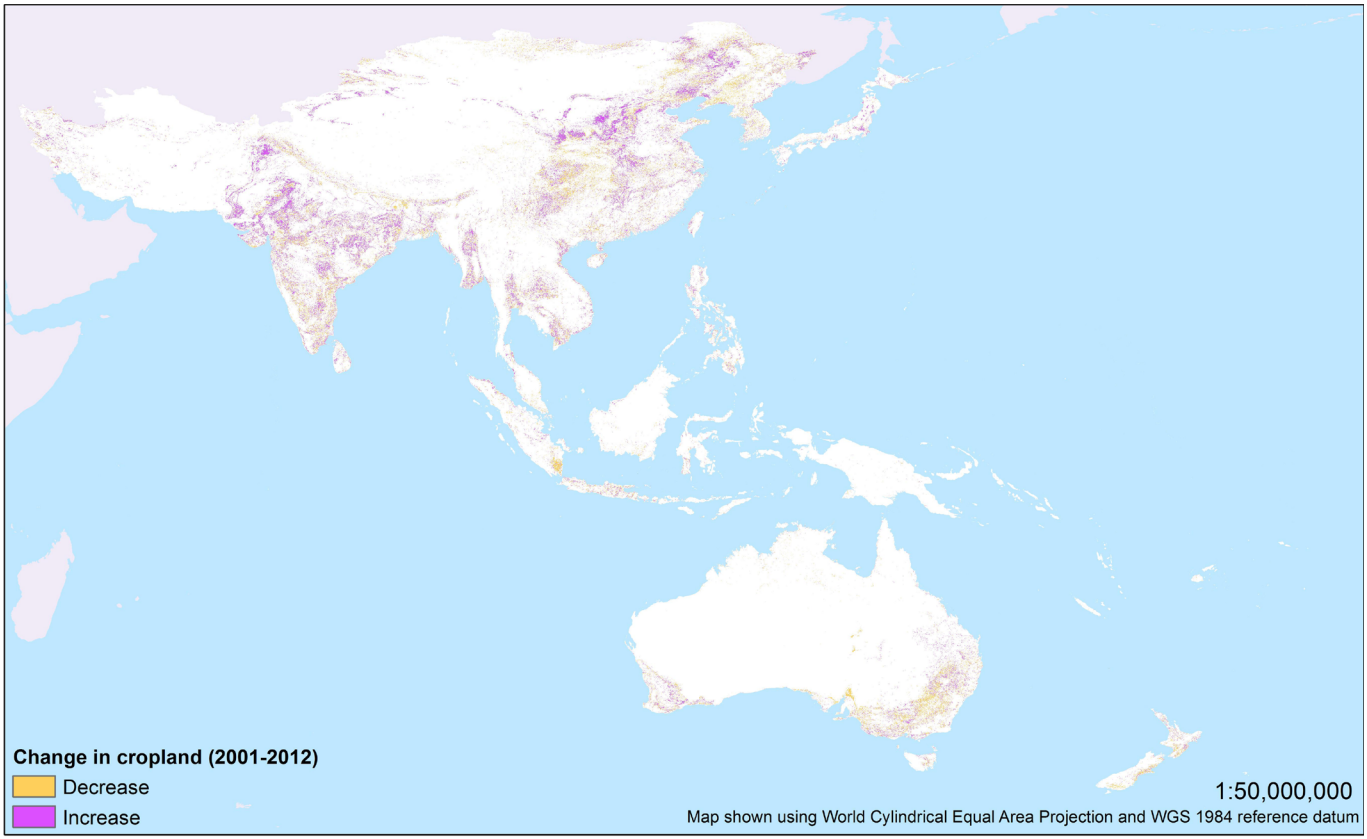
Source: DiMiceli *et al.* 2011

land reforms and stalled improvements in land tenure will negatively impact land productivity (Lawry *et al.* 2014). The demand for agricultural land could grow in the future with estimates suggesting that expansion of area under agriculture would contribute to 20 per cent of the necessary food production increase by 2050 (FAO 2009).

Rangelands

In Asia, rangelands provide significant amounts of grazing for livestock and provide livelihoods for millions of rural communities – in Mongolia, for example, more than 80 per cent of the country's area is used by pastoralists (Reading *et al.* 2006). Rangelands cover about 40 per cent of the land area of China, or 400 million hectares, of which Tibet has the largest area followed by Inner Mongolia and Xinjiang (Sheehy *et al.* 2006). Nearly 70 per cent of the land area of Kazakhstan is rangelands but this has been in continuous decline over the past few decades because of conversion to agriculture, overgrazing, changing livestock management practices and other pressures including climate change.

Figure 2.2.4: Asia and the Pacific, change in cropland, 2001–2012

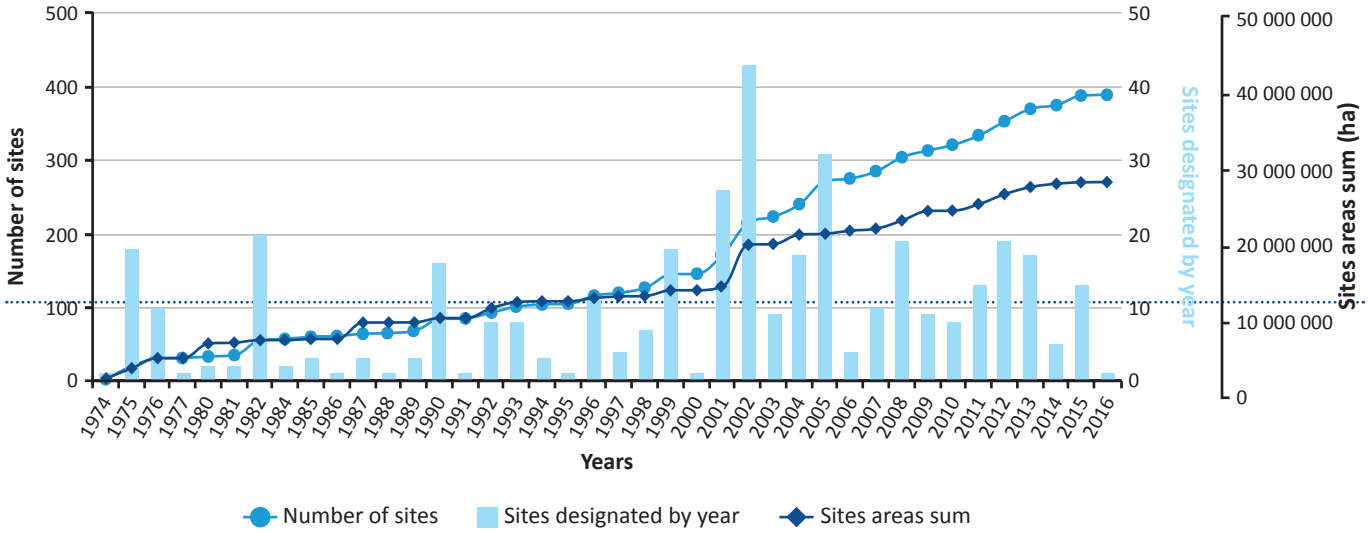


Source: Friedl *et al.* 2010

Wetlands

Wetlands constitute an important part of land ecosystems in Asia and the Pacific. In 2015, Asia had 302 sites registered with the Ramsar Convention on Wetlands of International Importance, of which Japan has the most, followed by China and India (Ramsar Convention Secretariat 2010). Southeast Asia has about 56 per cent of the world's tropical peatlands, and 42 per cent of the world's mangroves is found in South and Southeast Asia (Gopal 2013) (**Figure 2.2.5**). The inland wetlands under Ramsar protection constitute 1.4 million hectares in Asia and 0.68 million hectares in the Pacific. The rate of wetland destruction varies geographically, with notable losses in Northeast and Southeast Asia, running at 1.6 per cent per year. In places where aquaculture, overfishing and storm damage have been severe, the rate of destruction can be as high as 80 per cent.

Figure 2.2.5: Asia and Oceania, trends in Ramsar wetland sites, 1974-2016



Source: Ramsar Convention Secretariat 2010

2.2.5 Impacts

Impacts on soil quality and productivity

Land resources in the Asia and the Pacific region are significantly impacted by deforestation, overgrazing and conversion of rangelands and forests. Soil pollution, erosion and salinization need urgent attention. Erosion is prevalent in parts of India and in the north of China (FAO 2014). Significant areas in North and Central Asia (211.7 million hectares), South (84.1 million hectares) and Southeast Asia (20 million hectares) are salt-affected, because of the expansion of area under irrigation and the use of brackish water, and 10 million hectares are affected by soil compaction (FAO and ITPS 2015). In India, 11 million hectares are estimated to be affected by wind erosion, 6.98 million hectares by soil acidity and 6.7 million hectares are salt affected (ICAR and NAAS 2010). Nearly 20 million hectares are affected by heavy metal contamination in China alone (FAO and ITPS 2015) and the area of contaminated soil could rise due to increasing economic activity in the region. Heavy use of ammonia-based fertilizers is known to cause soil acidity in Northeast and South Asia (FAO and ITPS 2015). The combined pressures of climate change, land degradation and soil quality changes have mixed impacts on the agricultural suitability of land (Zabel *et al.* 2014).

Areas in Australia are projected to experience a net decline in agriculturally suitable land, while a few pockets in Southeast Asia will have an increase in agriculturally suitable land. Soil salinization is a major problem in semi-arid and arid zones, as well as in irrigated areas with poor drainage. Salinity costs global agriculture an estimated USD12 billion per year, and this figure is increasing (Pitman and Läuchli 2002). Land degradation has significant impacts on water resources especially in terms of soil water content and groundwater recharge. Forest fires can negatively impact the soil quality (Certini 2005) and given the increase in forest fires due to

multiple factors (Goldammer *et al.* 2004), these should be considered as an important pressure operating on soils in the years to come.

Urbanization and industrialization are increasing landfill-led land pollution. Although landfills are often designed to contain contaminants, using a bottom liner and a leachate collection system, leaks often occur and contaminants can reach surface and underground water bodies. Industries produce a variety of wastes hazardous to people and the environment including heavy metals (mercury, zinc and lead), and pesticides, for example, aldrin and dieldrin. The sources of these materials include industry, farmlands, commerce, hospitals, urban settlements and nuclear installations.

Social impacts

Nearly 12 per cent of the population lives in degraded areas of Asia and the Pacific (UNDP 2013), and this proportion may increase in years to come (Foresight: Migration and Global Environmental Change 2011) with significant social impacts. Direct impacts of large-scale land-use changes include displacement of indigenous people, loss of biodiversity and a reduction in important forest products. Land degradation has had severe impacts on human development in the region (Ahrends *et al.* 2015). Land conversion has often led to permanent deforestation, a decline in soil fertility and accelerated erosion (Van Vliet *et al.* 2012), and imperils associated livelihoods (Lindenmayer *et al.* 2012). Intensive land-resource use is resulting in several socio-physical impacts in the Hindu Kush Himalayan region. The link between environmental degradation and migration is widely acknowledged and land degradation is an important factor especially in short-term migration (Shah 2005). Land-degradation induced migration is projected to increase in Asia in the years to come (ADB 2012; Foresight: Migration and Global Environmental Change 2011). Large-scale land acquisition has also been emerging as an important driver of human migration and economic marginalization (Siciliano 2012).

Ecosystem services in the Koshi Tappu Wildlife Reserve, Nepal generate economic benefits of USD16 million per year, equivalent to USD982 per household (Sharma *et al.* 2015). Sound policy and institutional mechanisms exist to empower local communities to preserve these services and to allow them to benefit from doing so, but they are rarely implemented.

Biodiversity and ecosystem impacts

It is important to recognize the links between land-use change and degradation and its impact on associated biodiversity and ecosystem services. Land-use and related pressures have caused severe damage to local species richness in Asia and the Pacific (Newbold *et al.* 2015). Rangelands of Northeast Asia provide valuable ecological services and support the livelihoods of local herders on the Qinghai-Tibetan Plateau (Harris 2010), but they are being degraded by overgrazing, policy changes and climate change (Xiong *et al.* 2008). According to Visconti *et al.* (2015) several species on peninsular Malaysia and insular Southeast Asia are at high risk of extinction by 2050 as a result of projected impacts of land-use changes such as conversion to forest plantations and natural forest logging.

Desertification

Of the 2 billion hectares of drylands in Asia, more than half are affected by desertification. The increasing dust storms are attributed to wind-related desertification processes, resulting from human impacts in arid, semiarid and sub-humid regions of northern China (Wang *et al.* 2013). The Land Degradation Assessment in Drylands (LADA) project revealed persistently declining land productivity throughout 1981–2003 for 24 per cent of global land, mainly south of the equator, in Southeast Asia and south China, and north-central Australia (Bai *et al.* 2008). Countries in the Asia and the Pacific region rank among the highest globally, with the most affected being China (457 million hectares), followed by India (177 million hectares), Indonesia (86 million

hectares) and Bangladesh (72 million hectares). Sand and dust storms are common in subtropical latitudes and dry savannahs, and in the mid-latitude drylands. There is a significant relationship between drylands, dust storms and anthropogenic land disturbance. Major storms occur when prolonged drought causes the soil surface to lose moisture and there are strong winds.

2.3 Biota and ecosystems

2.3.1 Introduction

Biological resources and ecosystems are part of the resource base for sustainable development and a source of livelihoods of rural people in the Asia and the Pacific region. Rapid economic growth and an increasing population, accompanied by expanding agricultural and industrial activities as well as unsustainable resource use, have major impacts on natural ecosystems and human well-being.

The Asia and the Pacific region covers 13 of 35 global biodiversity hotspots, where the greatest number of endemic species is found, but their habitats are threatened by human activities (CEPF 2015). Unfortunately, deforestation in the tropical rain forest zone is a particular threat to species survival. The area of plantations is increasing in many places, but these often lack the diversity of species and do not replace lost forest ecosystem services.

In addition to forests, social wellbeing and prosperity in the Asia and the Pacific region are dependent on the products and services that marine ecosystems provide. Healthy oceans and coasts are critical not only for food security but also for poverty eradication, sustainable economic growth, preservation of traditional cultures and trade facilitation. Human action, however, is diminishing the capacity of many marine ecosystems to continue to provide these services.

The fifth *Global Environment Outlook* (GEO-5) described the state and trends of biodiversity and analysed six policies

Key Messages

Adverse trends in biodiversity are likely to continue due to expansion of extensive agriculture, oil palm and rubber plantations, illegal trade of wildlife and plants, aquaculture and unsustainable resource uses.

- Intact ecosystems and biodiversity is not equally distributed among the countries and sub-regions of Asia and the Pacific.
- Threatened native mammal and plant species increased by more than 10 and 18 per cent respectively in the last decade.
- Three-quarters of all threatened birds on oceanic islands are in danger from invasive species.
- Captured fisheries are shifting throughout the region in response to both overfishing and migratory stocks, especially in the Pacific Islands.
- About a quarter of hard warm-water corals are threatened, mainly due to high thermal stress and dumping of plastic debris and micro-plastic hazardous waste in the oceans.

Degradation of biota and ecosystems affects the livelihoods of 50-80 per cent of rural people in Asia and the Pacific countries dependent on forest products and fishery resources.

related to biodiversity. This section follows the DPSIR framework to present key driver indicators that trigger ecosystem and biodiversity pressures. In addition, the cause-effect relationship between pressures and ecosystem state/trends, and consequently impacts on biota, ecosystems and society are included (**Figure 2.3.1**). Key policy responses are discussed in Chapter 3. As GEO-5 did, this section used up-to-date and accessible reports, and reviewed scientific articles to support the assessment.

2.3.2 Drivers

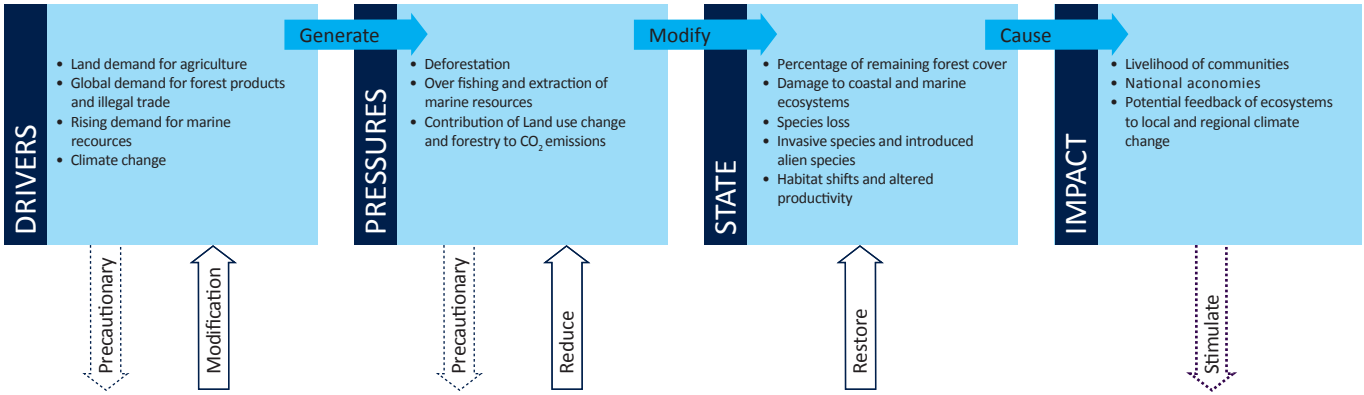
Land demand for agriculture and infrastructure development

Asia and the Pacific accounts about 30 per cent of the world's land area, however it houses more than 60 per cent of the world's population (UNESCAP 2011). About half of the countries in the regions are in deficit and overshoot, needing 188 per cent of their biocapacity to support their population (Global Footprint Network 2015). The massive population of Asia and the Pacific lives on limited resources; the region's per person fish consumption footprint was 94 per cent of the world average in 2011, the cropland footprint 80 per cent, the forest footprint 63 per cent, the grazing footprint 31 per cent, and the built-up foot print 112 per cent, all causing degradation of ecosystem services. See more detail in Chapter 1 and Section 2.2.

Global demand for forest products and the illegal trade of wildlife and plants

Demand for, and consumption of, wood products are recognized as key drivers of forest degradation and the Asia and the Pacific region has been classified as the world's largest timber importer since 2005 (FAO 2009). Besides, the estimated value of illegal wildlife and wood products trade in Asia and the Pacific is about USD2.5 billion and USD17 billion a year respectively the 1960s (Oswell 2010). The largest single amount, USD200 million, was contributed by elephant ivory, followed by pangolins, rhino horn, bear products and tiger parts. Demand for Siamese rosewood (*Dalbergia cochinchinensis*) found in mainland Southeast Asia has significantly increased due to attractive market prices and high demand in China. The price of rosewood at source

Figure 2.3.1: DPSIR indicators for ecosystems and biota in the Asia and the Pacific region



Source: UNEP

is about USD1 000–2 000 per cubic metre but increases to USD50 000 in the end-user market in China (Singh 2013). To control its international trade, Siamese rosewood was included on the Convention on the Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendix II during the 16th Conference of the Parties (CITES 2013).

Rising demand for marine resources

The cumulative effects of human actions, combined with climate change, are threatening the long-term sustainability of coastal and marine resources in the region. While the utilization of inshore fisheries resources is vital to local communities for subsistence and for income, over the past 30-40 years, human populations have increased, and the commercialization of the fishery has increased, with dramatic impacts. For example, Asia and the Pacific continues to be the world's largest producer of fish with capture production reaching 47.4 million tonnes. China accounts for approximately 32 per cent of the total regional production followed by Indonesia (11 per cent) and India (10 per cent) (Funge-Smith *et al.* 2012) (**Table 2.3.1**)

Inshore fishery resources are enormously important for the survival of coastal communities, their food security and livelihoods. Excessive demand has led to overfishing by highly mechanized fleets, as well as overexploitation of artisanal fisheries, contributing to major emerging pressures on marine habitats (UNEP *in press*).

Table 2.3.1: The amount and relative proportion of capture-fishery production in Asia and the Pacific countries

Country	Production (tonnes)	Regional Production %
China	15 665 587	33.1
Indonesia	5 384 418	11.4
India	4 694 970	9.9
Japan	4 141 312	8.7
Myanmar	3 063 210	6.5
Philippines	2 615 753	5.5
Viet Nam	2 420 800	5.1
Thailand	1 827 199	3.9
Republic of Korea.	1 745 971	3.7
Bangladesh	1 726 586	3.6
Malaysia	1 437 507	3.0
Taiwan, Province of China	851 505	1.8
Cambodia	490 094	1.0
Pakistan	453 264	1.0
Sri Lanka	437 468	0.9
New Zealand	436 640	0.9
Total	47 392 284	100.0

Source: Funge-Smith *et al.* 2012

Climate change

Studies have shown that certain climatic regimes are associated with particular plant communities or functional types (Walter 1985). Changes in climate will alter the configuration of terrestrial and marine ecosystems. Biodiversity-rich forests, however, are likely to be less vulnerable to climate risks and impacts than degraded and/or fragmented forests and plantations dominated by a single or a few species (Trisurat *et al.* 2014).

Changes to marine ecosystems driven by climate change raise serious concerns for the possible decline in seagrass meadows and seaweed beds due to storms and warmer waters; the migration of tropical pelagic fish and other marine species to previously cooler waters; the loss of diversity in coral fish and coral-dependent organisms; and risks to the marine food chain from ocean acidification, potentially affecting fisheries (FAO 2011a). Coral reefs in the region are already affected by coral bleaching due to high thermal stress from climate change-induced temperature increases (**Figure 2.3.2**).

2.3.3 Pressures

Deforestation

Deforestation not only reduces suitable habitats, but also results in habitat fragmentation, diminishing patch size and core area, isolation of suitable habitats and consequently increased extinction rates. Large mammals are generally the first species to disappear as a result of habitat fragmentation (Sodhi 2010). For example, the extensive conversion of tropical rainforests to oil palm monocultures since the 1960s has resulted in a loss of biodiversity such as the orangutan (*Pongo pygmaeus*) in Sumatra and Borneo (Cramb and Curry 2012). This was, however, significantly reversed by approximately 200 000 hectares per year because of large scale afforestation in China (1.86 million hectares) and Viet Nam (177 000 hectares) between 2000 and 2010 (FAO 2015a).

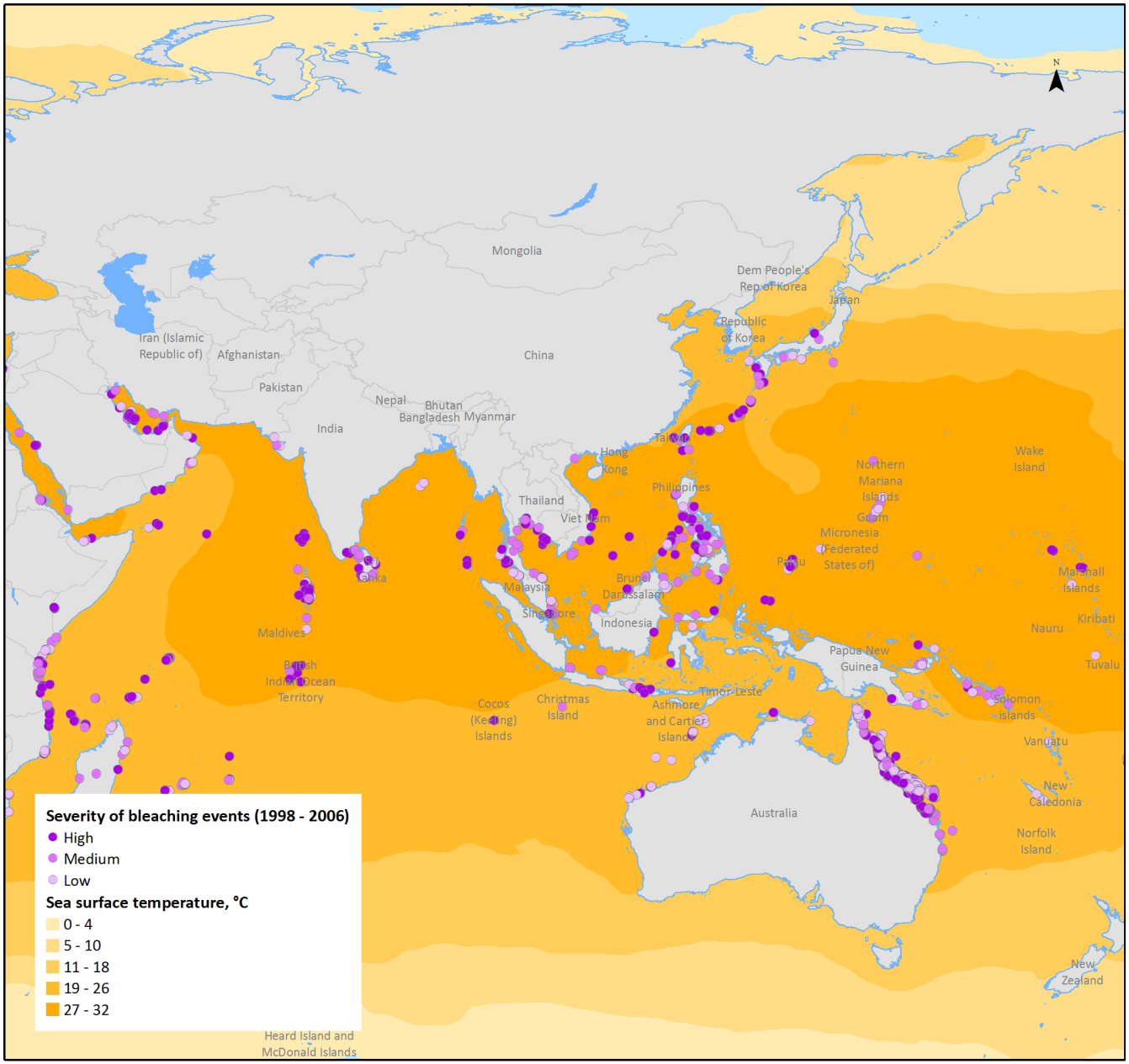
Forest cover in northern Thailand is projected to decline from 57 per cent in 2002 to 45 per cent in 2050 under the three recent-trend scenarios, but could be 50 and 55 per cent, respectively, under integrated management and conservation-oriented land-use scenarios. The predicted trends of land-use change would increase the number of forest patches and decrease the average mean patch size and thus create more fragmentation. In contrast, conservation-oriented scenarios maintain similar forest landscape patterns. As a result, mean species abundance (MSA - ranking from 0 (low) to 1 (high)) is projected to decrease from 0.52 in 2002 to 0.45, 0.46, and 0.48, respectively, in 2050 under the three recent-trend scenarios (Trisurat *et al.* 2010).

Overfishing and extraction of marine resources

In the coastal and marine environments, marine habitats are lost due to destructive fishing practices, poor agricultural land use and inappropriate coastal development. Such practices can reduce fishery productivity, create erosion, reduce coastal ecosystem health and limit livelihoods. Sedimentation as a result of habitat destruction for coastal development and land reclamation can have a severe impact (Halpern *et al.* 2012). Overfishing has caused significant declines in some stocks in waters under national jurisdiction and of some migratory and straddling stocks. Illegal, unreported and unregulated (IUU) fishing is putting these stocks at risk. Some 3.4–8.1million tones of fish are taken by IUU fishing each year in the Asia and the Pacific region (APEC 2014).

The health of coral reefs in the Pacific region that provide most of the sand on the beaches is threatened by years of abuse, increasing surface temperature and sea level rise, increased turbidity associated with coastal development and loss of mangroves, heightened nutrient discharges, chemical pollution and damage from extreme natural events (SPREP 2012a). Hazardous chemicals and nutrient pollution find their way into the marine environment though effluent, dumps, storm runoff, sewage and wind-blown dust, and are

Figure 2.3.2: Severity of coral bleaching Asia and the Pacific and areas of high thermal stress in the Asian and Pacific oceans, 1998–2006



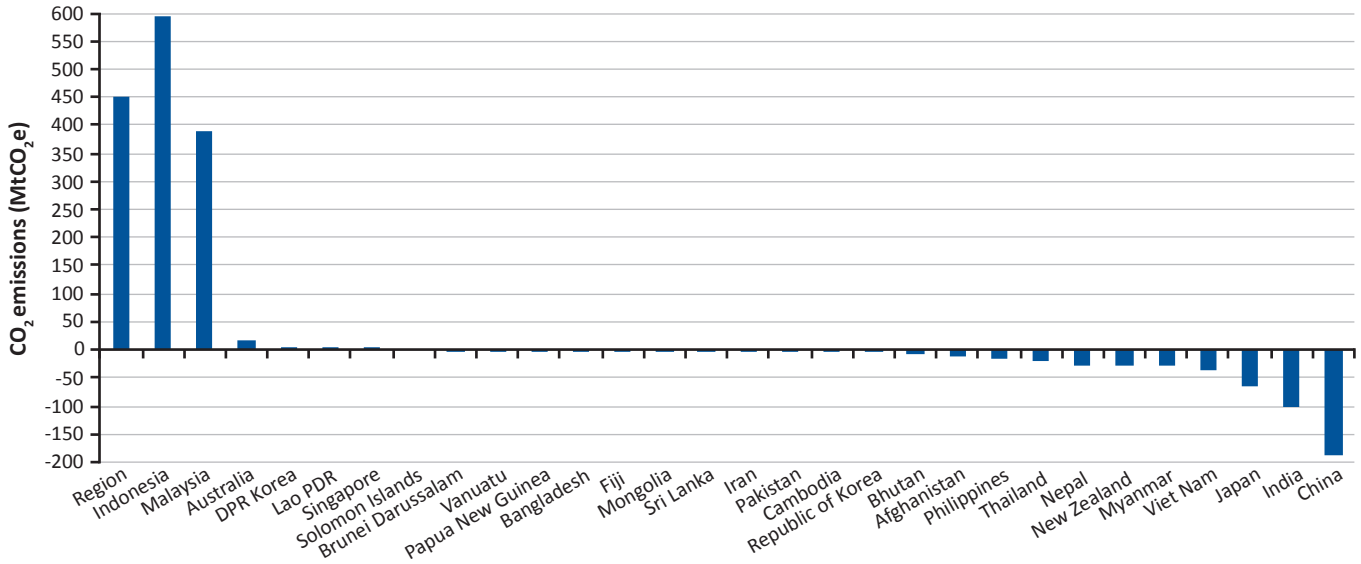
Source: Reef Base 2014

especially damaging to coastal marine nursery areas such as seagrass beds, coral reefs and mangrove forests. Siltation, oil pollution, poisons and plastic trash also contribute to extensive damage to inshore marine environments. All these activities contribute to endangering ecological goods and services from marine ecosystems.

Contribution of land-use change and deforestation to carbon dioxide emissions

Land-use change and the forestry sector was a sink for greenhouse gases in the Asia and the Pacific region in 1994 (or the closest year reported), reducing greenhouse gases in the atmosphere by 316 million tonnes carbon dioxide equivalent, 4 per cent of total emissions (UNFCC 2005). The 2012 greenhouse gas inventory indicates, however, that land-use change and deforestation has become a net source of emissions: 1 050 million tonnes of carbon dioxide equivalent or 6.2 per cent of total greenhouse gas emissions (FAOSTAT). This is due to the large amount of deforestation in Indonesia, 24.1 million hectares; Australia, 5.2 million hectares; Cambodia, 2.8 million hectares; Papua New Guinea, 2.8 million hectares and Malaysia, 1.1 million hectares from 1990 to 2012 (FAO 2010). In contrast, China, India, Japan and Viet Nam are recognized as carbon dioxide absorbers due to their large-scale reforestation in recent years (**Figure 2.3.3**).

Figure 2.3.3: Change in carbon dioxide emissions from land-use change and forestry, million tonnes of carbon dioxide equivalent, 1990–2012



Source: WRI 2015

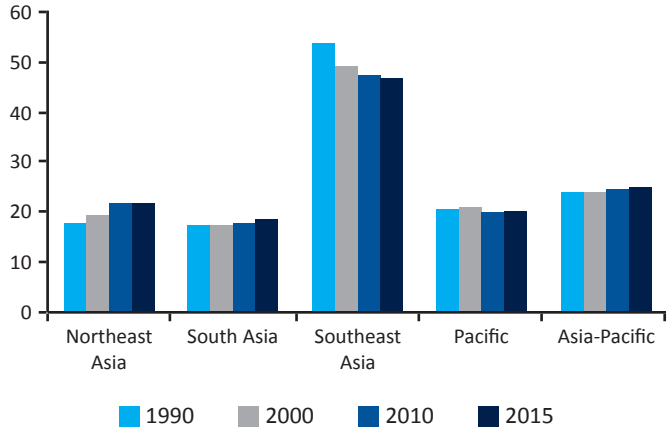
2.3.4 State and trends

Remaining forest cover

The remaining forest cover in the Asia and the Pacific region is 722 million hectares or 24.67 per cent of the land area (**Figure 2.3.4**). From 2000–2015, the forested area in China increased by 31.3 million hectares. In 2015, 208 million hectares or 21.67 per cent of its land was covered by forests, of which 119 million hectares were natural forests, and 79 million hectares plantations, the largest plantation cover in the world (FAO 2015a).

Approximately 32.6 per cent of 6.39 million hectares of Indian forests are under different stages of fragmentation, and highly fragmented regions across the Indian landscape harbour a number of endemic species, some of them of medicinal importance, that need conservation (Roy *et al.* 2013). Land-cover change and fragmentation of forests in the Nepal's Kailash Sacred Landscape are negatively impacting various ecosystem services (Uddin *et al.* 2015).

Figure 2.3.4: Asia and the Pacific forest area, 1990 –2015 by sub-region



Source: FAO 2015a

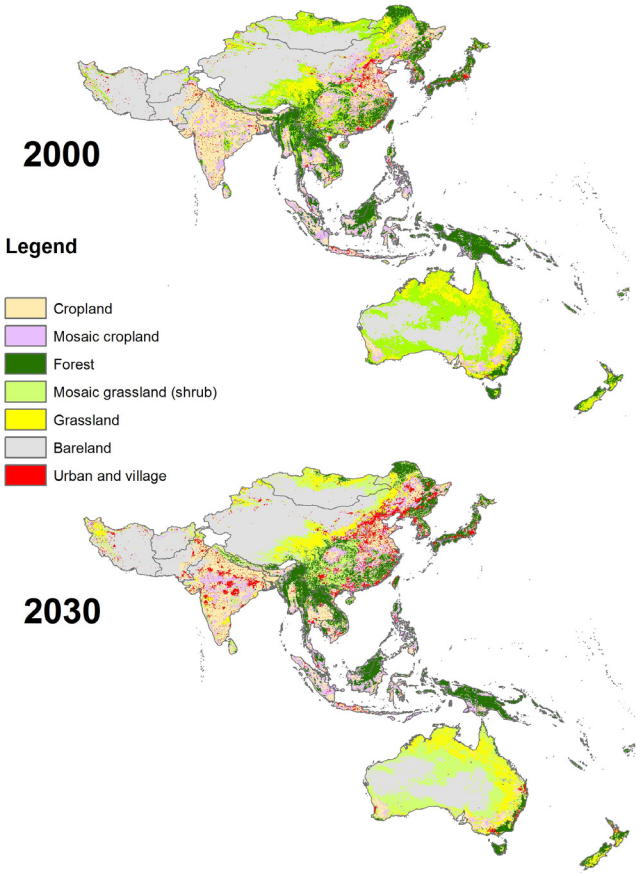
Model-based assessments suggest that forest cover in Asia and the Pacific between 2000 and 2030 will remain relatively stable due to effective protection and the introduction of certified forest management practices (Eitelberg *et al.* 2015). However, a high intensity of land systems in cropland, mosaic cropland and grassland used for food production is projected, especially in Australia, China and India (**Figure 2.3.5**).

Damage to coastal and marine ecosystems

Coastal ecosystems are of critical importance to countries and territories of Asia and the Pacific as they are areas of remarkable biological productivity and high accessibility. The existence of functional links between mangroves, seagrass beds, coral reefs and to some extent the open ocean means that degradation of one habitat type will adversely affect the health of neighboring ones.

Asia and the Pacific is home to approximately 45 per cent of the world's coral reefs with the majority located along the coasts of Southeast Asia and western and central Pacific islands. Reefs, rivers, mangrove spawning grounds and other inshore fisheries, particularly those near urban areas and villages, have been dangerously overfished and degraded. For example, the sea cucumber, trochus, live coral, live reef fish and aquarium fish trades have increased, and fragile spawning aggregations of large finfish and seasonal migrations of smaller species have suffered, with 79 per cent of spawning aggregations reportedly in decline from the 1970s to the late 2000s (De Mitcheson *et al.* 2008). The effect has been a dramatic collapse of inshore fisheries, with a vast number of species at all trophic levels disappearing or becoming economically or ecologically extinct (SPREP 2014). The continuing harvesting of many populations of fish is mainly related to commercial fishing operations, in conjunction with an increase in fishing pressure from an ever-increasing human population. Oceanic mega-fauna populations are unlikely to be able to support the massively increasing fishing pressure to which they are currently subjected: more than 5 645 commercial vessels alone were actively fishing in the Pacific Ocean in 2011 (Harley *et al.* 2012).

Figure 2.3.5: Projected land-use system, 2030



Source: Eitelbert *et al.* 2015

There is a growing concern over the increased amount of plastic debris and micro-plastic hazardous waste finding its way into the sea that has adverse impacts on marine organisms. There are no updated data available on the amount of marine debris deposited into the marine and ocean environment within the Asia and the Pacific region or the specific impacts on biota (Chapter 2.6).

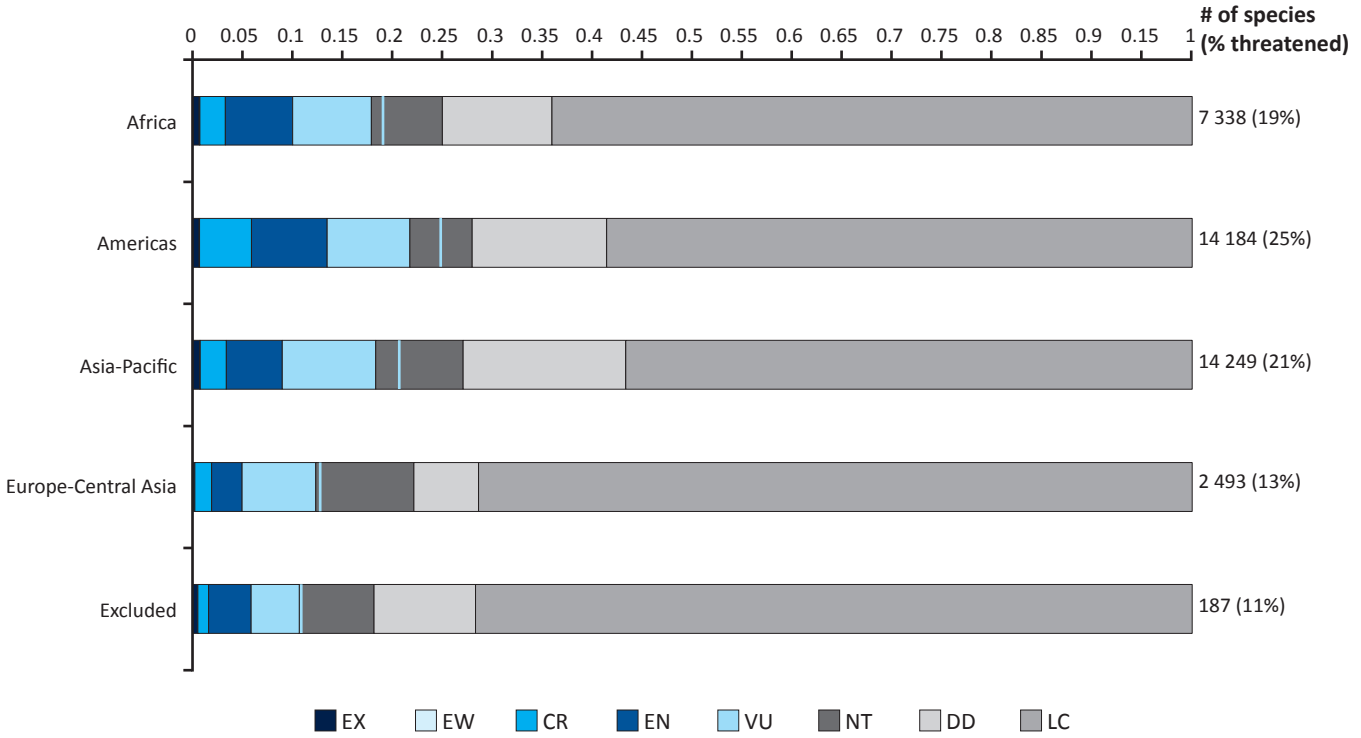
Most pollution in the ocean originates from industry, agriculture or domestic sources on land. One exception is the extraction of gas and oil from the sea floor. Deep-sea mineral extraction is a potential future threat, particularly in relation to the exploitation of manganese nodules in the Cook Islands, Kiribati, Niue and Tuvalu; cobalt-rich crusts in Fiji, Niue, Papua New Guinea, Palau, the Solomon Islands, Tonga and Vanuatu, and seafloor massive sulphide deposits in Kiribati, the Republic of Marshall Islands, the Federated States of Micronesia, Samoa and Tuvalu (SPREP 2014; Halpern *et al* 2012).

Species loss (abundance and diversity)

The Asia and the Pacific region contains the world's largest number of threatened species (**Figure 2.3.6**). In 2015, 4 071 plants and 5 250 vertebrates (mammals, birds, reptiles, amphibians and fish) were categorized as threatened species, with Indonesia at the top of the list with 186 species of threatened mammals. The overall number of threatened mammal species in Asia and the Pacific has increased steadily, from 1 031 in 2004 to 1 138 in 2015. In the Pacific islands, more than a third of all sharks and rays, 25 per cent of hard (reef-building) warm-water corals, a fifth of marine mammal species and a quarter of conifers and cycads are threatened. The number of threatened invertebrate species has increased from 824 species in 2008 to 1 025 species in 2015 (Pippard 2008; IUCN 2015). In addition, threatened plant species in the Asia and the Pacific region have increased from 3 466 in 2006 to 4 114 in 2015 or 18 per cent (IUCN 2015). Southeast Asia contains almost 34 per cent of the world coral reefs. However, over 70 per cent of coral reefs in the region are threatened by overfishing, destructive fishing practices and sedimentation from land-based activities (Burke *et al.* 2002).

Although high rates of threatened species and extinction are reported in this region, at the same time new species have been discovered and described due to its diverse habitats. For example, 1 584 species of plants and vertebrates were discovered in the Greater Mekong region (Cambodia, Lao PDR, Myanmar, Thailand, Viet Nam and Yunnan province of

Figure 2.3.6: Red list categories for species in each region in 2015



Notes: EX-extinct; EW-extinct in the wild; CR-critically endangered; EN-endangered; VU-vulnerable; NT-not threatened; DD-data deficient; LC-least concern
Source: IUCN 2015

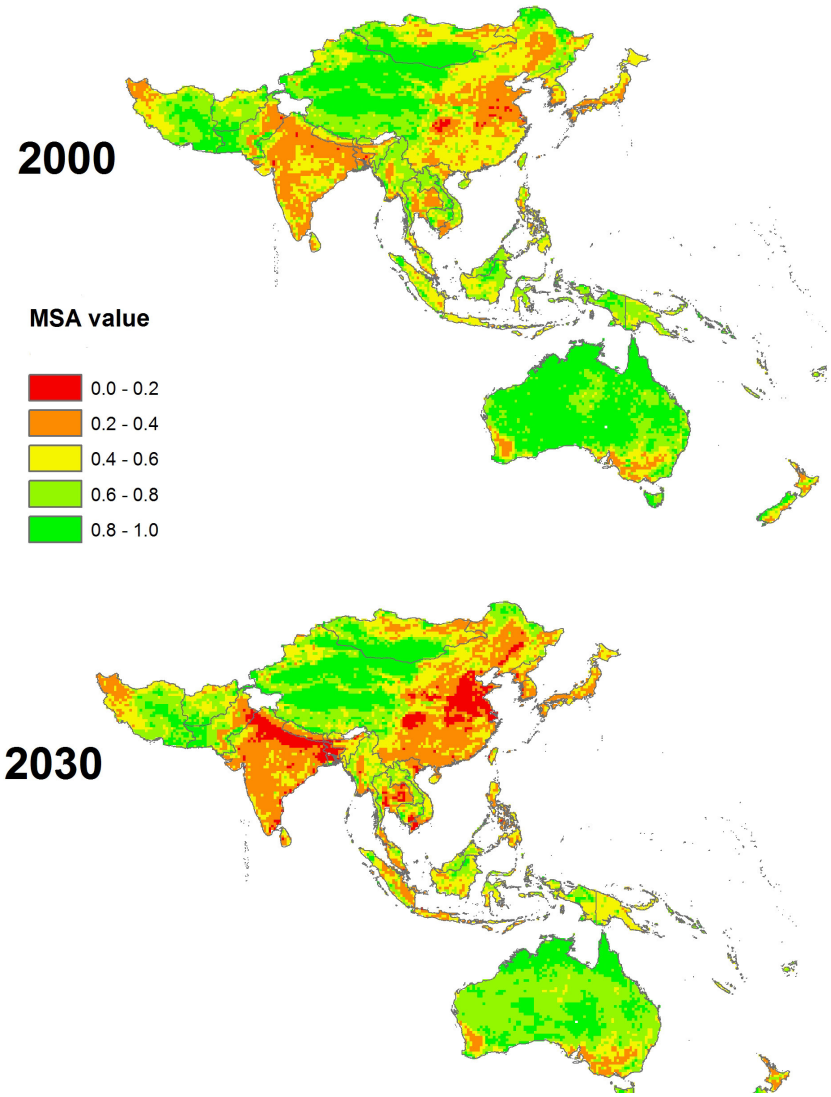
China) between 1997 and 2010 (WWF 2011). In addition, 133 plant, 26 fish, 10 amphibian, 1 reptile, 1 bird and 1 mammal species were newly described in the eastern Himalayas between 2009 and 2014 (WWF 2015). These new discoveries point to the need for more trained taxonomists and funding for surveys in remote parts of the region.

The Global Biodiversity Assessment model (GLOBIO 3) indicated that the Mean Species Abundance (MSA) value of the Asia and the Pacific region will decline from 0.63 in 2000 to 0.57 in 2030. High loss is expected in China and India due to rapid economic development (Alkemade *et al.* 2009). The MSA for Oceania and Japan, 0.78 in 2000, will decrease slightly, mainly as a result of climate change. The MSA score in Thailand is considerably lower, 0.37, but Lao PDR and Yunnan, China, have higher MSA scores, 0.65 and 0.67 respectively (**Box 2.3.1**).

Invasive and introduced alien species

Release of hatchery-produced seed is a commonly used approach for inland fisheries resource enhancement, with seed of alien species used in release programmes in some countries. Lack of control of genetic quality/attributes in indigenous species' seed used for a release programme may result in potential negative impacts on biodiversity and

Box 2.3.1: Projected mean species abundance (MSA), 2030



Source: Alkemade *et al* 2009

The Global Biodiversity Assessment model (GLOBIO 3) was developed to assess the relationships between environmental pressure factors and biodiversity. Pressure factors used in the model comprise changes in land use (agriculture, forestry and settlements), climate change, infrastructure, fragmentation and nitrogen deposition. By combining results related to individual pressures, the overall change in biodiversity is calculated in terms of mean species abundance (MSA ranking from 0 (completely destroyed) to 1 (pristine)) and the extent of ecosystems (Alkemade et al. 2009).

genetic diversity of natural populations. The use of invasive alien species may result in competition with indigenous species and negative impacts on their diversity (Lymer 2010).

Invasive species are implicated in more than half of known bird extinctions on islands, mainly in the Asia and the Pacific region, and studies show that three-quarters of all threatened birds on oceanic islands globally are in danger from invasive species due to predation by introduced invasive mammals such as rats, cats, mongooses and feral dogs; herbivory and habitat degradation by goats, cattle and pigs; and disease transmission through introduced and invasive micro-organisms (UNEP *in press*). In addition, the introduction of brown tree snake (*Boiga irregulars*) through cargo directly transported from Guam to Pacific Islands causes substantial impacts on native bird species (Rodda and Savage 2007).

Globally, from 1 086 attempts to remove invasive vertebrates from islands, 924 (85 per cent) have succeeded. The majority of the successes, 584 of 924, have taken place in the Pacific sub-region (Island Conservation *et al.* 2014).

BirdLife Pacific Partnership has treated 30 islands for five species of introduced mammals across Fiji, French Polynesia, New Caledonia and Palau (BirdLife International 2008).

Habitat shifts and altered productivity

Geographical distribution of species and vegetation types is projected to shift radically due to climate change. Vegetation modelling studies suggest significant forest dieback towards the end of this century and beyond, especially in tropical, boreal and mountain areas (Fischling *et al*. 2007; McClean *et al*. 2005; Miles 2002). In a warmer world, the current carbon-regulating services of forests acting as carbon sinks may be lost entirely, as land ecosystems turn into a net source of carbon dioxide later in the century (Seppälä *et al*. 2009). In India, about 77 and 68 per cent of the forest grids are likely to experience vegetation shift under the IPCC A2 and B2 scenarios of climate change respectively by the 2080s (Ravindranath *et al*. 2006).

Continued warming is likely to result in ongoing elevation range contractions, and eventually species extinctions, particularly at mountaintops. Trisurat (2015) reported that future climate change would eradicate most suitable habitats for wetland birds, for example the sarus crane (*Grus antigone*), giant ibis (*Thaumatibis gigantea*) and lesser adjutant stork (*Leptoptilos javanicus*) in the Emerald Triangle forest complex along the borders of Cambodia, Lao PDR and Thailand.

From 1999–2008, China's total living-wood growing stock and forest growing stock had net increases of 1.13 billion cubic metres and 1.12 billion cubic metres respectively. In addition, biomass productivity in the grassland ecosystems in China also increased from 94 million tonnes of biomass in 2005 to 106 million tonnes in 2012 after conservation and desertification control measures (Ministry of Environmental Protection of PRC 2014).

Coastal overfishing and the loss of inshore marine biodiversity arguably constitute some of the most serious threats to conservation in the Pacific. However, initiatives such as locally-managed marine areas (**Figure 2.3.7**) show strong scope to reverse the current trend of overfishing.

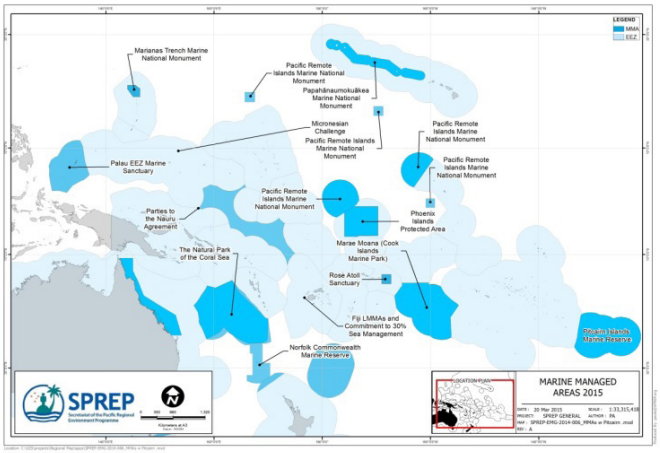
2.3.5 Impacts

Livelihood of communities dependent on forest and fisheries resources

Non-wood forest products play an important role for the poor residing in remote forested areas. They generate employment for millions of people in the Asia and the Pacific region; for example 49 per cent of household income in India and 45 per cent in upland Lao PDR. Harvested non-wood forest products are used for food, nutrition and healthcare, and are recognized as the main contribution to food security and nutrition for forest-dependent communities (Hansda 2009).

Fisheries are nutritionally important for the people of the Lower Mekong Basin. Fish are the primary source of animal

Figure 2.3.7: Pacific Ocean managed marine areas, 2015



Source: SPREP 2015

protein, and a major supplier of several micronutrients, notably calcium and vitamin A. Consumption of fishery products is about 46 kilograms per person per year of fresh fish equivalent, or 34 kilograms per person per year. There are no readily-available foods to substitute for fish in the diets of people in the Lower Mekong Basin, so fisheries harvested from wetland ecosystems are extremely important for food security and household income (Lymer *et al.* 2008). Agriculture and wetland services account for 80 per cent of household income in Xe Champhone in Lao PDR (MRC 2015). Degradation of natural ecosystems and extinction of species would have significant impacts on local livelihoods.

National economies

The Food and Agriculture Organization of the United Nations (FAO) (2009) reported that the forest industry contributed approximately USD90 billion or 1.4 per cent of Asia and the Pacific's GDP in 1990. Although gross value added increased by about USD29 billion from 1990 to 2006, the share of the forestry production sector declined to about 1 per cent of regional GDP.

Asia and the Pacific accounted for about 50 per cent of global economic growth between 2000 and 2010. With long coastlines and diverse marine activities, Asia and the Pacific Economic Cooperation (APEC) economies have developed active marine industries that make up a substantial part of their domestic economies. In 2014, the value of China's gross ocean products (GOP) was USD962 billion, 9.4 per cent of its GDP, with tourism, fishery, transport and ship building also making major contributions (Ebarvia, M. and Corazon, M. 2016). Income generated from capture fisheries and aquaculture was the major source of foreign income for many of the region's island countries, including Kiribati, the Maldives, the Marshall Islands, the Solomon Islands, Tuvalu and Vanuatu (Lymer *et al.* 2010).

Potential feedback of ecosystems to local and regional climate change

Terrestrial ecosystems are shaped by the climate, but they also influence the climate. The magnitude of monsoonal precipitation changes depends on the location of deforestation, with remote effects showing a larger influence than local effects. Widespread deforestation between 1700 and 1850 led to a 30 per cent decline in precipitation in India, and a 10 per cent decline in China (Takata *et al.* 2009). Devaraju *et al.* (2015) found that remote forcing from large-scale deforestation in the northern middle and high latitudes shifts the Intertropical Convergence Zone southward. This results in a significant decrease in precipitation in the Northern Hemisphere monsoon regions. The South Asian monsoon region is affected the most, with an 18 per cent decline in precipitation over India.

El Niño Southern Oscillation foreshadows projected effects of climate change in the Pacific sub-region in terms of a weakening of trade winds and the warming of the surface layers (SPREP 2012b). Such effects increase tuna catches in the central Pacific and reduce them further west (Lehodey *et al.* 1997).

2.4 Freshwater

2.4.1 Introduction

Water is a critical resource for human needs, agriculture, industrial production and preserving ecosystems. The Asia and the Pacific region has less than 30 per cent of the world's internal renewable freshwater resources and there is extreme variation in per person availability from 1 179 cubic metres in South Asia to 31 669 cubic metres in the Pacific Islands (FAO 2014a). The region's water resources thus need to be monitored, conserved and utilized judiciously to meet the increasing and competing demands.

2.4.2 Drivers

Water resources in Asia and the Pacific are stressed due to the large population, agricultural expansion and intensification, rapid urbanization, industrial growth and climate change.

With 60 per cent of global population, demand for food and energy are high. Of the total land area, 53 per cent was used for agriculture in 2007, rising by 6 per cent in 1970–2007 in contrast to just a 1 per cent increase in the rest of the world (UNEP 2011). Agriculture's water requirement is correspondingly high, accounting for 90 per cent and above of withdrawals in several countries in South and Southeast Asia (FAO 2014b).

The primary energy demand in Asia and the Pacific was 4.985 billion tonnes of oil equivalent in 2010 and this is expected to increase by 2.1 per cent per year for the next 25 years, higher than the estimated world average growth rate of 1.5 per cent per year (ADB 2013a). Nuclear and coal-based thermal power plants consume 75–450 cubic metres of water per megawatt-hour (IEA 2012). Biofuel ethanol production is similarly water intensive, consuming 88.38 cubic metres per megawatt-hour for sugarcane cultivation and 0.522 cubic metres per megawatt-hour for ethanol processing (Spang *et al.* 2014).

Urbanization in Asia was 43 per cent in 2010 and is expected to reach 63 per cent in 2050, close to the global average of 67 per cent (ADB 2012). Of the 22 global mega-cities, with populations greater than 10 million, in 2013, 13 were in Asia (UNESCAP 2013) and 15 in 2014 (UN-Habitat and UNESCAP 2015). This large population concentrating in urban areas requires access to safe water and sanitation.

There are competing demands for water varying with the extent of urbanization. In South, Northeast and Southeast Asia, agriculture accounts for 82 per cent of water

Key Messages

Water scarcity and deteriorating water quality challenge services and security in multiple dimensions including human health, drinking water, sanitation, food production and loss of ecosystem services.

- Unsafe sanitation, disposal of untreated wastewater, runoff of agrochemicals contaminate surface and groundwater sources which are responsible for increased water-borne diseases, especially, in population-dense urban areas.
- Climate change effects on water security will be pronounced in rivers dependent on Himalayas. It will also cause alteration of rainfall patterns and sanitation of coastal aquifers, especially, in Small Island Nations and deltas;
- Widespread use of pharmaceutical and personal care products, nanomaterials, and organochlorides are contaminating various water sources leading to increased exposure to human health risk.

withdrawals, municipalities for 9 per cent and industry for 9 per cent (Frenken 2012). Industry's share of water use is high in China (23.2 per cent). In Australia, Japan and New Zealand the agriculture share ranges from 62–67 per cent, municipalities from 15–21 per cent, and industry from 13–23 per cent (FAO 2015e). Water productivity – GDP in 2005 constant prices divided by annual total water withdrawals – varies widely in the region, with developed countries such as Japan having high water productivity of USD53 per cubic metre compared to USD2 per cubic metre for countries in South Asia other than the Maldives (World Bank 2013).

Climate change impact on water resources is particularly pronounced in Asia since rivers originating in the Hindu Kush Himalayas are among the world's most melt-water-dependent systems. This region, extending over 3 500 kilometres, is the source of ten large Asian river systems – the Amu Darya, Brahmaputra (Yarlungtsanpo), Ganges, Indus, Irrawaddy, Mekong (Lancang), Salween (Nu), Tarim (Dayan), Yangtse (Jinsha) and Yellow River (Huanghe) – and provides water for 1.3 billion people, 20 per cent of the world's population. The Brahmaputra, Ganges and Indus river basins alone support around 700 million people (Eriksson *et al.* 2009) with around 144 900 hectares in the Indus basin irrigated, 156 300 hectares in the Ganges basin, and 6 000 hectares in the Brahmaputra basin (Immerzeel *et al.* 2010). Water security is aggravated by factors such as increased flooding due to Himalayan glacier melting, decreased river flows due to reduced snow cover, changes in rainfall and rainfall patterns, and higher rates of chemical reactions in water bodies due to warming.

2.4.3 Pressures

The increased water demand for agricultural, domestic and industrial use has led to overexploitation. The resulting increased scarcity of water and decreased water security compromises water availability for human wellbeing and economic development. Moreover, water-dependent ecosystems, such as wetlands, can be pushed beyond their tipping points, leading to irreversible environmental impacts.

As a result of the large population and growing regional economy, pollution of surface and ground water sources is rampant due to the release of untreated sewage, agricultural run-off, industrial effluents, and leaching from waste landfills. Salinization of fresh water sources in coastal areas due to incursion of seawater is aggravated by rising sea level. The Water Quality Index, based on dissolved oxygen, acidity, conductivity, total nitrogen and total phosphorous, shows a large variation in the region (Esty *et al.* 2008). Against a target value of 100, the values are in the range of 34.0–99.4, with New Zealand having the best water quality.

2.4.4 State and trends

Table 2.4.1 summarizes water-related issues in the region such as susceptibility to floods, cyclones and drought, elevated ecosystem/climate change risk and poor access to sanitation.

Water quantity

Mapping the total renewable water resources per person – cubic metres per person per year – in 2014 indicates low water availability in Northeast and South Asia (**Figure 2.4.1**). Baseline water stress – the ratio of total annual water withdrawals to total available annual renewable supply – indicates moderate to high stress (rating 3–5) in Afghanistan, Australia, India, Japan, Republic of Korea, Mongolia, Pakistan, Philippines and Singapore (WRI 2013). Monthly consumptive use of ground and surface water flows indicates heavily populated river basins – Tarim and Yongding He in China and the Cauvery, Indus and Penner in India – face severe water scarcity for 8–12 months per year (Hoekstra *et al.* 2012).

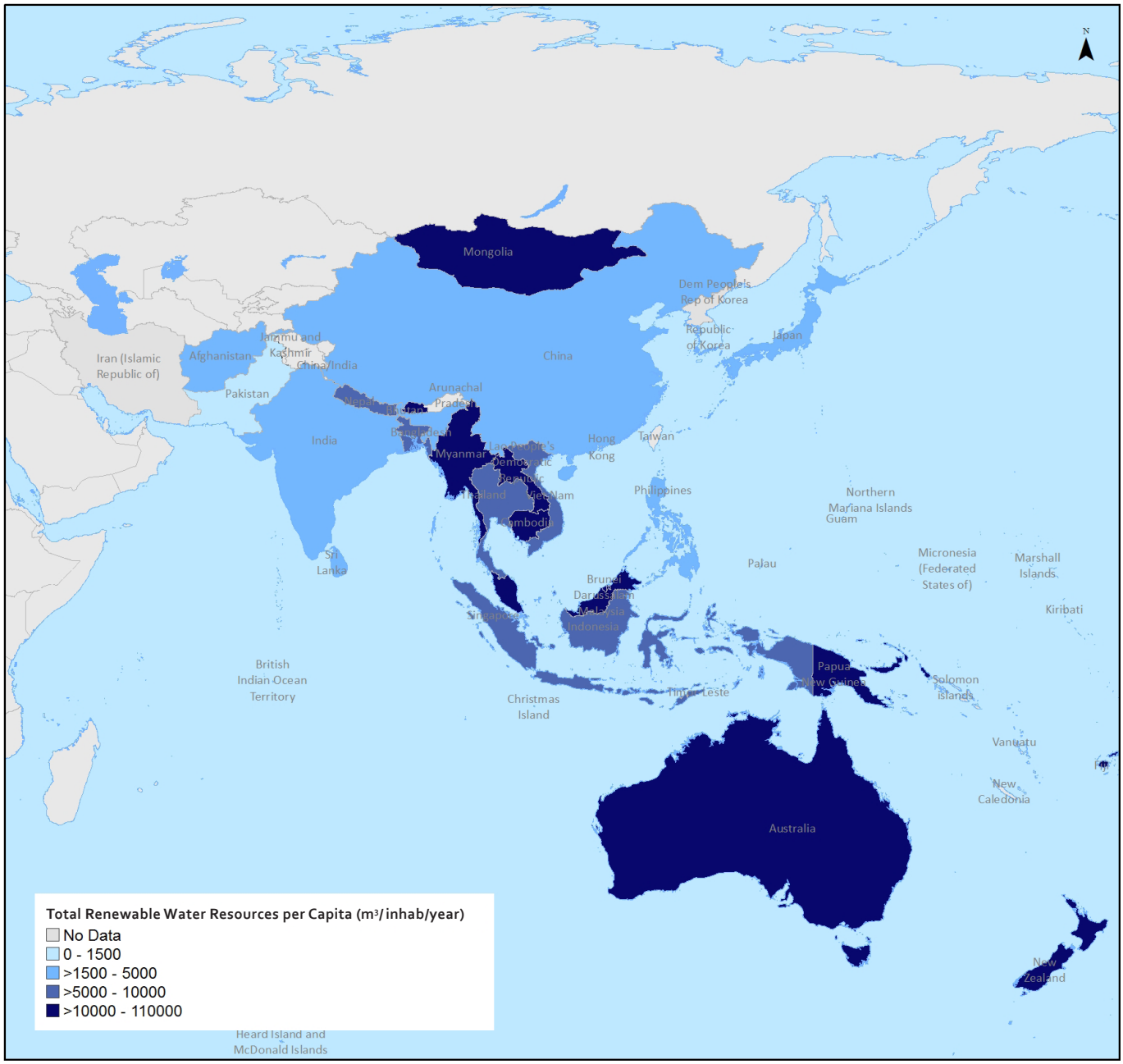
Climate change, rising temperatures and changes in precipitation cause enhanced evapotranspiration, variations in seasonal extremes and in glacier volume (Bolch *et al.* 2012) and changes in snow and glacier melt (Lutz *et al.* 2014), all of which alter the hydrological regime of Hindu Kush Himalayas river systems. Glacier melting has also occurred in New Zealand (UNEP 2008) and China (Ives 2012). In 1978,

Table 2.4.1: Water-related issues faced by countries in the Asia and the Pacific region

Country	Increasing water scarcity threat	High water utilization	Deteriorating water quality	Poor water quality and low water endowment	Flood-prone countries	Cyclone-prone countries	Drought-prone countries	Elevated ecosystem/ climate change risk	Poor access to drinking water	Poor access to sanitation
Afghanistan	X		X***		X***		X***	X***	X	X
Australia							X			
Bangladesh					X	X		X		X
Bhutan				X						
Cambodia					X	X	X	X	X	X
China					X	X		X		X
Korea DPR*				X	X					
India	X				X		X	X		X
Indonesia			X		X	X	X	X		X
Lao PDR**					X	X	X	X	X	X
Malaysia			X		X	X	X			
Maldives	X			X				X		
Myanmar				X	X	X	X	X		
Nepal				X				X		X
Pacific Islands						X		X		X
Pakistan	X	X	X					X		
Papua New Guinea				X	X	X	X		X	X
Philippines	X		X		X	X	X	X		
Sri Lanka								X		
Thailand			X		X	X	X	X		
Viet Nam					X	X	X	X		

*Democratic People's Republic of Korea; ** Lao People's Democratic Republic; ***personal communication
Source: WWAP 2012

Figure 2.4.1: Asia and the Pacific, total renewable water resources per person, cubic metres per person per year, 2014



Source: FAO 2015d

New Zealand had glaciers covering around 1 160 square kilometres, with an ice volume of around 53 cubic kilometres. Between 1977 and 2005 an 11 per cent decrease in ice volume was reported (UNEP 2008). In China, rivers such as Tarim are affected due to melting of glaciers in the mountains of Tian, Kunlun, Karakoram, and the eastern Pamir (Ives 2012).

Rivers are also affected by dams and reservoirs that cause fragmentation that affects their flow and connectivity. A study on the impact of fragmentation on large river systems has found many in Asia and the Pacific to be moderately or strongly affected (Nilsson *et al.* 2005). The strongly affected rivers include Chang Jiang and Haihe in China.

Irrigated agriculture is a key sector, accounting for up to 90 per cent of consumptive water use. The largest areas under groundwater irrigation are in India, 39 million hectares, and China, 19 million hectares, (Siebert *et al.* 2010) leading to overexploitation of groundwater sources. Nearly half of the world's total groundwater use is by Bangladesh, China, India, Nepal and Pakistan (IGRAC 2010), with groundwater levels having fallen in northern India, Pakistan and northern China (ADB 2013b). The groundwater recharge is further affected by deforestation, expanding agriculture and urban growth leading to rapid runoff that does not provide sufficient time for infiltration. A recent study has examined the world's 37 largest aquifers, including seven in Asia and the Pacific, and determined the renewable groundwater stress calculated as the ratio between groundwater use and groundwater availability (Richey *et al.* 2015). Of the seven aquifers studied in the region, five are overstressed or variably stressed and two are unstressed.

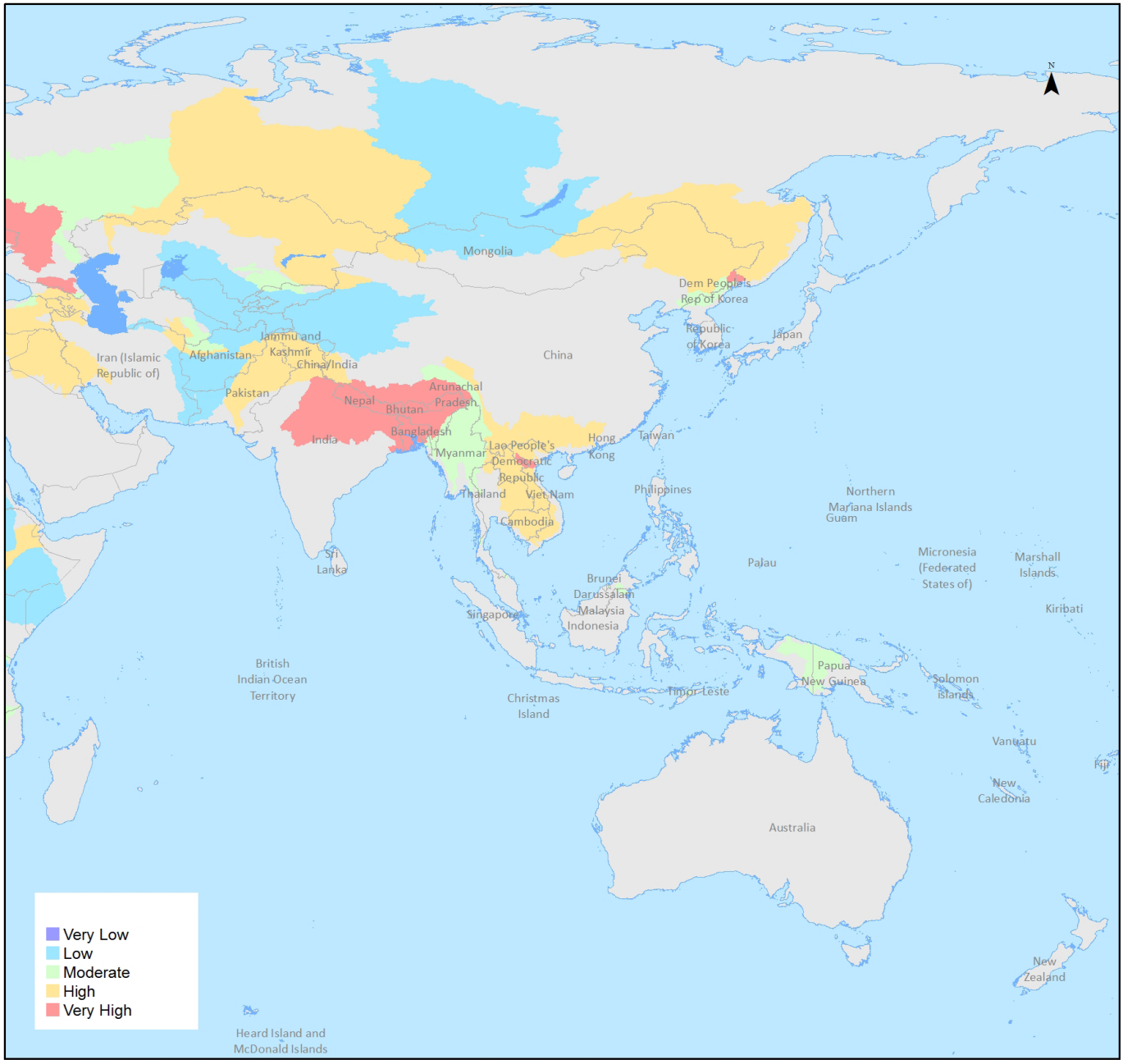
Water quality

The common pollutants in the region are organics, nutrients (nitrogen and phosphorous), dissolved salts, heavy metals, pesticides and chemicals from industrial activities. The sources are untreated or partially treated sewage, agricultural runoff, industrial wastewater and landfill leachate, and nutrient and sediments washed from degraded land by heavy rainfall. Several river basins – the Ganges, Haihe, Huaihe, Indus and Yellow river basins, and some river stretches in southern India – have high organic pollution (UNEP 2015). This can be further aggravated by other pollution such as increased salinity as seen in the Ganges and Indus river basins.

A major cause of water pollution is poor sanitation, including defecation in the open, leading to contamination of surface and groundwater sources by organics, nutrients and bacterial coliform. Globally, the percentage of population using improved sanitation facilities was 68 per cent in 2015 (UNDP 2015), while in Asia and the Pacific it ranged from 29 per cent in the Solomon Islands, to 100 per cent in, among others, Australia, Japan, Republic of Korea and Singapore in 2012 (World Bank 2012). In 2015, sanitation coverage was below 50 per cent in South Asia (Afghanistan, India and Nepal), Southeast Asia (Cambodia and Timor-Leste) and Pacific (Kiribati, Papua New Guinea and Solomon Islands) (UN MDG database). Only 30 per cent of the wastewater generated in urban India is treated (CPCB 2012) while the coverage in Japan is 100 per cent (Ueda and Benouahi 2009). Untreated sewage emanating from sewer leaks leads to high nitrate levels in urban groundwater, as observed in Bangkok, Jakarta and Metro Manila (Umezawa *et al.* 2009). Microbial pollution from human and livestock sewage, in addition to being localised, also spreads to rivers and coastal areas as observed in bays of Pacific islands, and the Java Sea coastal areas; it has also affected aquaculture in Bay of Bengal and South China Sea (UNEP 2006).

Eutrophication, the excess growth of algae, is caused by high loading of nutrients – nitrogen and phosphorous – in water bodies resulting in reduced water quality, oxygen depletion and growth of harmful algal blooms (**Figure 2.4.2**). The sources of nutrients are urea in fertilizers and in the manufacture of various plastics and chemicals, untreated sewage, agricultural runoff, and atmospheric wet and dry deposition of nutrients during smoke haze events (Sundarambal *et al.* 2010). In attempts to enhance food production, over-application of chemical fertilizers is a common practice in China, India, Philippines and Thailand, leading to high nutrient overloads (Novotny *et al.*

Figure 2.4.2: Asia and the Pacific, nutrient pollution in river basins in 2015



Source: UNEP-DHI and UNEP 2016

Box 2.4.1: Emerging contamination by pharmaceutically active compounds and nanomaterials

An emerging class of contaminants is pharmaceutically active compounds, due to the widespread use of pharmaceuticals and personal care products (Zhang et al. 2015), and engineered nanomaterials used in agriculture, medicine, environmental remediation and various consumer products (Keller et al. 2013; Gottschalk and Nowack 2011). Direct discharges of untreated sewage have led to high concentrations of pharmaceuticals in various Indian rivers (Mutiyar and Mittal 2014; Shanmugam et al. 2014). Bacteria in municipal wastewater treatment plants develop resistance to multiple antibiotics and are a secondary pollutant of water sources (Huang *et al.* 2012). The widespread presence of synthetic musks and benzotriazole ultraviolet stabilizers (BUVSs) as well as polybrominated diphenyl ethers (PBDEs) and organochlorines (OCs) in Asia and the Pacific coastal waters has been established by analysing mussels collected from several countries including China, India, Indonesia, Japan, Republic of Korea, Philippines and Viet Nam (Nakata et al. 2012; Ramu et al. 2007). The presence of OCs has also been established by their uptake on polyethylene pellet samplers collected from beaches across India, Indonesia, Japan, Malaysia, Thailand and Viet Nam (Ogata et al. 2009). Engineered nanomaterials are known to be present in wastewater and sewage sludge (Keller et al. 2013) but the extent of contamination in Asia and the Pacific is yet to be documented.

2010). Eutrophication may also make coastal waters more vulnerable to ocean acidification (Cai *et al.* 2011) and affect the bio-geological cycling of mercury in reservoirs, as algae are capable of binding mercury (He *et al.* 2008). The toxic blooms of cyanobacteria (blue-green algae) contain the microcystis genus that can cause liver and colorectal cancers (Davis *et al.* 2009). The magnitude and frequency of harmful algal blooms is projected to increase as a consequence of eutrophication and climate change (O'Neil *et al.* 2012).

Metals tend to accumulate in river-bed sediments, and river water analysis has shown high levels of aluminium and zinc in West Java, lead in Erdenet (Mongolia), and manganese, iron, and chromium in the rivers of Dhaka, Bangladesh and Japan (Sikder *et al.* 2013). The sources of heavy metals are untreated industrial discharge from tanneries, metal finishing units and highway runoff. Heavy metals are the main contaminants in up to 80 per cent of urban rivers in China, along with varying amounts of nitrogen, phosphorous and organic compounds (Qu and Fan 2010).

Arsenic contamination in groundwater, a widespread issue in Bangladesh and India, is also affecting China, Iran Mongolia, Nepal and Pakistan (Rahman *et al.* 2009; Winkel *et al.* 2008; Mukherjee *et al.* 2006). Another contaminant is naturally-occurring fluoride affecting large populations in southern and north-western India (Amini *et al.* 2008; Jacks *et al.* 2005) as well as in Sri Lanka, central and western China (Wetzelheutter 2013).

Seawater intrusion, linked with coastal erosion and extensive groundwater extraction, has been documented in Australia, Bangladesh, Japan, Maldives, Malaysia, Philippines, Thailand, Viet Nam, and Pacific island states and territories including Fiji and Guam (Faneca Sanchez *et al.* 2015; Berthe *et al.* 2014; Baharuddin *et al.* 2013, Morgan *et al.* 2013, Bergqvist *et al.* 2012, Benjakul 2009). As a result of climate change, increased river salinity is projected for southwest coastal Bangladesh by 2050 (Dasgupta *et al.* 2014).

2.4.5 Impacts

Poor water quality, low availability and poor sanitation cause waterborne diseases. An estimated 1.8 million deaths occur annually in Asia and the Pacific due to water-related diseases including diarrhoea and cholera. (WHO 2008). Salt intrusion

and higher turbidity from stronger, frequent storms and erosion from deforestation provides favourable growth conditions in tropical estuaries for bacteria such as *Vibrio* that causes cholera (Lara *et al.* 2009). Other diseases related to water, sanitation and hygiene include intestinal nematode infections, protein-energy malnutrition, trachoma, schistosomiasis, lymphatic filariasis, malaria and dengue. Disability-adjusted life years lost due to unsafe water, sanitation and hygiene in the region totals 24.78 million per year (Anand 2012).

Another factor affecting human health from water pollution is the accumulation of heavy metal in plants that are then consumed as food. Many studies have looked at accumulations of arsenic, cadmium, copper, lead and mercury in vegetables, rice and other edible plants (Arunakumara *et al.* 2013; Lu *et al.* 2015). The extent of bioaccumulation depends on irrigation methods, much less arsenic accumulation has been observed in rice grown by sprinkler irrigation compared to that grown using continuous flooding irrigation (Spanu *et al.* 2012).

Water pollution affects mammals and birds using inland water sources: globally 24 per cent of mammals and 12 per cent of birds are estimated to be threatened by it (Pacific Institute 2010). Freshwater fish and amphibians also face the risk of extinction. Changes in river flows due to infrastructure developments, which can reduce the transport of nutrients downstream, also impact ecosystems. Freshwater ecosystems provide more than USD75 billion in goods and services that can be threatened by water quality problems (Pacific Institute 2010). Fragmentation of rivers by dams has an adverse effect on the ecosystems besides impacting humans due to loss of flood plain fisheries and flood recession agriculture (Nilsson *et al*. 2005).

The risk of floods is increased due to soil erosion, accumulation of solid wastes in rivers, and changes in land-use patterns affecting flood plains and water runoff.

Because of frequent severe floods and droughts, the region's water security is adversely affected by contamination of water and falling availability.

Rapid urbanization has led to increases in water demand and extraction of groundwater, particularly when surface waters are polluted. Extraction is one of the causes of land subsidence in coastal cities (Deltares 2015) including Bangkok, Ho Chi Minh City, Jakarta and Manila and increases the risk of flooding and damage to critical infrastructure and buildings.

Water security is a concern in this region that is undergoing rapid urbanization, and climate change could lead to conflicts due to competition for this limited resource.

2.5 Coasts and oceans

2.5.1 Introduction

Asia and the Pacific's coastline (Table 2.5.1) has multiple shore types. The region contains the world's two largest archipelagic nations (Indonesia and Philippines) and all five of the world's nations that are entirely atolls (Kiribati, Maldives, Marshall Islands, Tokelau and Tuvalu).

Approximately 45 per cent of the world's mangrove forests are on its tropical and subtropical coasts and approximately 40 per cent of the world's coral reef area is in Southeast Asia (Hijioka *et al.* 2014). The Coral Triangle of 5.7 million square kilometres covering the ocean waters of Indonesia, Malaysia, Papua New Guinea, the Philippines, Solomon Islands and Timor-Leste (Hijioka *et al.* 2014) is recognized as the global centre of marine biodiversity based on its extremely high biodiversity and goods and services value (APEC 2014). In the South Pacific, the exclusive economic zones (EEZs) and the connecting high seas of 15 island states that cover nearly 40 million square kilometres of the Pacific

Key Messages

The Asia Pacific region contains the world's two largest archipelagic nations (Indonesia and Philippines) and all five of the world's nations that are entirely atolls. The region also contains about 45 per cent of the world's mangrove forests and about 40 per cent of the world's coral reef area.

- More than 325 million people are expected to live in the coastal zone by 2025.
- Emerging economies impact on coral reefs, mangrove forests, salt marshes, seagrass beds and kelp forests and severe erosion prevails on one-quarter to one-third of the coastlines in Southeast Asia.
- About 60 per cent of the mangroves in Asia and the Pacific have been cleared for coastal development and more than 80 per cent of its coral reefs are at risk.
- Climate change impacts of increasing sea surface temperature, ocean acidification and sea-level rise are exacerbating coastal and marine degradation.
- Coastal areas are highly overfished and the nearshore and capture fish stocks depleted throughout the region.

Ocean represent the world's largest conservation area (Conservation International 2010). Both the Coral Triangle and Pacific Oceanscape have policy implications for ocean management. Ocean and coastal resources support key industries and economic sectors, including fisheries and coastal tourism within the Asia and the Pacific region.

The Pacific island communities face specific problems in terms of energy security, waste management, and conservation of natural resources and marine ecosystems (UNU 2015). Pacific island states are among the world's areas most vulnerable to changing climate and ocean and coastal degradation, with more than 50 per cent of the population living within 1.5 kilometres of the coast. International airports, capital cities, roads and other infrastructure on these small islands are sited along the coasts, or on tiny coral islands (APEC 2014).

2.5.2 Drivers

Climate change

Climate change , with its impacts of increasing sea-surface temperature, ocean acidification and sea-level rise, is an increasing driver of pressures on coastal and marine systems in the Asia and the Pacific region. Ocean warming, changes in ocean circulation and abrupt shifts in precipitation patterns have strongly impacted the Pacific island economies. A general trend of increased frequency of natural disasters caused by hydro-meteorological events, such as cyclones and flooding, prevails in the region (APEC 2014).

Of the ten economies in the world that are at greatest risk from climate-change impacts, six are in the Asia and the Pacific region, including low-lying Pacific island economies (APEC 2014). Coastal systems and low-lying areas in the region will increasingly experience adverse impacts such as submergence, coastal flooding and coastal erosion due to relative sea-level rise. Regionally, South, Southeast and Northeast Asia and the Pacific island states have been identified as the most vulnerable (Wong *et al.* 2014). Compared to other regions, Asia has the greatest exposure in terms of population and assets. Globally, the top five nations classified by population in coastal low-lying areas are in Asia – Bangladesh, China, India, Indonesia and Viet Nam (Wong *et al.* 2014).

Increased atmospheric carbon dioxide causes ocean warming and ocean acidification that increase the solubility

Table 2.5.1: Asia and the Pacific: coastline length (>500 kilometres)

Country	Coastline length, km
Indonesia	54 716
Philippines	36 289
Japan	29 751
Australia	25 760
China	16 799
New Zealand	15 134
India	7 000
Micronesia, FS	6 112
Solomon Islands	5 313
Papua New Guinea	5 152
Malaysia	4 675
Viet Nam	3 444
Thailand	3 219
Coral Sea Islands	3 095
Vanuatu	2 528
French Polynesia	2 525
Korea, DPR	2 495
Iran	2 440
Korea, Rep.	2 413
New Caledonia	2 254
Myanmar	1 930
Palau	1 519
Northern Mariana Is	1 482
Sri Lanka	1 340
Kiribati	1 143
Fiji Islands	1 129
Pakistan	1 046
Timor-Leste	706
Maldives	644
Bangladesh	580

Source: CIA 2016

of calcite, magnesium-calcite and aragonite, essential components of shells and skeletons of marine organisms (Pörtner *et al.* 2014). Continuation of current trends in sea-surface temperatures and ocean acidification in the region would result in large declines in coral-dominated reefs by mid-century (Hijioka *et al.* 2014).

In 2012, the annual economic damage of ocean acidification-induced coral reef loss by 2100 was estimated at USD870 billion and USD528 billion, respectively for the A1 and B2 Special Report on Emissions Scenarios (SRES IPCC) (Gattuso *et al.* 2014a). Such trends represent a very large GDP loss for the economies of many coastal regions or small islands that are dependent on coral reefs (Gattuso *et al.* 2014b). Regional variability in El Niño-Southern Oscillation (ENSO) periodicity in the Pacific has a strong influence on fisheries production (Hoegh-Guldberg *et al.* 2014).

Sea-level rise will not be uniform in space and time as it is influenced by natural modes of climate variability in different regions of the globe. Also, many large cities on Asian deltas and coastal plains have subsided during the past 100 years: about 4.4 metres in eastern Tokyo, 2.6 metres in Shanghai and 1.6 metres in Bangkok (Wong *et al.* 2014).

For low-lying coastal areas on islands and atolls, sea-level rise poses one of the most widely recognised climate change threats. The average rate of sea-level rise is estimated at 0.77 and 1.5 millimetres per year in the Pacific and Indian Oceans respectively (UN-Habitat 2015). Rates up to four times the global average, about 12 millimetres per year, have been reported between 1993 and 2009 in the tropical western Pacific where there are a large number of small island communities (Nurse *et al.* 2014). Sea-level rise projections in small island regions under an intermediate low-emissions scenario by the end of the century, compared to 1986–2005, are 0.5–0.6 metres in the Pacific and Indian Oceans, and 0.4–0.5 metres in the North Indian Ocean, similar to global projections of 0.4–0.7 metres (Nurse *et al.* 2014).

Natural hazards

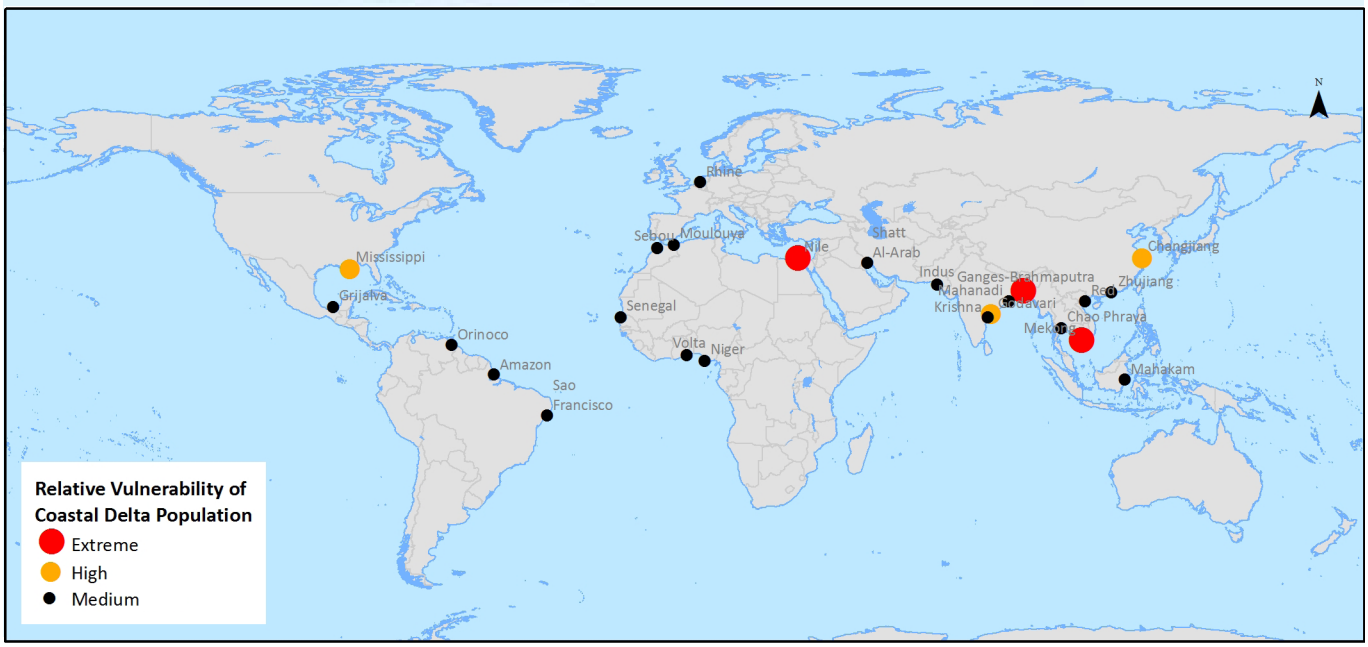
The Asia and the Pacific region is one of most disaster-prone regions in the world accounting for 90 per cent of the increase in people affected by intense disasters from 1971–1980 to 2001–2010 (APEC 2014). In recent decades hydro-meteorological disasters such as floods and storms, and climatological disasters such as droughts but not earthquakes and volcanic eruptions have been trending upwards (Thomas *et al*. 2013).

Of the global population exposed to tropical cyclones, 90 per cent are in Asia. By the 2070s, the top Asian cities in terms of population exposure to coastal flooding will be Bangkok, Dhaka, Guangzhou, Hai Phong, Ho Chi Minh City, Kolkata, Mumbai, Shanghai and Yangoon (Hijioka *et al*. 2014). Three of the world's five most populated cities – Delhi, Shanghai and Tokyo – are located in high-risk flood areas (Hijioka *et al*. 2014) (**Figure 2.5.1**).

Coastal flooding in Bangladesh and deltaic areas (**Figure 2.5.1**) of the Asia and the Pacific region is caused by heavy rainfall and landfall of typhoons and cyclones. Six Southeast Asian countries have sea-level rise higher than the mean global average (Wong *et al.* 2014). In the absence of adaptation, hundreds of millions of people and billions of US dollars assets are projected to be affected by coastal flooding (**Figure 2.5.2**) and will be displaced due to land loss, with the majority from Northeast, Southeast and South Asia (Wong *et al*. 2014).

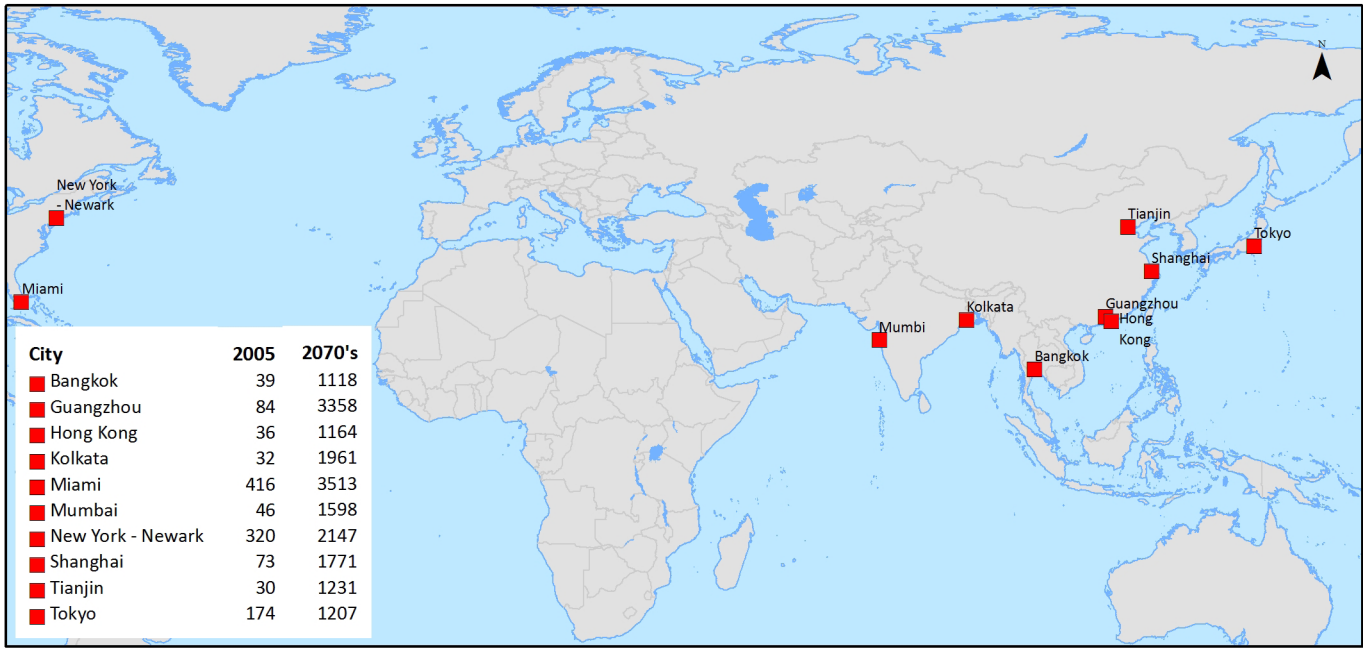
Compared to continental coasts, many Asia and the Pacific islands are inherently more vulnerable to natural hazards

Figure 2.5.1: Asia, most vulnerable deltas



Source: IPCC 2007

Figure 2.5.2: Global, top ten cities ranked by asset exposure (USD billion) to coastal flooding, 2070's



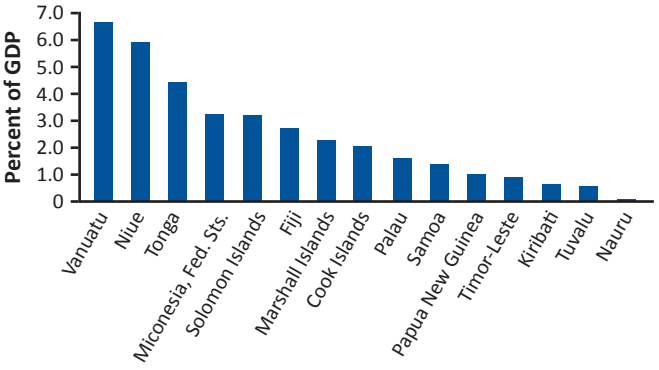
City	2005	2070's
Bangkok	39	1118
Guangzhou	84	3358
Hong Kong	36	1164
Kolkata	32	1961
Miami	416	3513
Mumbai	46	1598
New York - Newark	320	2147
Shanghai	73	1771
Tianjin	30	1231
Tokyo	174	1207

Source: Nicholls *et al.* 2008

since they are volcanically and/or seismically active (Terry and Goff 2012). In particular, the Pacific island states (**Figure 2.5.3**) are vulnerable to a range of natural hazards such as cyclones and floods, and earthquakes and tsunamis (SPC 2014).

Livelihoods can be impacted negatively by natural disasters, economic crises and climate change. On coastal areas highly exposed to cyclones and typhoons the poor tend to be more exposed to natural disasters because they live on hazardous land (UNESCAP 2013). Evidence suggests that climate change and climate variability and sea-level rise will exacerbate multidimensional poverty in most developing countries. By 2050 areas of storm surge zones are expected for Bangladesh, China, India, Indonesia, and the Philippines, with a combined total of more than 58 million people at risk (Olsson *et al.* 2014).

Figure 2.5.3: Pacific island states, economic losses due to tropical cyclones, earthquakes and tsunamis



Source: World Bank 2012a

Coastal tourism

Tropical coastal tourism is a major industry in the Asia and the Pacific region, contributing significantly to economic growth and local employment. Earlier development of coastal tourism in the region was largely unplanned, resulting in detrimental environmental and socio-cultural impacts (Wong 2013). The coastal tourism industry is, however, increasingly aware of the need to preserve coastal ecosystems, particularly in niche areas of eco and dive tourism (Wilson and Tisdell 2015). In Thailand, Koh Tao grants the second highest number of dive certificates in the world after Cairns on the Great Barrier Reef region of Australia (Wongthong and Harvey 2014).

Southeast Asia has advantages compared with other areas, with Indonesia, Malaysia and Thailand being successful coastal tourism destinations while the Cambodia, Philippines and Viet Nam have enormous potential (Mazumder *et al.* 2013). While cruise tourism is one of the world's fastest growing tourist activities, the Asia and the Pacific share of 6 per cent of global market is small and remains in the product-introduction phase (UNWTO 2012).

Coastal tourism continues to be highly vulnerable to weather, climate extremes and rising sea levels. Reef tourism is also sensitive to ocean temperature and acidity. Within the tropics, developing countries and small island states relying on coastal tourism are most vulnerable to present and future weather and climate extremes, future sea-level rise, and the additional impacts of coral bleaching and ocean acidification (Wong *et al.* 2014).

Shipping and port development

Seaborne trade has been a driver of economic development of Asian-Pacific countries and sea lines of communication to regional countries have increased. The region has two significant sea lines of communication, one passing through the South China Sea to the Indian Ocean and the Middle East, the other passing through the East Sea to the Pacific Ocean and the Pacific coast of North America.

For ship movements, Asia remained the main global loading and unloading area in 2013, with a 41 per cent share of total loading and 58 per cent of unloading. Of global seaborne trade, dry cargo accounted for the largest share, 70.2 per cent, followed by tanker trade (UNCTAD 2014). Asia had 15 of the world's 20 leading container ports in 2011–2013. All the top ten ports are located in Asia and 11 of the top 20 in China (UNCTAD 2014).

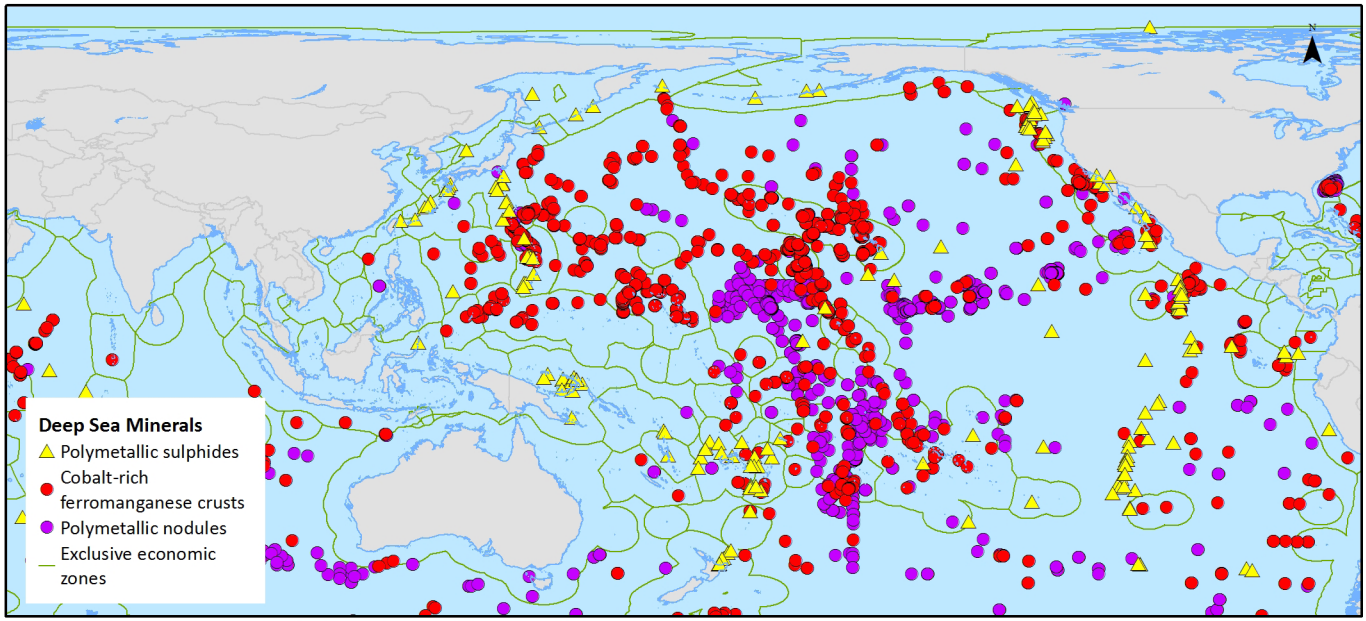
In contrast, the Pacific island states face shipping-related challenges resulting from their size, remoteness, exposure to natural hazards and vulnerability to the impacts of climate change. Their remoteness from main global trade routes is a major disadvantage in terms of cost and time. Furthermore, as open small economies, the Pacific small island developing states are also vulnerable to global economic and financial shocks (UNCTAD 2014).

Deep sea mining

Deep sea mining for minerals represents a new driver in the waters of Asia and the Pacific. Three main kinds of deep-sea mineral resources (**Figure 2.5.4**) – sea-floor sulphide deposits, manganese nodules and cobalt-rich ferromanganese crusts – have been discovered within the national jurisdictions of several Pacific island states.

Massive sulphide deposits have been found in the EEZs of a number of island states, presenting a challenge and an opportunity for Pacific island nations, who are new to deep-sea mining. Papua New Guinea has issued a pioneering lease for deep seabed mining, the Solwara 1 Project (SPC 2013). Plans for mining in the Bismarck Sea, off Papua New Guinea, are already at an advanced stage, and partners expect mining operations to begin in 2018 (Goddard 2015).

Figure 2.5.4: Deep sea minerals in Pacific



Source: UNEP 2014

2.5.3 Pressures

Increased coastal population

Despite its vulnerability, the coastal zone has inherent attractiveness for human settlement (Costanza *et al.* 2011), with the increasing population taking advantage of terrestrial and marine resources. Continued urbanization in the region will draw greater populations into its coastal zone.

In China, export-driven economic growth has been associated with very rapid coastward migration (McGranahan *et al.* 2007). In Viet Nam, 80 per cent of the country's most rapidly growing industrial sector is located within a coastal corridor from Hai Phong to Ho Chi Minh City. The coastal urban agglomerations host a considerable portion of both the urban population and ongoing development of manufacturing and service infrastructure (Chun 2015).

By 2025 Asia's population is projected to increase by 25 per cent, translating to 325 million more people living in the coastal zone (**Table 2.5.2**), where the potential environmental impact will be greatest (Schwartz 2005).

Coastal zone degradation

Southeast Asia is identified as a terrestrial and marine biodiversity hotspot. Asia and the Pacific is under pressure from coastal zone degradation in various forms and ways. The emerging economies of the region exert considerable pressures on biodiversity and habitats with coral reefs, mangrove forests, salt marshes, seagrass beds and kelp forests, which are of enormous value to the region, having

Table 2.5.2: Asia and the Pacific: change in coastal populations within 100 kilmetres of the coast, 2000-2025

Country	Population change, 2000–2025 within 100 km from coast, ('000 people)	Increase (%)
Australia	4 574	27
Bangladesh	28 315	40
Cambodia	1 376	52
China	48 991	16
Fiji	322	38
India	85 062	32
Indonesia	60 110	29
Japan	-4 892	-4
Korea, DPR	5 642	26
Korea, R	5 650	12
Malaysia	9 092	42
Myanmar	8 967	37
New Zealand	1 118	30
Pakistan	10 274	72
Papua New Guinea	1 674	57
Philippines	30 157	40
Singapore	1 325	37
Solomon Islands	400	90
Sri Lanka	5 113	27
Thailand	3 326	14
Viet Nam	24 474	37

Source: Schwartz 2005

already been adversely affected. The degradation of coastal ecosystems has been exacerbated by decreasing ecological resilience and by climate change (APEC 2014).

Most of Asia's tropical and temperate coastal ecosystems are already under such severe pressure that the added impacts of climate change are hard to detect. For coastal areas, sea-level rise will be the key factor, particularly if combined with changes in cyclone frequency or intensity, or, in Arctic Asia, with a lengthening if the open-water season (Hijioka *et al.* 2014).

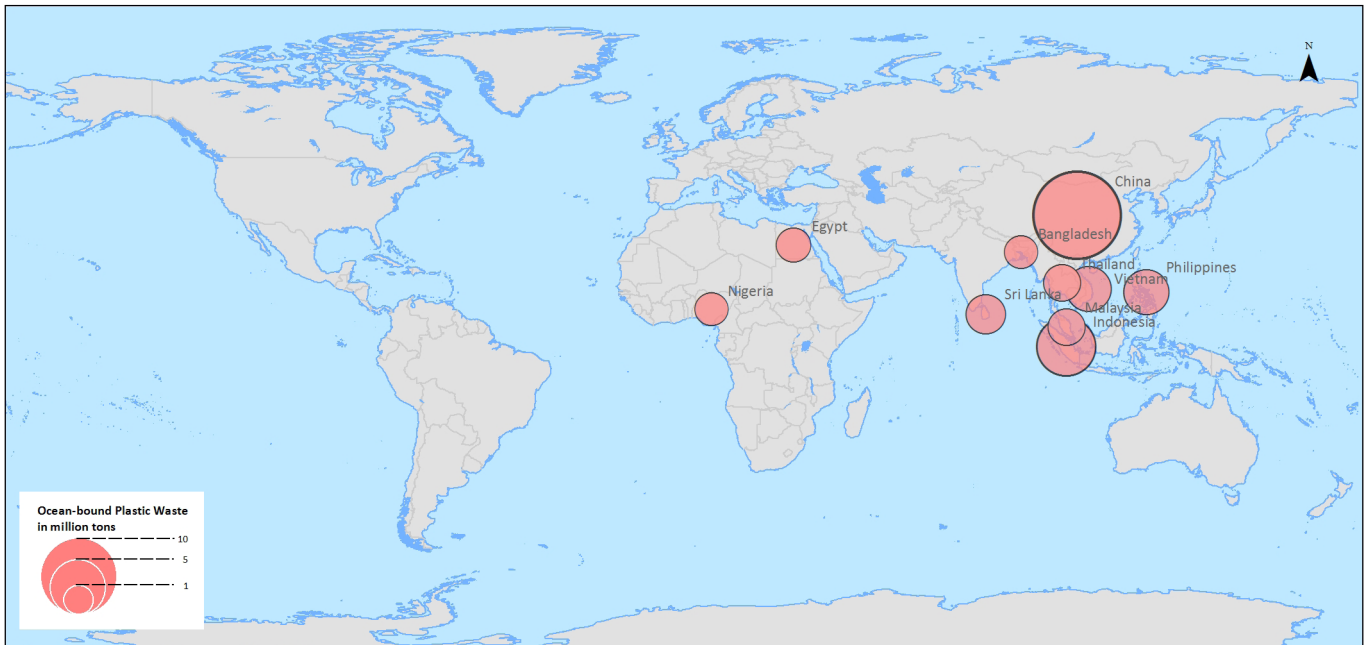
Pollution and marine litter

Oxygen-minimum zones (OMZs) are naturally present in many habitats, including marine sediments, but are expanding due to anthropogenic influences. Future warming will accelerate the spread of hypoxic zones, especially in temperate to sub-polar regions (Pörtner *et al.* 2014).

In Asia, rapid economic and population growth in the coastal areas, combined with increasing industrial production, consumption and trade of food and energy, have placed huge environmental pressures on coastal ecosystems. Of these effects, the intensification of hypoxia has been the most fundamental in estuarine and coastal marine systems. Until recently, hypoxic areas were located mainly in developed countries, but the largest future increases in the number of hypoxic areas are expected in southern and eastern Asia (STAP 2011).

Commensurate with mass production in the 1940s, plastic waste started to accumulate in the oceans, some dumped from ships. International agreements banning waste disposal at sea only came into force half a century later in 1988. A category of plastic waste, termed microplastics, is of increasing concern (GESAMP 2015). Most of the waste found in the oceans, whether it is washed up on the shores or spiralling in gyres, comes from land-based sources (**Figure 2.5.5**). On the basis of the estimated mass of plastic waste generated in 2010 by populations living within 50 kilometres of the coast, the top five land-based sources of ocean's plastic waste in Asia were, in order,: China, Indonesia, Viet Nam, the Philippines and Sri Lanka (Jambeck *et al.* 2015).

Figure 2.5.5: Top ten sources of plastic waste



Source: Parker 2015

2.5.4 State and trends

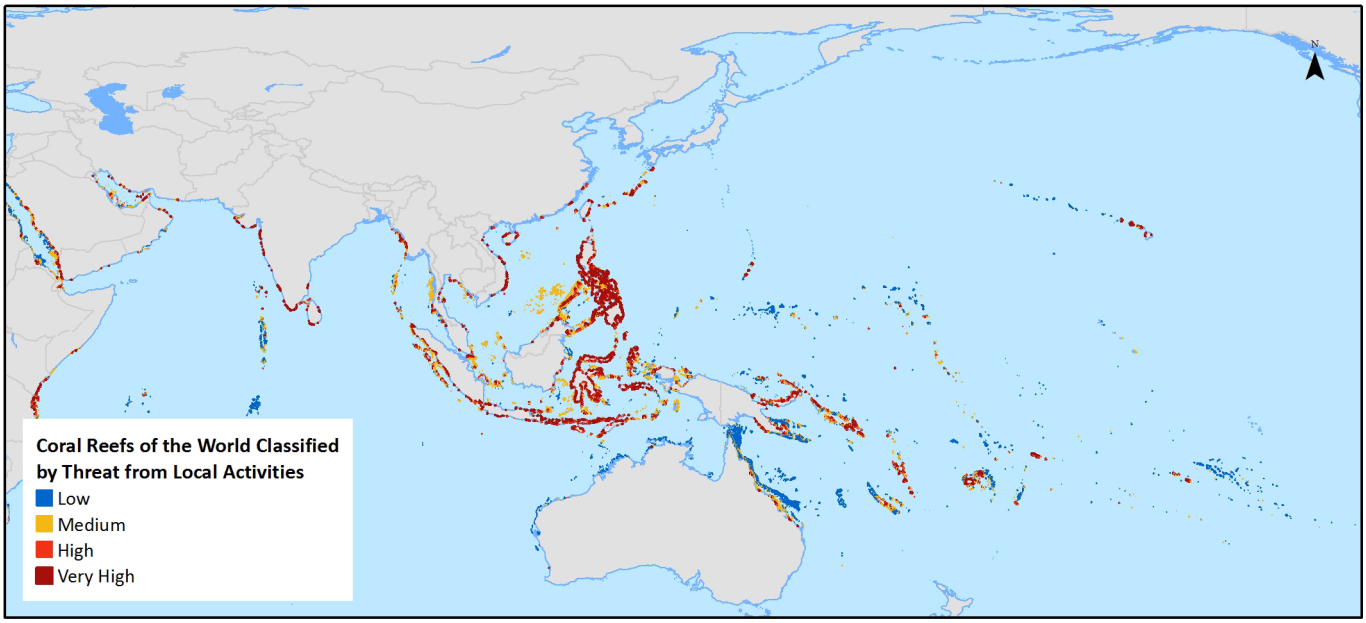
Ecosystem loss and coastal erosion

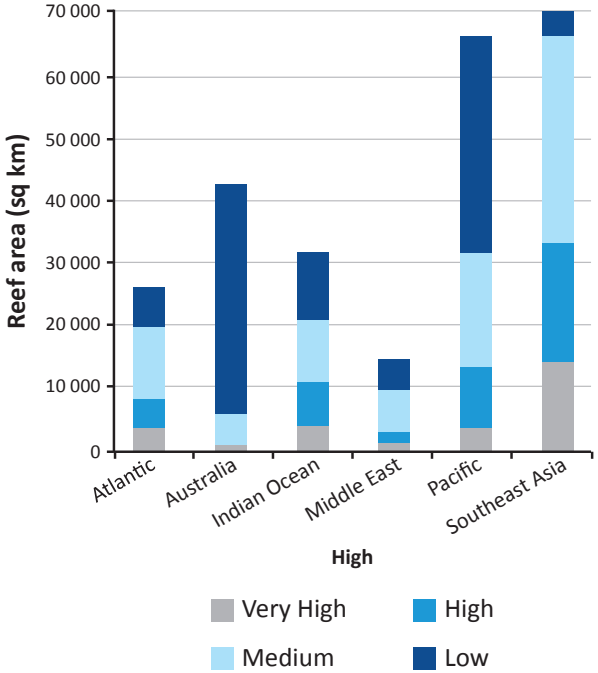
About 60 per cent of the original extent of mangroves in Asia and the Pacific have been cleared for coastal development, aquaculture activities and land reclamation (APEC 2014). In Southeast Asia the destruction of mangrove forests stems mainly from their conversion for brackish-water aquaculture (Macusi *et al.* 2011). The lack of adequate coastal zone management plans and subsequent site allocation in many countries has led to conflicts among competing users for land and water (FAO 2014). Food and faecal and metabolic wastes from intensive fish farms can result in the eutrophication of water in rivers and coastal bays (WOR 2013).

Coral reefs (**Figure 2.5.6**) face unprecedented threats from the combination of rapid population growth, destructive fishing practices, eutrophication and sedimentation, and natural climate variability (Macusi *et al.* 2011). In the Asia and the Pacific region more than 80 per cent of coral reefs are at risk and 56 per cent are at high risk. In South Asia most coral reefs have been impacted negatively by coral bleaching and ocean warming (APEC 2014). The Pacific, with about 50 per cent of its reefs threatened, has experienced the largest increase in threat over the past ten years (Burke *et al.* 2012).

Within the Asia and the Pacific region, widespread damage to coral reefs, correlated with episodes of high sea-surface temperature, has been reported in recent decades (Hijioka *et al.* 2014). The degree of impact, however, depends on

Figure 2.5.6: Reefs at risk from integrated local threats, by area of reef in various sub-regions, square kilometres, 2012





Sources: WRI 2012, Burke *et al.* 2012

the adaptability of the coral reefs to thermal stress and the interaction of multiple drivers (Pörtner *et al.* 2014). From 1985 to 2012, tropical cyclones, coral predators and thermal stress-related coral bleaching and mortality led to a decline in coral cover on the Great Barrier Reef by about 51 per cent. Future impacts of climate-related drivers – ocean warming, ocean acidification, sea-level rise, more intense tropical cyclones and rainfall events – will exacerbate the impacts of non-climate–related drivers (Hoegh-Guldberg *et al.* 2014).

Coastal erosion became an issue of emerging concern in littoral countries of the East Asian Seas in 2009. Severe, 1–5 metres per year, to very severe erosion, >5 metres per year, prevails on one-quarter to one-third of the coastlines in six Southeast Asian countries (Cambodia, Indonesia, Malaysia, Philippines, Thailand and Viet Nam) (UNEP 2012a). Coastal erosion is often exacerbated by human activities that deprive the coast of sediments or protection. Mangroves, salt marshes, and seagrass beds decline or can move inland unless they receive sufficient fresh sediment to keep pace.

Overfishing

As marine organisms live in limited temperature ranges and are sensitive to temperature extremes (Pörtner *et al.* 2014), climate change may lead to a massive redistribution of fisheries catch potential with large increases in high-latitude regions but large declines in the tropics (Hijioka *et al.* 2014). At even relatively low levels of warming of 1–2 °C, many coastal natural systems are in jeopardy.

The coastal areas of the region are highly overfished and the fish stocks depleted (Macusi *et al.* 2011). In the Western Central Pacific stocks are now in a critical condition with most fully exploited or overexploited. The Bay of Bengal and the Andaman Sea are also heavily exploited (WOR 2013). Illegal, unreported and unregulated (IUU) fishing exacerbates the problem of overfishing and threatens the livelihoods of fishers and other stakeholders. After West Africa, the Western Central Pacific Ocean is the region with the highest rate of IUU fishing, estimated to be 34 per cent of the total catch (WOR 2013).

Marine areas beyond national jurisdictions (ABNJ or the high seas) are increasingly under threat from human activities, including seabed mining, navigation and fishing. In Asia, the Republic of Korea, New Zealand and Russia are at the forefront of deep-sea fishing. Around 70 per cent of the ships employ trawl nets that can reach a depth of 2 000 metres. Bottom fishing has significant impacts on cold-water corals or the ecosystems on seamounts, which are destroyed when nets come in contact with the bottom, and fish species are quickly wiped out (WOR 2013).

Saltwater intrusion

In coastal regions of Asia, including Bangladesh and much of Southeast Asia, sea-level rise threatens the salinization of coastal aquifers, with effects on drinking water sources and coastal ecosystems (WWAP 2015a). By 2050, climate change is projected to cause significant changes in river salinity in the southwest coastal area of Bangladesh. An increase in moderate to high saline river area, 5–10 deciSiemens per metre, from 8–27 per cent, and an increase in highly saline river area, >10 deciSiemens per metre, from 35–40 per cent is projected (Dasgupta *et al.* 2014).

Over-withdrawals have threatened groundwater sources. Aquifer levels have fallen by 20–50 metres in cities including Bangkok, Manila, and Tianjin and by 10–20 metres in many others (Hijioka *et al.* 2014). Excessive groundwater abstraction may also result in saltwater intrusion. All aquifers in Ho Chi Minh City are affected by salinity. In Bangkok, a serious concern is the increased concentration of chloride and total dissolved solids in groundwater (WWAP 2015b).

For the Pacific islands the impacts of saltwater intrusion are serious. Wave overtopping and wash-over have been shown to impact freshwater lenses dramatically and could become more frequent with sea-level rise. On atoll islands, the population, infrastructure, agricultural areas and fresh groundwater supplies are all vulnerable to extreme tides, wave and surge events and sea level rise. There is a growing concern amongst the island communities of the Pacific and Indian Oceans that freshwater scarcity and more intense

droughts and storms could lead to deteriorating standards of sanitation and hygiene (Nurse *et al.* 2014).

2.5.5 Impacts

Environmental impacts

Increased coastal population growth and development have serious and negative environmental impacts on the coasts and oceans of Asia and the Pacific and these are likely to be exacerbated by climate change and coastal hazards. Climate change may lead to a massive redistribution of fisheries catch potential with large increases in high-latitude regions, including Asian Russia, and large declines in the tropics, particularly Indonesia (Hijioka *et al.* 2014).

Widespread damage to coral reefs correlated with episodes of high sea-surface temperature has been reported in recent decades. Continuation of current trends in sea surface temperatures and ocean acidification would result in large declines in coral-dominated reefs by mid-century (Hijioka *et al*. 2014). The degree of impact will depend on the coral reefs' adaptability to thermal stress and the interaction of multiple drivers (Pörtner *et al.* 2014). The Great Barrier Reef is highly vulnerable to both warming and acidification with increased frequency and severity of coral bleaching, disease incidence and mortality (Reisinger *et al.* 2014).

Impacts on livelihoods

Livelihoods can be impacted negatively by natural disasters, economic crises and climate change. In coastal areas highly exposed to cyclones and typhoons, the poor tend to be more exposed to natural disasters because they live on hazardous land. As the population of the Asia and the Pacific region increases, more people are living in coastal areas and cities, especially in the mega-cities that have more than 10 million inhabitants (UNESCAP 2013). Evidence suggests that climate change, climate variability and sea-level rise will exacerbate multi-dimensional poverty in most developing countries. By 2050 storm surge zones, with a combined total of more than 58 million people at risk, are expected in Bangladesh, China, India, Indonesia, and the Philippines (Olsson *et al*. 2014).

The people more likely to be affected are those with livelihoods dependent on the coast (agriculture, fishing and tourism) as they are unable or unwilling to move inland. The small island developing states, with their high proportion of productive capital located on the coast, are particularly at risk (CRED 2015).

2.6 Waste

2.6.1 Introduction

The Asia and the Pacific region is facing serious waste management issues. There have been various initiatives, however, for promoting integrated solid waste management across the region.

With rapid population increase, economic growth, industrialization and urbanization, waste generation in Asia and the Pacific is increasing. It is facing various issues including poor waste separation, low collection rates, unsafe informal recycling practices and uncontrolled disposal (UNEP and ISWA 2015; Pariatamby and Tanaka 2014). These issues are common in developing countries and particularly critical for small island developing states due to their limited land capacity and fragile ecosystems. Besides that, the lack of a common definition of waste for all countries, a coherent and systematic database and a good national reporting system on waste management are also big issues in the region.

There have been various initiatives across the region since the end of the 1990s to promote concepts such as integrated solid waste management, cleaner production, the 3Rs – reduce, reuse, recycle, zero waste; the sound material-cycle society, and the circular economy. Japan launched its 3R Initiative in 2004 and, together with the United Nations Centre for Regional Development (UNCRD), established the

Key Messages

Total waste generation is increasing at an alarming rate. Poor waste management leads to serious impacts on human health, pollution and environmental degradation, critical land management issues in small island developing states (SIDS) and greenhouse gas emission.

- Municipal solid waste generation accounted for 43% of the world total in 2014 and it is projected to rise to 1.4 billion tonnes annually to 2030. The region has experienced emergence of new and complex waste streams like e-waste, food waste, construction/demolition waste, disaster waste and marine litter.
- In developing countries, waste avoidance and reduction measures are weak; waste collection rates range from low to moderate without proper waste segregation at source.
- Waste recycling rates are low and the recycling usually is implemented by the informal sector.
- Uncontrolled dumping is still the main waste disposal method in the region leading to leachate run off, methane emission and other environmental problems. However, recent emergence of waste to energy investment programs could be further enhanced for better waste disposal.

The region requires a more effective national reporting system on waste management especially in the developing countries.

Regional 3R Forum in Asia and the Pacific in 2009. Together with promotional initiatives in many countries, the small island developing states adopted the Pacific Region Solid Waste Management Strategy 2010–2015 in 2009, as well as the SIDS (Small Island Developing States) Accelerated Modalities of Action (SAMOA) Pathway for dealing with environmental issues in 2014. As in other parts of the world, there have also been many multi-stakeholder waste management initiatives including community-based waste management in Asia and the Pacific (Anschütz 1996). Various technologies such as mechanical biological treatment (MBT), composting, landfill mining and reclamation, and waste-to-energy, have also been developed and applied in the region.

2.6.2 Drivers

Population growth, fast economic development and rapid urbanization are the key drivers of waste generation in Asia Pacific.

Asia and the Pacific population is growing rapidly and expected to be around 5 billion people by 2050. The region also has the fastest economic growth in the world, with a steady rise in GDP due to the growth of manufacturing powers including Japan, Republic of Korea and Australia, as well as emerging economies such as China and India. With this economic development, per person income has increased and there has been a rapid emergence of a rising middle class, from 21 per cent in 1990 to 56 per cent of total population in 2008 in Asia (ADB 2010). At the same time, the region is experiencing the fastest rate of urbanization in the world, accounting for nearly 48 per cent of global urban population in 2014 and projected to increase to about 63 per cent by 2050 (Section 1.1).

2.6.3 Pressures

Increasing consumption, especially among the emerging middle-income class, inefficiency in resource use and inadequate urban infrastructure are the main pressures on waste management in Asia and the Pacific.

With population growth, income improvement and the emerging middle class, consumption has been increasing, but is dependent on the unsustainable and inefficient use of resources. Rising sharply over the past four decades, Asia and the Pacific's material consumption accounted for more than 50 per cent of the world total in 2015 (Section 1.2). At the same time, however, the region's material use relative to its economic productivity has not improved and is still very high – double the global figure and nearly four times the average of the rest of the world in 2015.

In addition, rapid urbanization, especially in developing countries, is usually accompanied by underdeveloped infrastructure, with inadequate waste management facilities or capacity for waste separation, collection, transfer and transport, treatment and disposal, and recycling and recovery.

2.6.4 State and trends

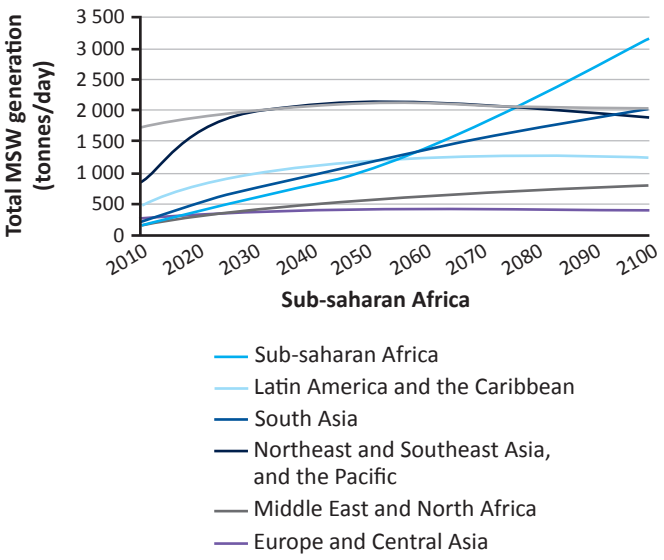
Waste generation

Waste generation in Asia and the Pacific is rising and new and complex waste streams are emerging.

According to the *Global Waste Management Outlook*, total global waste is around 7–10 billion tonnes per year, of which total municipal solid waste (MSW) is around 2 billion tonnes (UNEP and ISWA 2015). With an average generation rate of 1.4 kilograms per person per day, the annual total MSW for Asia and the Pacific was estimated at around 870 million tonnes in 2014, accounting for 43 per cent of the world total.

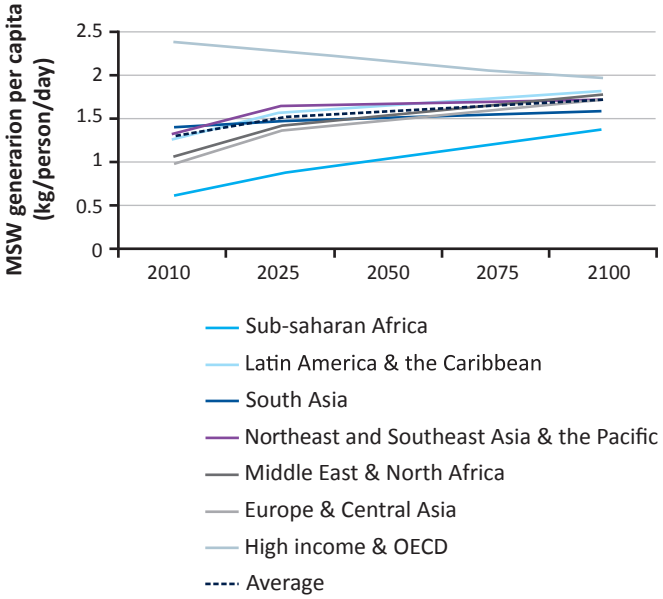
The quantity of generated municipal solid waste has a strong correlation with a country's income level, with higher-income countries producing more per person than lower-income countries. The Northeast and Southeast Asia and Pacific municipal solid waste generation rate of about 1.4 kilograms per person per day in 2010 was one of the highest in the world, but still much lower than in the Organisation for Economic Co-operation and Development (OECD) countries (~2.4 kilograms per person per day) (**Figure 2.6.1**).

Figure 2.6.1: Municipal solid waste (MSW) generation projections in different regions of the world, tonnes per day, 2010–2100



Sourcse: UNEP and ISWA 2015

Figure 2.6.2: Municipal solid waste generation projections per person, by region, kilogrammes per person per day, 2010–2100



Sources: UNEP and ISWA 2015

Municipal solid waste generation in Asia and the Pacific is projected to increase until 2030, when it could be 1.6 kilograms per person per day or around 1.4 billion tonnes a year (**Figure 2.6.2** and **Figure 2.6.3**).

With regard to the composition of municipal solid waste, the organic share comprises a greater proportion in low-income countries (50–70 per cent) than in high-income ones (20–40 per cent). The percentage of paper is also proportional to income levels, at 23 per cent of municipal solid waste in high-income countries, 19–11 per cent in middle-income ones and 7 per cent in low-income countries. The proportion of plastic, however, is less dependent on income levels than other waste types, at around 8–12 per cent across the board.

Household hazardous waste is estimated to make up less than 1 per cent of all municipal solid waste across all income groups, but its presence makes certain management options difficult (**Figure 2.6.4**).

Alongside the increase in municipal solid waste generation, Asia and the Pacific is now facing complex waste streams, including e-waste, food waste, construction and demolition waste, disaster waste and marine litter.

E-waste

Globally, as populations have increased so, too, has e-waste, reaching about 40 million tonnes in 2013 and forecast to be around 50 million tonnes in 2018. The Asia and the Pacific region is one of the largest generators of e-waste owing to the presence of China, Japan and India, three of the top five e-waste-generating countries in the world (together with the USA and Germany), with absolute volumes of 6 million tonnes, 2.2 million tonnes and 1.7 million tonnes respectively in 2014 (Balde *et al*, 2015).

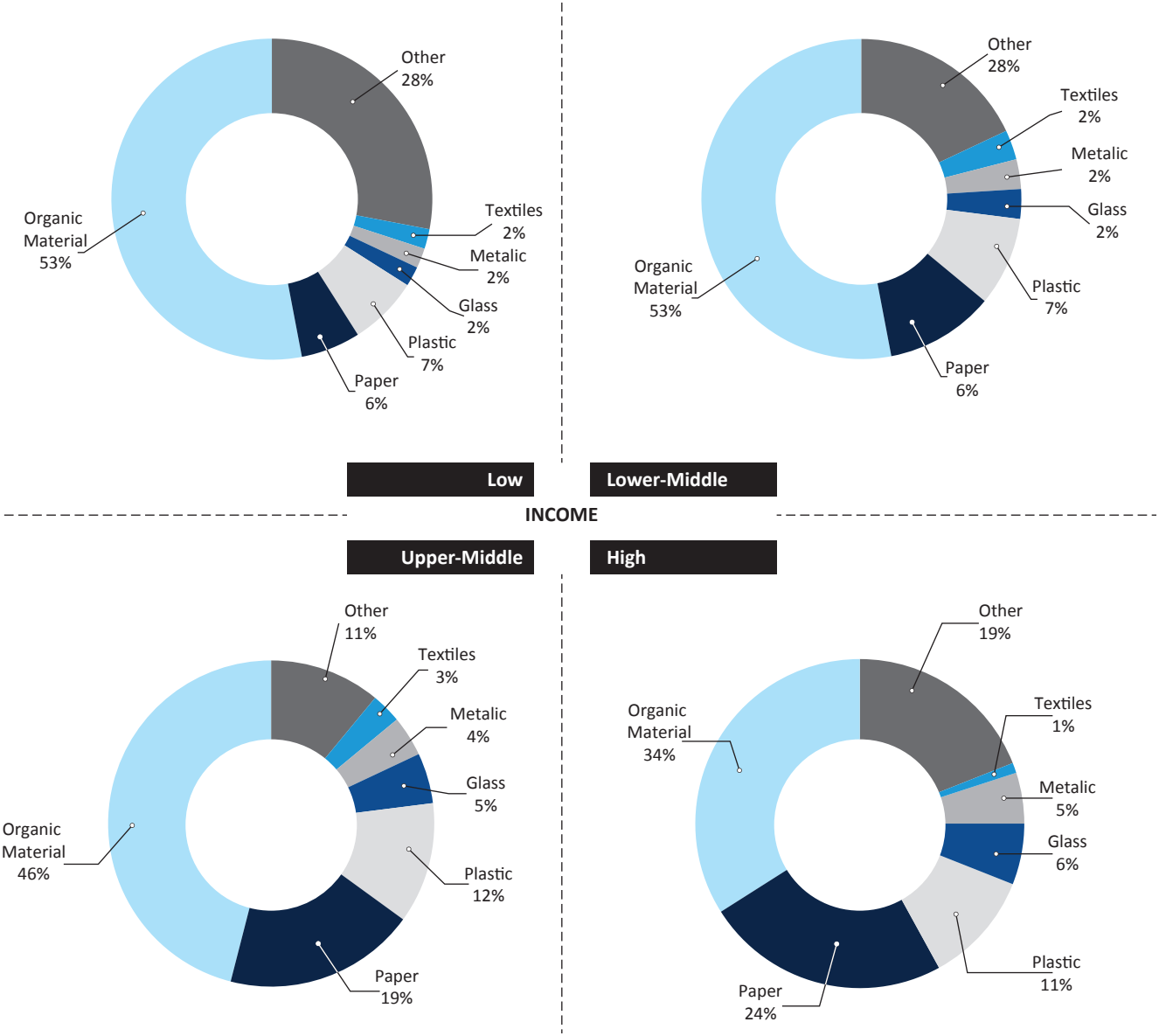
Food waste

With rising consumption, especially by the middle-income class, food waste is a major concern in large parts of the developing world and especially in the more developed economies of Asia and the Pacific, such as in China, Japan, the Republic of Korea and Singapore (FAO 2011b). On average, approximately 11 kilograms of food are wasted per person per year in developing Asian countries, and around 80 kilograms per person in developed countries such as Japan and the Republic of Korea (APO 2006); around half of all food is wasted in the Republic of Korea and Indonesia (**Figure 2.6.4**).

Construction and demolition waste

Rapid industrialization and urbanization has lead to rising construction and demolition waste and a lack of available

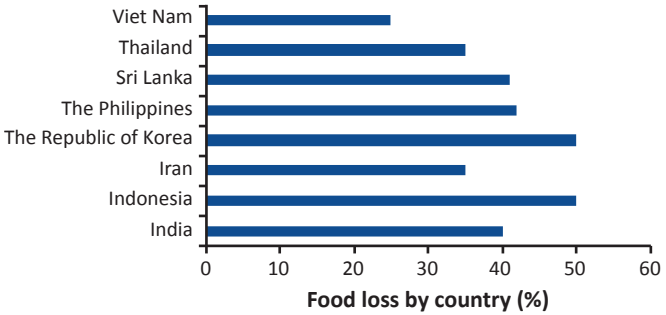
Figure 2.6.3: Composition of municipal solid waste by country and income group



Source: UNEP and ISWA 2015

Notes: Based on data from 97 countries (22 in Africa; 14 Asia and the Pacific; 35 Europe; 19 Latin America/Caribbean; 2 North America; 5 West Asia). Dates of the data vary between 1990 and 2009. "Other" means other inorganic waste.

Figure 2.6.4: Estimated food loss, by country



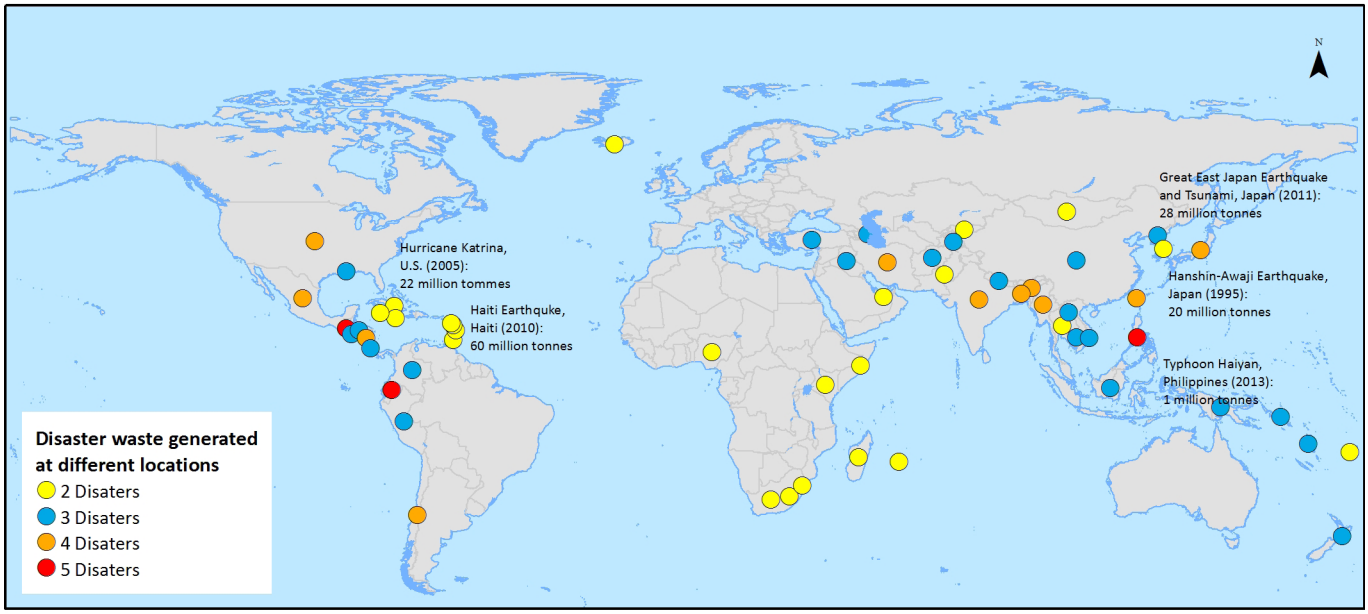
Source: APO 2006

land to dispose of such high-volume materials is an issue that every country in Asia and the Pacific now faces. About 350 million tonnes of this type of waste is generated annually in China (ADB 2015) and 531 million tonnes in India (Somvanshi 2014). In New Zealand, construction and demolition waste may represent up to half of all the waste generated.

Disaster waste

In the context of climate change, natural disasters and climate extremes are forecast to increased, destroying property and creating disaster waste. As one of the most vulnerable regions to climate change and natural disasters, Asia and the Pacific is facing an increase in this kind of waste. The Haiyan typhoon, for example, created 1 million tonnes of waste in the Philippines in 2013; the 2011 earthquake in Japan resulted in 28 million tonnes of waste; the accompanying tsunami produced an estimated 6.15 million tonnes of debris in Ishinomaki alone, equivalent to 103 years of the city's solid waste production in normal circumstances (UNEP 2012) (**Figure 2.6.5**).

Figure 2.6.5: Disaster waste generated at different locations across the world



Source: UNEP and ISWA 2015

Marine litter

Marine litter, from various human activities, both on land and at sea and is an emerging environmental issue**.** There are about 18 000 pieces of plastic on the surface of every square kilometre of the world's oceans, and these are augmented by an estimated 4.8–12.7 million tonnes of plastic waste that enter the oceans every year (UNEP and ISWA 2015), much of it collecting in the five sub-tropical ocean gyres, forming floating garbage patches (UNEP 2006). Asia and the Pacific has a large ocean area and thus is facing a rise in marine litter, mainly plastics waste. In the waters around Australia, up to 70 per cent of the marine litter that enters the sea ends up on the seabed, while 90 per cent of floating marine litter is plastic or polystyrene. In Indonesia alone, 690 000 items were found to be present per square kilometre on the seafloor and 29.1 items per square metre on the shorelines (Greenpeace *undated*).

Waste management

Waste avoidance and reduction have not received the attention they deserve in the developing countries of Asia and the Pacific.

Waste avoidance and reduction is the first priority in an integrated waste management hierarchy, followed by reuse, recycling and disposal. As in many other regions of the world, waste avoidance and reduction have not received enough attention in Asia and the Pacific. Beginning in the 2000s, concepts such as cleaner production, the 3Rs, design for environment, extended producer responsibility, circular economy and green growth emerged. Much of the progress so far, however, is in economically more developed countries such as Japan, the Republic of Korea, New Zealand and Australia (UNEP and ISWA 2015), while most of the region's developing countries still struggle to implement end-of-pipe treatment, and proactive or preventative measures are only now emerging.

Waste collection rates range from low to moderate in Asia and the Pacific's developing countries, with waste separation and collection at their highest levels in the developed countries of the region.

Waste separation and collection are a very important part of municipal solid waste management, with the promotion of separation at source and efficient collection systems playing important roles in recycling. Waste collection efficiency varies by region, income level within countries and cities. According to the *Global Waste Management Outlook*, the average collection rate in low-income countries is 36 per cent, in lower-middle income countries 64 per cent, in upper-middle income countries 82 per cent, and almost 100 per cent in high-income countries (UNEP and ISWA 2015).

In the developing countries of Asia and the Pacific, waste collection rates are moderate, at 40–80 per cent, but reach almost 100 per cent in more developed economies such as Japan, Australia, Republic of Korea and Singapore (Waste Atlas, 2015). In developed economies, collection is capital-intensive and mechanized while in developing countries, it still is labour intensive and usually lacks a good transfer stations system (UNEP and ISWA 2015)). Waste separation at source is a common practice in more developed countries while in low- and middle-income countries, there has been informal waste separation with different types of waste collected separately for transfer to a facility and recycling.

There is tremendous potential for waste resource recovery in Asia and the Pacific, however, recycling rates are generally low and mainly carried out in the informal sector.

With rising waste generation and new waste streams such as e-waste, food waste, construction and demolition waste, the region's potential for recycling is very high. In general, recycling rates in high-income countries have increased progressively over the past 30 years, while in lower-income countries the informal sector often only achieves recycling rates of 20–30 per cent for municipal solid waste (UNEPand ISWA 2015).

Biomass waste is usually reused or recycled in Asia and the Pacific. In many rural towns, backyard composting is a long-standing tradition; pig and poultry farmers routinely collect food waste from households and restaurants for animal feed and some large cities have set up mechanical composting plants.

Secondary materials such as ferrous and non-ferrous metals, paper and plastics are also recycled to a high level in the region, with China playing an important role. China accounts for 60 per cent by weight of global imports of aluminium scrap, 70 per cent of globally recovered paper and around 56 per cent of global plastic scrap (UNEP and ISWA 2015).

E-waste contains gold, copper, lead, cadmium, mercury and plastics, which are usually recovered to reduce the extraction of virgin materials. Around 84 per cent of e-waste collected globally is recycled, and the intrinsic material value of global e-waste was worth around USD60 billion in 2014 (Balde *et al.* 2015). E-waste recycling is also a very common in many Asia and the Pacific countries, including China, India and Viet Nam.

A number of countries in Asia and the Pacific have introduced the extended producer responsibility mechanisms and thus promote recycling **,** which is usually being implemented by industries in more developed countries. In most of developing countries, however, recyclables are usually collected by waste-pickers, transferred to household-scale recycling facilities where environmentally sound management usually is either absent or practised on a limited basis, and informal and unsafe recovery and recycling methods are commonplace.

The highest recycling rates of construction and demolition waste are in high-income countries, where they can be as high as 99 per cent, for instance in Japan and New Zealand, while they are relatively low in China (5 per cent in 2013) and moderate in India (50 per cent in 2014) due to concerns over quality, lax enforcement and ambiguous regulations (UNEP and ISWA 2015).

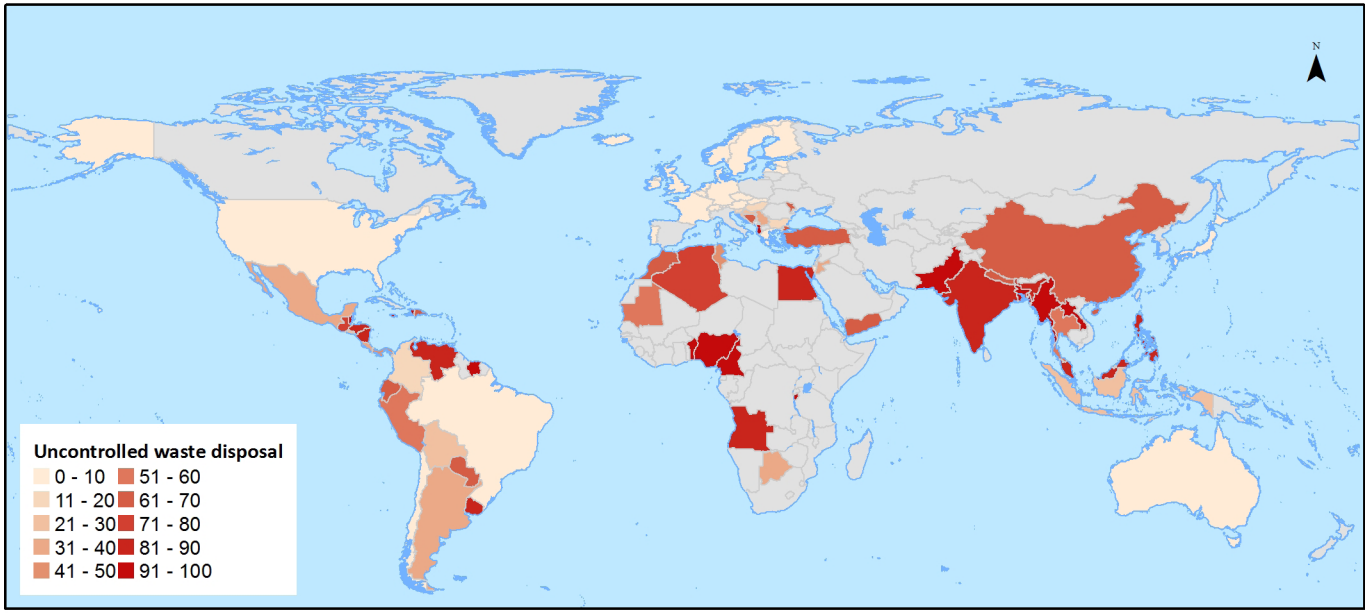
Uncontrolled dumping is still the main waste disposal method across Asia and the Pacific's developing countries. Investment in waste-to-energy technologies has been emerging.

Uncontrolled landfilling and open burning have been the most prevalent waste disposal method in the Asia and the Pacific region (**Figure 2.6.6**). While controlled waste disposal rates can reach 95–100 per cent in upper-middle and high-income countries, it is often below 50 per cent in low-income ones, and no controls on disposal is still relatively common in rural areas (UNEP and ISWA 2015). With economic development, however, some countries such as Thailand, Indonesia, the Philippines and Viet Nam, have gradually developed well-designed and operated sanitary landfills (UNEP and ISWA 2015)). Disposal presents a particular challenge for many small island developing states in the Pacific sub-region due to the limited availability of land. Many countries in the region now have been promoting 3R measures to increase the waste diversion from landfilling.

Waste incineration is capital intensive, requires skilled manpower for operation and maintenance and therefore is popular in more developed economies such as Australia, Japan, the Republic of Korea and Singapore. In some developing countries, this method is used mainly for hazardous waste disposal due to its high investment cost and stringent control of air emission.

With rising energy demand and the need to mitigate greenhouse gas emissions, investment in waste-to-energy technologies, including incineration with energy recovery, biofuel and biogas, has now emerged in the region with investment in waste-to-energy in Japan, India and China accounting for 7, 5 and 4 per cent of the world investment in 2015 respectively (ISWA 2015). The electricity production output from renewable municipal waste in Asia Pacific has increased nearly 5 times, from 988 GWh in 1990 to 4 952 GWh in 2013 (Asia Pacific Energy Portal, 2016). It has been estimated that there were 765 energy-from-waste plants worldwide with capacity of 83 million tonnes of waste per year in 2014, of which 150 are from China (UNEPand ISWA 2015). In 2012, Thailand generated 193.40 megawatts of energy by biogas and in Viet Nam there were 130 000 installed household biogas units (Biogas Asia Pacific Forum, 2013). In addition, the use of suitable waste materials in manufacturing processes for energy and/or resource recovery, such as co-processing wastes in cement kilns, is practised in China, Malaysia and Viet Nam (Huang *et al.* 2012).

Figure 2.6.6: Uncontrolled waste disposal worldwide



The map shows the percentage of total waste disposed of or burnt in uncontrolled sites; the darker the area, the more waste is disposed of by uncontrolled means.
Source: UNEP and ISWA 2015

2.6.5 Impacts

Poor waste management leads to serious impacts on human health, especially in the informal recycling sector and at open dumps.

Waste, as a discarded material, is often unhygienic, and hazardous waste, such as e-waste, may contain toxic components. Waste can also contain decaying materials, especially organic matter, which is a medium for various viruses that cause disease. If not collected, waste can accumulate in urban rivers and drainage canals – vectors for diseases such as cholera and dengue. In the developing countries of Asia and the Pacific, uncontrolled waste dumping and informal recycling using primitive and obsolete technology have had harmful impacts on the health of workers, waste pickers and people living nearby.

Moreover, unforeseen events at dump sites, such as flooding or landslides, can have serious impacts on local people, as occurred with a landslide at a dumpsite in the Philippines in 2000.

Inadequate treatment of waste can cause pollution and environmental and ecosystem degradation.

If not properly collected, waste can decay and cause air pollution, unpleasant odours and degradation of soil, surface and groundwater, and ecosystems. Birds and marine species have been harmed or killed by entanglement or ingestion of plastic waste in the ocean. The natural capital cost of the impact of plastics on marine ecosystems is at least USD13 billion per year (UNEP and ISWA 2015).

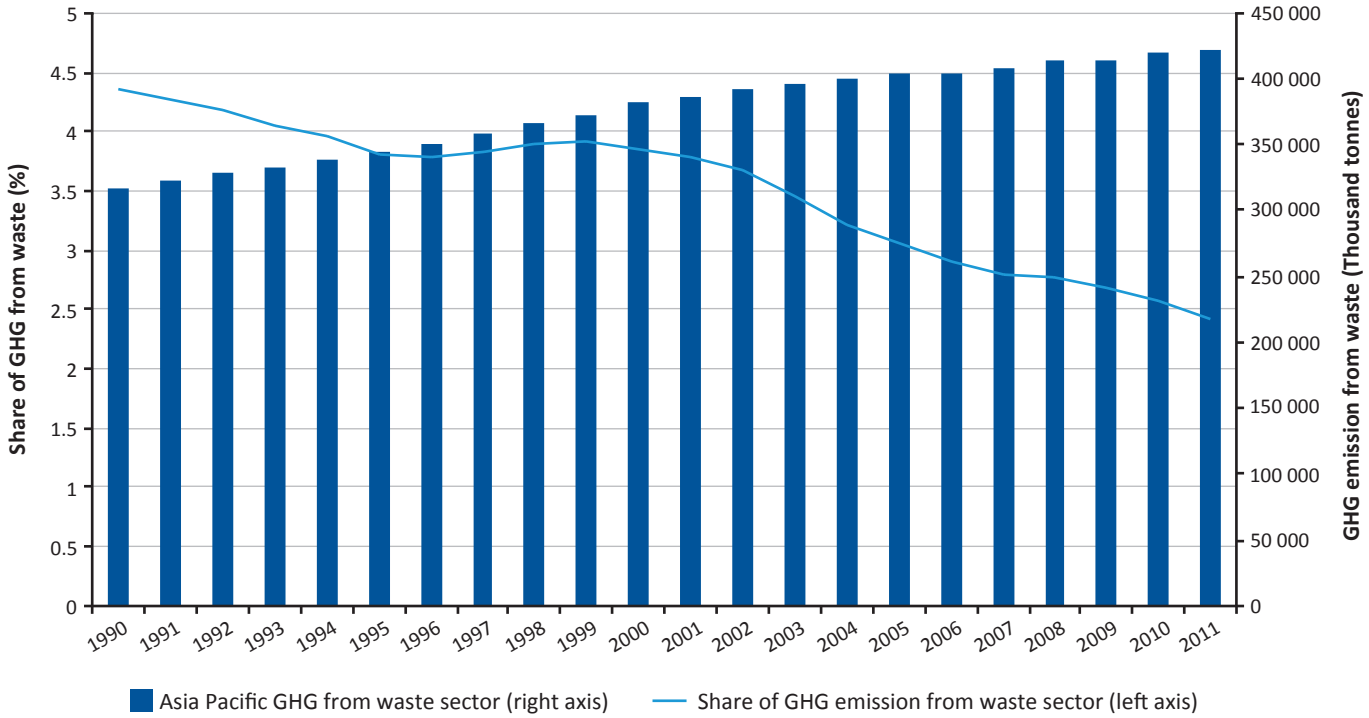
Informal recycling using primitive and obsolete technologies

can cause air, water and soil pollution. Dumpsites on land can pollute both surface and groundwater, especially if they are located alongside rivers or the sea. Former dumpsites, particularly those that contain hazardous waste, are a major category of contaminated sites (UNEP and ISWA 2015). Waste incineration can cause air pollution, especially when hazardous and nylon wastes are burned in uncontrolled furnaces.

Uncontrolled landfill sites contribute to increasing greenhouse gas emissions.

Together with energy, agriculture, industrial processes, land use, land-use change and forests, waste management is one of the sectors that emit greenhouse gases. Total global greenhouse gas emissions in 2010 amounted to around 49 billion tonnes (10^9 tonnes) of carbon dioxide equivalent (IPCC 2014), of which solid waste management accounted for around 3 per cent, or nearly 1.47 billion tonnes, with most of that attributable to methane emissions from uncontrolled landfill sites (UNEP and ISWA 2015).

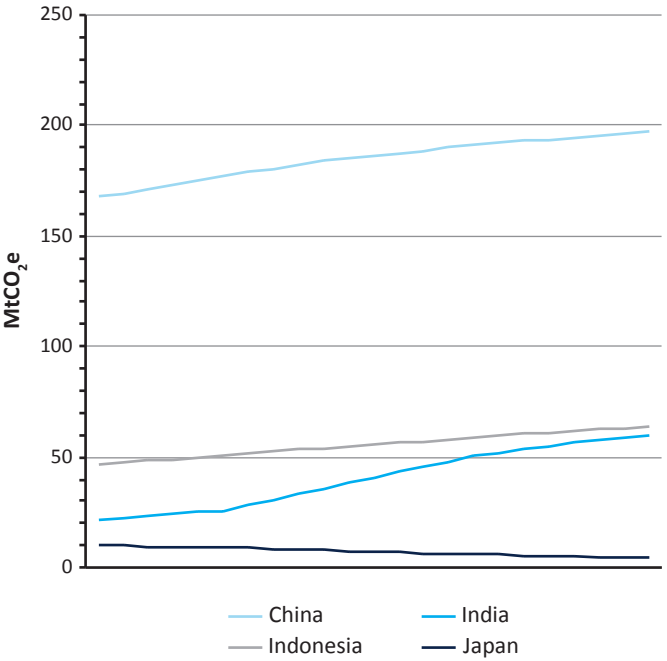
Figure 2.6.7: Greenhouse gas emissions (GHG) from the waste sector in Asia Pacific, thousand tonnes of carbon dioxide equivalent, 1990–2011



Note: Indonesia is excluded due to incompleteness of data
Source: UNEP 2015a

With rising waste generation and prevalent uncontrolled dumping, the absolute value of greenhouse gas emissions from the Asia and the Pacific waste sector (excluding Indonesia) rose from nearly 317 million tonnes of carbon dioxide equivalent in 1990 to 419 million tonnes in 2010. The share of emissions from the waste sector in the region, however, has decreased from nearly 4.4 per cent in 1990 to below 2.6 per cent in 2011 (**Figure 2.6.7**), explained by increases in emissions from other sectors, especially energy and industrial processing, as well as better waste management practices in developed countries. Figure 2.6.8 shows that emissions from waste continue to grow in China, India and Indonesia, but have been falling in Japan.

Figure 2.6.8: Greenhouse gas emissions from the waste sector of the region's four biggest emitters, million tonnes of carbon dioxide equivalent, 1990–2012



Note: Data are extracted from the World Resource Institute (WRI) database available on WRI website.
Source: WRI 2015

See references for Chapter 2

Credit: Shutterstock/Chungking ▶

Chapter 3

Policies, Goals and Objectives: Review of policy responses and options

The regional assessments of the *Sixth Global Environment Outlook* (GEO-6) include an evaluation of the extent of the policy response on environmental issues in each region. This completes the DPSIR framework analysis of driving forces, pressures, states, impacts and responses. In addition to assessing the extent of the policy response there is a need to assess its effectiveness or, in other words, how the response element changes pressures, states or impacts. The assessment of policy effectiveness in this section is conducted by:

- evaluating whether international environmental goals have been achieved;
- reviewing particular policy success stories;
- assessing the enabling conditions for successful environmental policies.

This approach highlights that the policy response is not an endpoint in itself; rather the effectiveness of policies must be continually evaluated, and adjusted if they do not have the intended effect on the pressures that impact the state of the environment.

3.1 Achieving internationally agreed environmental goals

The deteriorating state of the environment in all its major dimensions – land, water, air, sea and biodiversity – points towards policy ineffectiveness at local, national, regional and global levels. Despite an increase in political awareness of deteriorating environmental conditions and the proliferation of regional and global agreements to address these conditions, real progress on combating threats to environmental quality is far below a satisfactory level. Countries are increasingly becoming party to multiple bilateral, regional or global environmental conventions and agreements, each of which have goals to improve environmental sustainability, but rarely measurable targets. As signatories to these agreements, countries are supposed to address common environmental problems by integrating the principles of sustainable development into national and sub-national policies and programmes, thereby reversing the trend of environmental degradation in multiple areas.

Key Messages

- The emergence of multiple global environmental goals clearly signals a need to reverse the trend of deteriorating environmental conditions across the region. Despite some deficiencies, the Millennium Development Goals (MDGs) have been successful in showing the effectiveness of a goal-based approach to problem solving.
- New or revised agreements on issues such as disasters, climate change, sustainable development and biodiversity, and the concept of green growth offer clear goals and targets to deal with multiple environmental challenges in a focused manner in the post-2015 period.
- However, implementation of these agreements poses significant challenges for countries that so far have a poor track record on implementing the policies and programmes that complement existing global or regional agreements.

◄ Credit: Shutterstock/ John Bill

Asia and the Pacific countries are signatories to major multilateral environmental agreements (MEAs) such as the Convention on Biological Diversity (CBD, the Ramsar Convention on wetlands of international importance, the United Nations Convention to Combat Desertification (UNCCD), the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, the Montreal Protocol on Substances that Deplete the Ozone Layer, the Sendai Framework for Disaster Risk Reduction 2015–2030, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Stockholm Convention on Persistent Organic Pollutants, the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, the Minamata Convention on Mercury and the Convention for the Prevention of Pollution from Ships (MARPOL). In addition many countries, for instance Bangladesh, the Philippines and Thailand, have set up national councils for sustainable development to facilitate mainstream economic, social and environmental objectives across all development sectors. The MEAs, together with efforts to achieve sustainable development at the national level, formulate a rather comprehensive global environmental governance system. However, these MEAs will not be able to make a substantial difference without equipping both existing and new environment and sustainable development institutions with strong accountability mechanisms.

The region has also seen an increase in regional and bilateral environmental agreements such as the 1986 Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (Noumea Convention), the 1995 Agreement on Cooperation for the Sustainable Development of the Mekong River Basin, the Ganges River Basin water-sharing agreement between India and Bangladesh (1977 and 1996), and the Association of Southeast Asian Nations (ASEAN) Agreement on Transboundary Haze Pollution. In addition, individual countries have adopted successful policies, either as a response to the changing landscape of global and regional agreements or developed domestically but separately from global or regional agreements. Examples include Green Development/Growth Policies in Cambodia, Fiji and Mongolia, specialized ministries such as Sri Lanka's Ministry of Sustainable Development and Wildlife and Pakistan's Ministry of Climate Change, and initiatives such as King Bhumibol's philosophy of a Sufficiency Economy in Thailand, and Gross National Happiness along with detailed indicator systems in Bhutan.

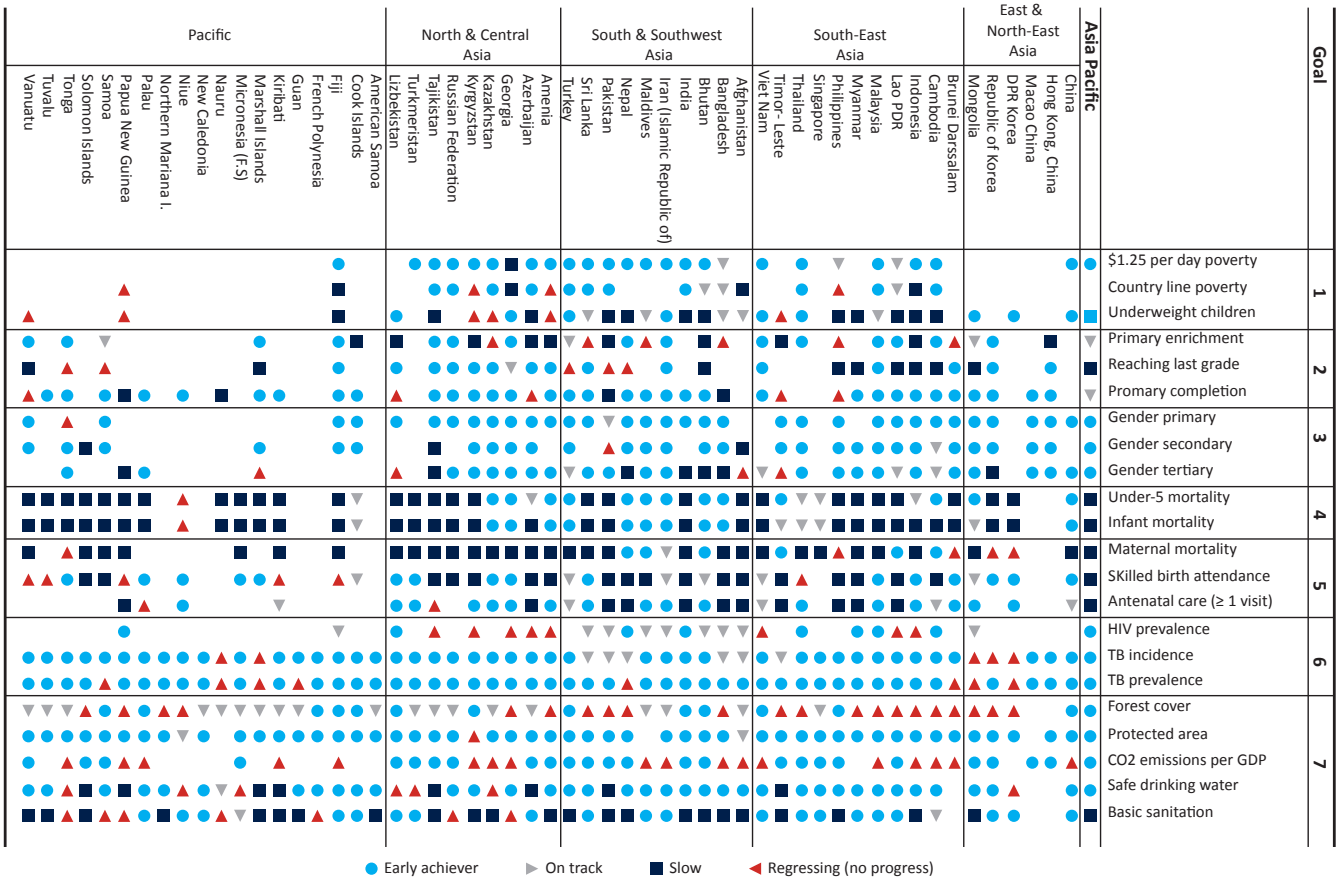
The MDGs have had a tremendous impact on development and the environment over the past 15 years in the region (**Figure 3.1.1**). During this period, a parallelism could be found between the implementation of major MEAs and MDG 7 on environmental sustainability, in one way or another. This section assesses environmental performance in the region with reference to MDG 7 while also touching on cross-cutting global and regional MEAs.

The MDGs were a significant departure from general to more focused policy attention and resource allocation for the promotion of socio-economic development in developing and least-developed countries, based on eight development goals and their targets. Governments across the region have incorporated the MDG framework into their national development planning and have benefited tremendously.

Despite increasing efforts and resources for implementing the MDGs, the region overall has been off track to achieve many of the targets, in particular those under Goal 7.

Goal 7 had three targets and ten indicators. Target 7.A, to integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources, is an overarching and broad target that comprises both policy integration and implementation. Integrating the principles of sustainable development into planning was relatively easy for countries, but implementing and measuring progress in reversing the loss of environmental resources was found difficult due to existing policy-implementation gaps in most of the countries. This target was a symbolic, directional reminder to all actors implementing MDGs that they should not be

Figure 3.1.1: Asia and the Pacific, progress on development indicators, by country



Source: UNESCAP *et al* 2015

achieved by ignoring the social, environmental and economic dimensions of sustainable development. The remaining targets were both time- and issue-bound, including 7.B to reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of biodiversity loss; 7.C to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation; and 7.D to have achieved, by 2020, a significant improvement in the lives of at least 100 million slum dwellers. Some of these targets are reinforced by MEAs or programmes such as CBD and the Aichi Biodiversity Targets or the United Nations Decade for Water 2005–2015. Ten indicators were used to monitor and assess performance relating to these targets.

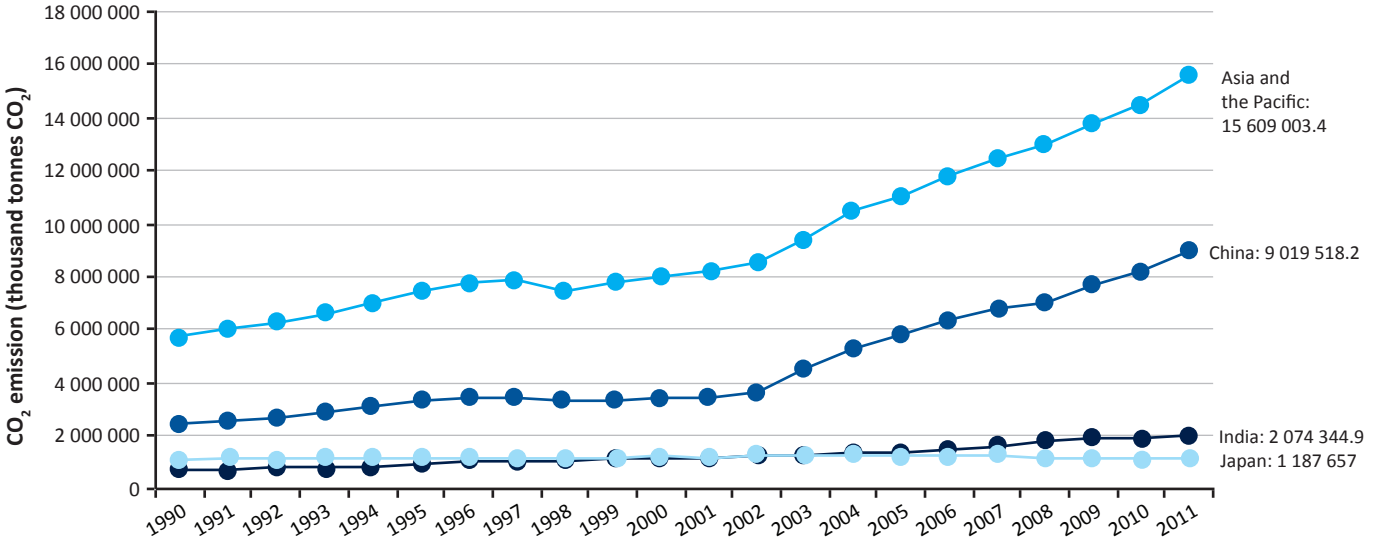
3.1.1 Climate and atmosphere

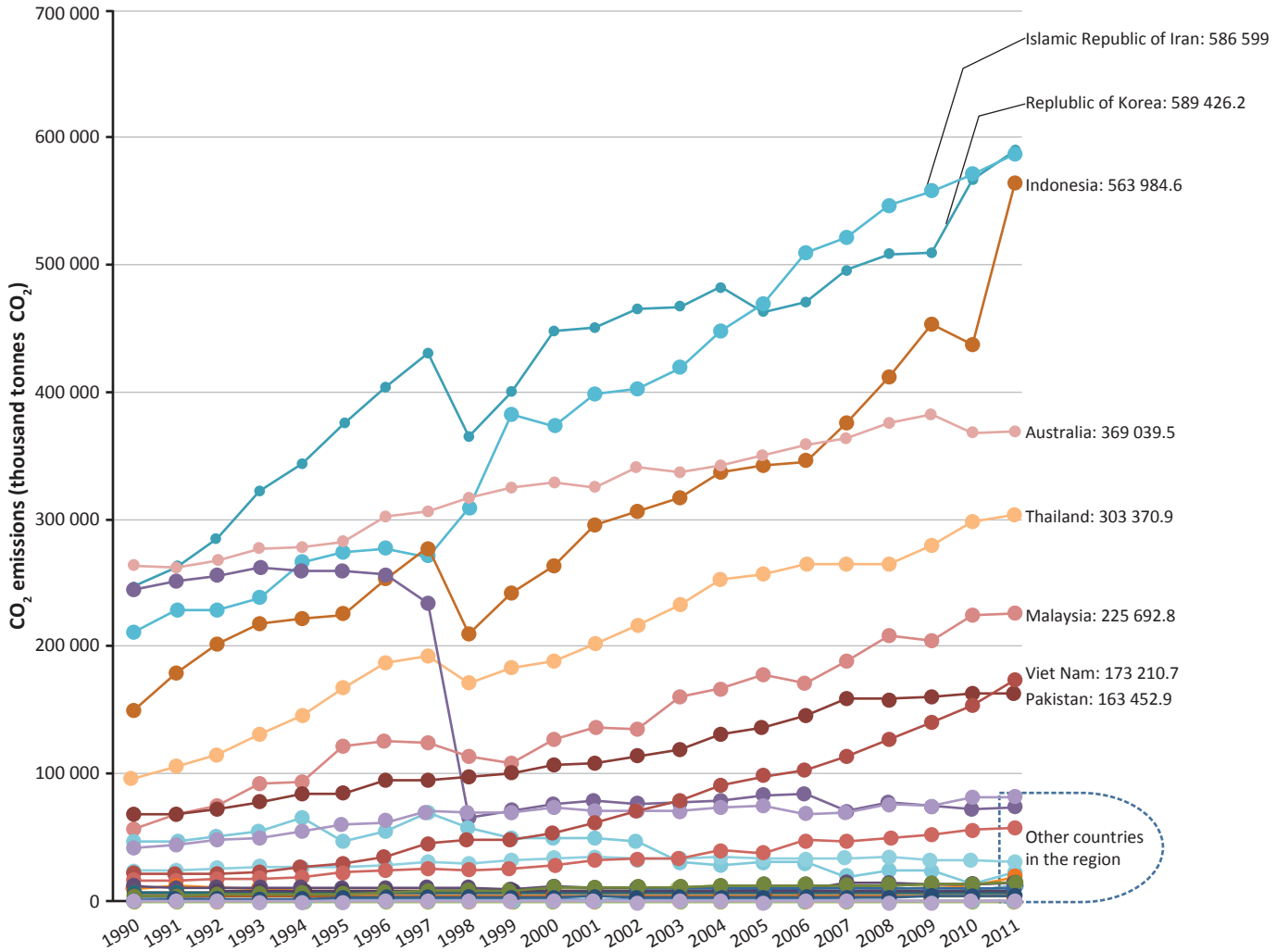
Two specific indicators on climate and atmosphere are monitored under Goal 7: carbon dioxide emissions, including total, per person, and per unit of gross domestic product (GDP); and consumption of ozone-depleting substances.

A rising trend in carbon dioxide emissions is a critical off-track indicator among the MDGs, both regionally and globally. Booming economic growth in the region and its identity as a global production house have been achieved through exploitation of the natural environment and at the cost of increased greenhouse gas emissions. The region is already the largest contributor of carbon dioxide emissions, mainly from China, India, Japan, the Republic of Korea and other emerging economies (**Figure 3.1.2**). The upward emissions trend indicates the weak impact of existing policy processes such as UNFCCC and the Intergovernmental Panel on Climate Change (IPCC) at national, regional and international levels. The Kyoto Protocol signed in 2005 under UNFCCC, and the subsequent Conference of the Parties (COP), drew up a range of initiatives and agreements on reduction targets for developed countries based on the principle of common but differentiated responsibility. The Kyoto Protocol was also credited for establishing a carbon market to promote the Clean Development Mechanism (CDM), which showed positive development at the beginning but failed to retain the level of momentum required to scale up cleaner technologies, especially after the 2008 financial crisis. In the post-2008 scenario, the trading of carbon emission reduction credits came to a virtual halt or was replaced by other domestic or bilateral market mechanisms. The efficacy of the COP process has been affected by inadequate policy responses on the part of major emitters and a lack of strong commitment towards a legally binding agreement. The latest of these targets, agreed at COP 21, is to "*keep a global temperature rise this century well below 2 degrees Celsius and to drive efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels*".

As a major turning point in 2015, the Sustainable Development Goals (SDGs) and the Paris Agreement that came out of UNFCCC COP 21 are expected to result in stronger commitments leading to an ambitious agreement and implementation framework that might lead to the revival of a global carbon market and other legal and regulatory instruments, promote innovation in carbon

Figure 3.1.2 a and b: Asia and the Pacific, carbon dioxide emissions, 1990–2011





Source: UNDESA (no date)

dioxide emission-reduction techniques and renewable energy generation, as well as moves towards a low-carbon society. These agreements could catalyse policies and measures that promote the decoupling of the energy sector from greenhouse gas emissions by boosting investment in renewable energy, energy efficiency in the industry, transport and buildings sectors, and structural changes in economies such as China. At present, India, Indonesia, Malaysia and Thailand are taking advantage of low oil prices to reduce fossil-fuel subsidies, whilst China, Republic of Korea and Thailand are piloting emission trading schemes. India and Japan have introduced a carbon tax, and Japan is also promoting the Joint Crediting Mechanism to facilitate the diffusion of low-carbon technologies. Countries have

submitted intended nationally determined contributions (INDCs), which act as a foundation for the implementation of the Paris Agreement. Countries in the Asia and the Pacific region introduced a range of voluntary targets to reduce carbon dioxide emissions as INDCs for discussion at COP 21. As of 28 February 2016, 39 countries in the region had already submitted their INDCs (**Table 3.1.1**).

Most INDCs in Asia and the Pacific have not aimed above 40 per cent emission reductions from the reference year or compared with business-as-usual unconditionally, and are ready to increase targets beyond that level only if they receive international support. Some Pacific island countries, however, are aiming for 100 per cent renewable electricity by 2030. China also sets an ambitious target of 56–60 per cent

Table 3.1.1: Asia and the Pacific, submission status of intended nationally determined contributions

	Countries	Emission reduction (unconditional)	Emission reduction (conditional)	Reference year	Target year
Australia, New Zealand					
1	Australia*	26–28%		2005	2030
2	New Zealand*	30%		2005	2030
The Pacific					
3	Cook Islands*	38% (electricity) by 2020	81% (electricity) by 2030	2006	2020, 2030
4	Fiji	10%	30%	BAU (2013~)	2030
5	Niue*	38% (electricity) by 2020	80% (electricity) by 2025		2020, 2025
6	Kiribati	13.7% by 2025 and 12.8% by 2030	61.8%	BAU (2000~2014)	2025, 2030
7	Republic of the Marshall Islands	32%	45% (indicative) below 2010 levels by 2030	2010	2025, 2030
8	Federated States of Micronesia*	28%	35%	2000	
9	Nauru	Equivalent to a 0.6 megawatt solar photovoltaic system	Based on identified mitigation actions	BAU	2020–2030
10	Palau	22% energy sector emission reductions 45% renewable energy target 35% energy efficiency target		2005	2025 2025 2025
11	Papua New Guinea		100% (electricity)	BAU	2030
12	Samoa*		100% (electricity)	2014	2025
13	Solomon Islands*	12–30%	27–45%	2015 (BAU projected from 1994–2010 data)	2025, 2030
14	Tonga	50% electricity generation from renewables by 2020 and 70% by 2030 Improve energy efficiency by reducing transmission losses to 9% with respect to 18% baseline		2010	2020, 2030 2020
15	Tuvalu				
16	Vanuatu	30% (energy), 100% (electricity)		BAU (2010~)	2030

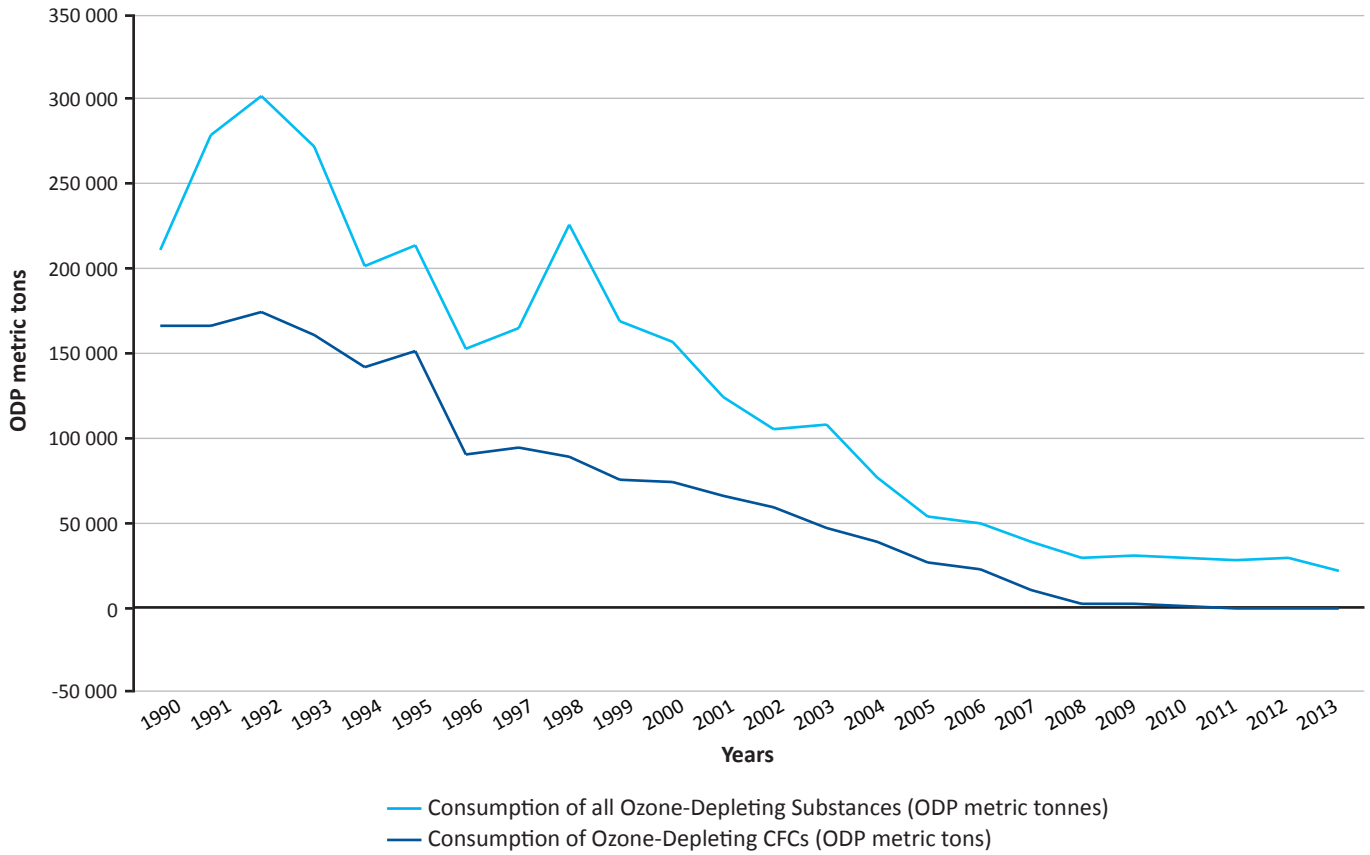
	Countries	Emission reduction (unconditional)	Emission reduction (conditional)	Reference year	Target year
Northeast Asia					
17	China*	60–65 (per unit of GDP)		2005	2030
18	Japan*	26%		2013	2030
19	Republic of Korea	37%		BAU (2020~2030)	2030
20	Mongolia	14%		BAU (2010~)	2030
Southeast Asia					
21	Cambodia		27% (+land use, land-use change and forestry)	BAU	2030
22	Brunei Darussalam	**Energy:** reduce energy consumption by 65% increase share of renewables to 10% **Land transport:** reduce morning peak hour CO_2 emissions from vehicles by 40% **Forests:** increase total gazetted forest reserves from the current 41% to 55% of total land area		BAU BAU	2035 2035 2035
23	Indonesia	29%	41%	BAU (2010~)	2030
24	Lao PDR*		Activity related targets	2000~2015	2015-2030
25	Myanmar	Sectors are identified for mitigation but without specific emission targets			
26	Malaysia	35% (per unit of GDP)	45% (per unit of GDP)	2005	2030
27	Philippines		70%	BAU (2000~)	2030
28	Singapore*	36% (per unit of GDP)		2005	2030
29	Thailand	20%	25%	BAU (2005~)	2030
30	Viet Nam	8%	25%	BAU (2010~)	2030
South Asia					
31	Afghanistan		13.6%	BAU (2005~)	2030
32	Bangladesh	5%	15%	BAU (2011~)	2030
33	Bhutan	Continue to become carbon neutral			2030
34	India*	33–35% (per unit of GDP)		2005	2030
35	Islamic Republic of Iran	4%	12%	BAU (2010~)	2030
36	Maldives	10%	24%	BAU (2011~)	2030
37	Nepal	- 80% electrification from renewable sources by 2050 - Maintain 40% of forest cover			
38	Pakistan	Specific commitments after reaching peak emissions, once reliable data on peak emission levels is available			
39	Sri Lanka	7%	23%	BAU (2010~)	2030
*Countries that are not using a business-as-usual (BAU) scenario as reference for emission reductions.					

Source: UNFCCC 2014

reduction by 2030, but based on GDP. India and Singapore are also using emission intensity per unit of GDP. While these targets seem ambitious, there are concerns that globally submitted INDCs will not be enough to limit warming to below 2°C above pre-industrial levels by the end of the century if stronger action is not forthcoming (IEA 2015). In terms of action being taken, there is huge diversity among countries but the majority of INDCs have prioritized energy, transport and forestry as the main areas for emission reductions. Periodic review of implementation of the INDCs and enhanced ambitions will be needed beyond 2030.

Consumption of ozone-depleting substances was another important indicator being monitored under MDG 7. The reduction and phasing-out of ozone-depleting substances is one of the few on-track indicators among the MDGs (**Figure 3.1.3**).

Figure 3.1.3: Asia and the Pacific, reduction in ozone-depleting substances, 1990–2013 (ozone-depleting potential-weighted tonnes, ODP tonnes)



Source: UNDESA (no date)

The successful global reduction in ozone-depleting substances can be attributed mainly to the Montreal Protocol, which aimed to phase out the use of halogenated hydrocarbons responsible for ozone depletion. The protocol has enabled its Parties, including those in Asia and the Pacific, to achieve specified goals for the reduction of ozone-depleting chemicals by more than 98 per cent, well ahead of mandated schedules (UNDG 2010). Some countries in Asia and the Pacific have even started to destroy their stocks, in particular of chlorofluorocarbons (CFCs). Credit also goes to the industrial sector, which has taken a lead in technology innovation and the transfer of environment-friendly alternatives. The protocol has also had a positive impact on climate change mitigation since many ozone-depleting substances are also global warming chemicals. However, hydrofluorocarbons (HFCs), which are among the replacement chemicals for CFCs, are also climatically active and long-lived, so also need to be regulated, especially given anticipated increases in urbanisation in Asia and the Pacific.

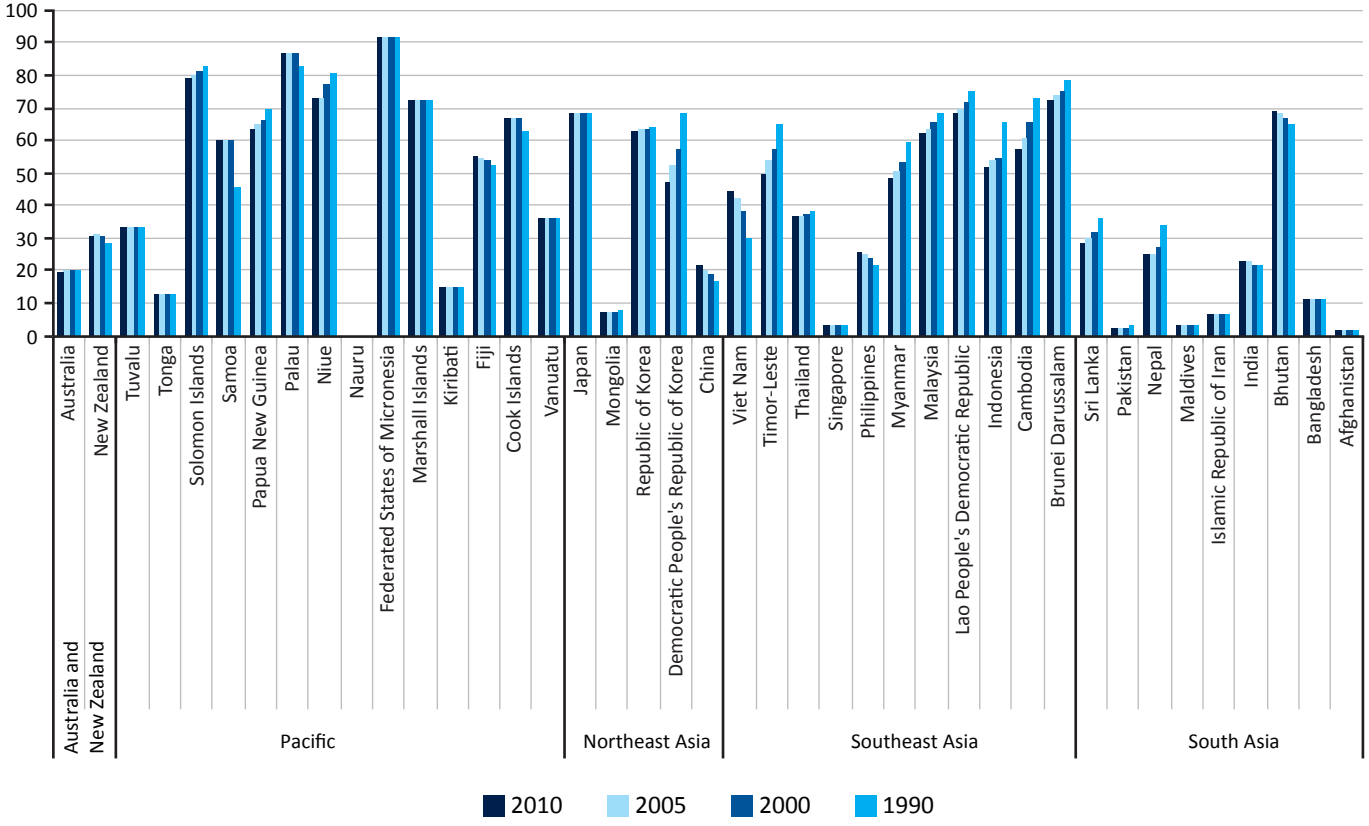
3.1.2 Forests and biodiversity

Three indicators are monitored under MDG 7 to assess progress on forests and biodiversity. The *proportion of land area covered by forest* is a means of assessing the state of forests. The countries in the region have made relatively slow progress on reversing the loss of natural resources, except for forest cover, which saw a net gain of 2.2 million hectares per year between 2000 and 2010 (UN 2015). This was mainly a result of massive reforestation, especially in China, and other good initiatives such as decentralization and clear tenure, alternative employment opportunities, joint forest management, community-based forest management and forest user groups in South and Southeast Asia (UNDG 2010). The net gain in forest cover, however, is offset by a continued high net loss in many countries in South and Southeast Asia including Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Sri Lanka and Timor-Leste (**Figure 3.1.4**). The rise of industrial plantations in the region and land-use change may have led to encroachments into carbon sink areas such as peatlands and high-conservation stock/value forests. Without proper land-use management on the part of the authorities and stringent enforcement of sustainable forestry and peatland management, this problem is likely to persist.

Future policy responses should aim to address the twin challenges of improving carbon stocks and halting the alarming rate of deforestation and degradation of primary stock by implementing sustainable forest management policies. Similarly, the region has to halt the rate of deforestation and degradation of primary forest and to conserve ecosystems that provide vital goods and services such as water, habitat for biodiversity, tourism opportunities and fresh air. Other environmental goals and initiatives, such as the UNCCD, the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD), and the CBD and Aichi Biodiversity Targets, should also be mainstreamed with forest management policies.

The *proportion of fish stocks within safe biological limits* is another indicator related to biodiversity. While data on fish stocks are not available from the MDG database, other sources have shown that the region is heavily reliant on captured fish and aquaculture as a food source. Since 2006, the region has been the leader in capture fisheries with more than half the global share (Funge-Smith *et al.* 2012). A considerable proportion of the region's capture production, as reported to the Food and Agriculture Organization of the United Nations (FAO), is not identified at the species level but instead is recorded as "*marine/freshwater fish not elsewhere included*" (Funge-Smith *et al.* 2012). The increasing amount of fisheries production *not elsewhere included* may indicate a strong trend towards the capture of smaller, lower-value species and this may hide the effects of overfishing on juveniles of higher-value species. Assessment of the fish stocks for the different groups of species in the South China Sea and Gulf of Thailand, Bay of Bengal and Andaman Sea, and Sulu-Sulawesi and Timor-Arafura Seas, has found that the majority of stocks or species groups are overfished or fully fished in most areas (Funge-Smith *et al.* 2012).

Figure 3.1.4: Asia and the Pacific, change in proportion of land covered by forest (percentage), 1990-2010



Source: UNDESA (no date)

There are several international and regional agreements relating to different fisheries (**Table 3.1.2**). These agreements have contributed to the regulating of fishing, for example through zoning of fishing areas, and classification and inventories of fishing vessels to control their number (Funge-Smith *et al.* 2012). However, much remains to be done to replenish fish stocks and combat overfishing at the international level because the demands on capture fisheries are driven by global factors rather than local ones.

The *proportion of terrestrial and marine protected areas* is another important indicator of biodiversity that has shown gradual improvement over time in Asia and the Pacific. The region's protected area coverage has been increasing gradually and several countries are nearing or already exceed 25 per cent of their total territory under protection, notably Australia, Bhutan, Brunei Darussalam, Cambodia, New Zealand and Palau (**Figure 3.1.5**). However, the countries which are lagging behind in making a progress

Credit: Shutterstock/ John Bill ▶

Table 3.1.2: Asia and the Pacific, status of international agreements related to fisheries

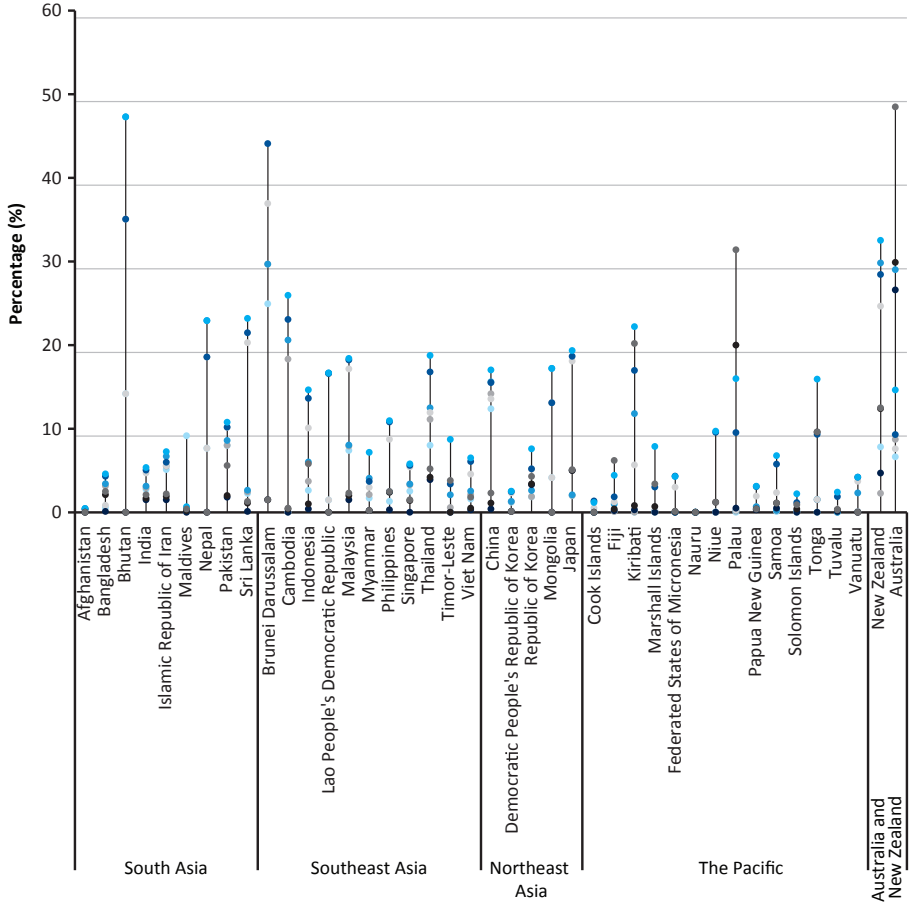
	UNCLOS		UNFSA		FAO compliance agreement	FAO Port state measures agreement	CBD	CITES	MARPOL Annex V
Sign	Rat Acc	Sign	Sign	Rat Acc	Acc	Sign Acc	Rat Acc	Rat Acc	Ac Acc
South Asia									
Afghanistan	1982						2002	1985	
Bangladesh	1982	2001	1995	2012			1994	1981	2002
Bhutan	1982						1995	2002	
India	1982	1995		2003			1994	1976	2003
Iran IR	1992			1998			1996	1976	2002
Maldives	1982	2000	1996	1998			1992	2012	2005
Nepal	1982	1998					1993	1975	
Pakistan	1982	1997	1996				1994	1976	1994
Sri Lanka	1982	1994	1996	1996		2011	1994	1979	1997
Southeast Asia									
Brunei Darussalam	1984	1996					2008	1990	
Cambodia	1983						1995	1997	1994
Indonesia	1982	1986	1995	2009		2009	1994	1978	
Lao PDR	1982	1998					1996	2004	
Malaysia	1982	1996					1994	1977	1997
Myanmar	1982	1996			1994	2010	1994	1997	
Philippines	1982	1984	1996	2014			1993	1981	2001
Singapore	1982	1994					1995	1986	1999
Thailand	1982	2011					2004	1983	
Timor-Leste		2012					2007		
Viet Nam	1982	1994					1994	1994	
					Northeast Asia				
China PR*	1982	1996	1996				1993	1981	1988
Japan	1983	1996	1996	2006	2000		1993	1980	1983
Korea DPR	1982						1994		1985
Korea RO	1983	1996	1996	2008	2003		1994	1993	1996
Mongolia	1982	1996					1993	1996	2003
					Australia and New Zealand				
Australia	1982	1994	1995	1999	2004	2010	1993	1976	1990
New Zealand	1982	1996	1995	2001	2005	2009	1993	1989	1998

	UNCLOS		UNFSA		FAO compliance agreement	FAO Port state measures agreement	CBD	CITES	MARPOL Annex V
Sign	Rat Acc	Sign	Sign	Rat Acc	Acc	Sign Acc	Rat Acc	Rat Acc	Ac Acc
					The Pacific				
Cook Islands	1982	1995		1999	2006		1993		
Fiji Islands	1982	1982	1995	1996			1993	1997	
Kiribati		2003		2005			1994		2007
Marshall Islands		1991	1995	2003			1992		1988
Micronesia FSO		1991	1995	1997			1994		
Nauru	1982	1996		1997			1993		
Niue	1984	2006	1995	2006			1996		
Palau		1996		2008			1999	2004	
Papua New Guinea	1982	1997	1995	1999			1993	1975	1993
Samoa	1984	1995	1995	1996		2009	1994	2004	2002
Solomon Islands	1982	1997		1997			1995	2007	2004
Tonga		1995	1995	1996			1998		1996
Tuvalu	1982	2002		2009			2002		1985
Vanuatu	1982	1999	1996				1993	1989	1991
					Other Asia Pacific				
	1982	1996	1996	2003	1996**	2010	1994	1978	1981
Kazakhstan							1994	2000	1994
Tajikistan							1997		
UK		1997	1995	2001/2003	1996**		1994	1976	1986
USA			1995	1996	1995	2009	***	1974	1987
Uzbekistan							1995	1997	
Total region****	35	36	19	25	6	6	41	31	24

Notes: n=47; sign=signed; rat=ratified; ac=acceded; acc=accepted
*excluding Taiwan Province of China, Macau SAR and Hong Kong SAR
**Through European Union
***USA signed CBD in 1993, but has not ratified/acceded to the convention
****Out of a total of 41 countries in the region (excluding France, Kazakhstan, Tajikistan, UK, USA, and Uzbekistan and see*above)
European Union signed the Port State Measures agreement in 2009 and approved it in 2011

Source: Modified from Funge-Smith *et al.* 2012

Figure 3.1.5: Asia and the Pacific, terrestrial and marine protected areas as a proportion of national territory



Source: UNDESA (no date)

have to increase their efforts to achieve the Aichi Biodiversity Target 11 of conserving at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

Protected areas usually fall under the legal jurisdiction of a country and are vital for conserving biodiversity and ecosystems. They are also generally recognized by international agreements such as CBD, the UNESCO World Heritage Convention and the Ramsar Convention. While the gradual improvement in protected areas can be seen as a positive outcome of various efforts in Asia and the Pacific, including the MDGs, national and multinational efforts should give further attention to their sustainable management, including through community participation, equitable access to services, maintenance of species richness and ecological health, especially in light of increasing human disruption and climate change impacts, and to revenue generation to support essential management tasks.

The *proportion of species threatened with extinction* is another indicator of biodiversity which is considered to be off track. The International Union for the Conservation of Nature (IUCN) *Red List of Threatened Species* shows an alarming increase in the number of threatened species in all taxonomic groups (IUCN 2015) (**Figure 3.1.6**). Many examples show that species can be brought back from the brink of extinction and their status improved through focused conservation action involving captive breeding, supplementary feeding, habitat management, and prevention of illegal poaching and trade (UN-MDGs 2015).

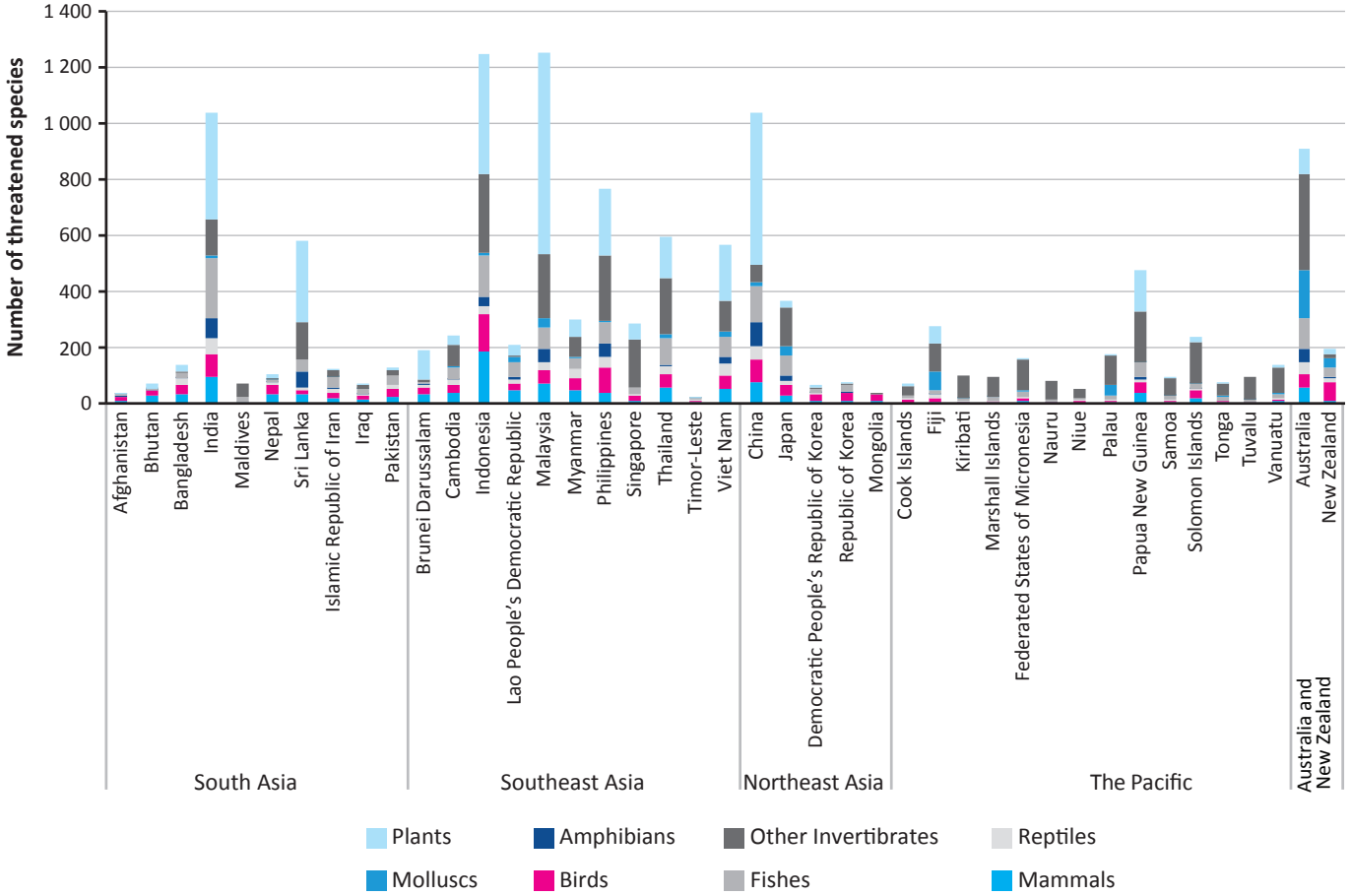
Many Asia and the Pacific countries are signatories to CITES, which has the power to restrict or even ban international trade that is considered to endanger a species. However, ineffective control of international demand and illegal trade continue to pose a significant threat. Preventing habitat loss also has to be achieved through maintaining forest cover or preserving protected areas. Coordinated and effective implementation of Aichi Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity and its targets 12, 13 and 14 and Sustainable Development Goal (SDG) 15 are vital to bring progress on-track. Consistent monitoring of progress on these related targets and goals in the post-2015 period is also advisable.

3.1.3 Water resources, drinking water and sanitation

The *proportion of total water resources used* is one of the most difficult indicators to assess because of a lack of readily available data. Relatively little attention was paid to overall water resource management during the MDG implementation period, since most of the focus was on achieving the targets related to drinking water and sanitation. Asia and the Pacific countries are still far behind in generating, updating and sharing information on their water resources. Based on the limited available information, the water resources of the region's countries can be characterized as falling between *abundant*, with less than 20 per cent of the available resource being used; through *approaching scarcity* at 25–60 per cent being used; and *scarce* at more than 60 per cent being used (**Figure 3.1.7**).

However, this information alone cannot illustrate the distribution of water security challenges in the region. Unsustainable use of surface water and groundwater, pollution and climate change are major issues in Asia and the Pacific. The region has failed to control pollution of its rivers, more than 80 per cent of which are considered to be in poor health (ADB and APWF 2013). Countries already have multiple policies on water resources as well as specialized ministries and departments to deal with water resources management. However, all policy responses for this issue are uncoordinated and constrained by capacity gaps for implementing them efficiently at the local, national, transboundary and international levels. A global survey has found that integrated water resource management,

Figure 3.1.6: Asia and the Pacific, threatened species

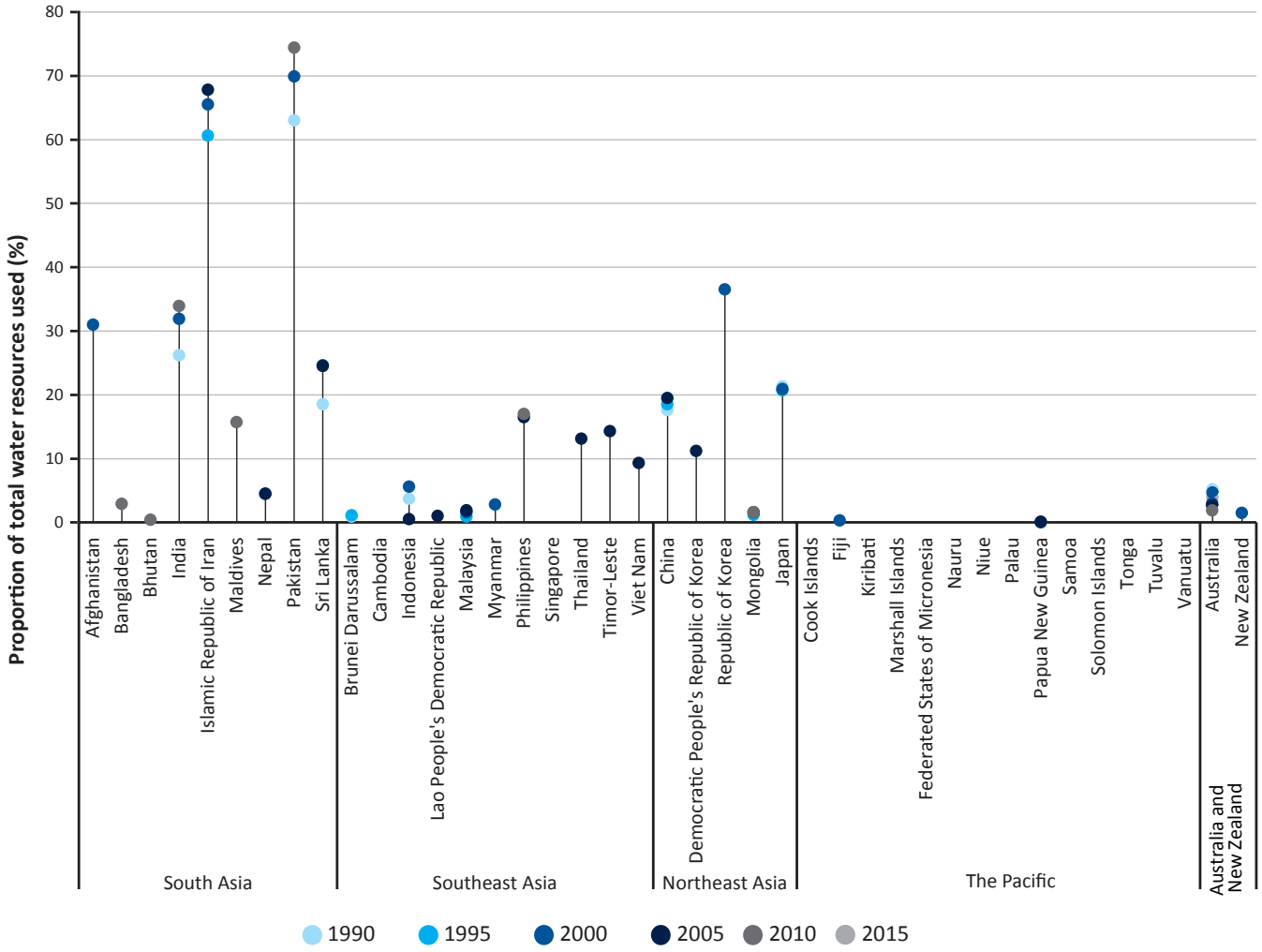


Source: IUCN 2015

which is considered vital for the successful management of both national and transboundary water resources, is fully implemented in only 15 per cent of the countries in the region (UNEP 2012). Other than the 1995 Mekong River Agreement, there are no transboundary agreements in the region through which countries sharing boundaries carry out joint planning, monitoring and evaluation exercises, and there are concerns about ineffective management of the Mekong River due to mainstream hydropower development.

Access to safe drinking water and basic sanitation are two major MDG challenges that aimed to halve the population without access to these services by 2015. Access to safe drinking water was an early achiever and met its target in the region in 2010. By 2015, more than 90 per cent of the population in most Asia and the Pacific countries had access to improved drinking water (**Figure 3.1.8**). However, this hides wide disparities between rural and urban areas, between men and women, and within and between countries. Although

Figure 3.1.7: Asia and the Pacific, water resource use in different countries, 1990–2015

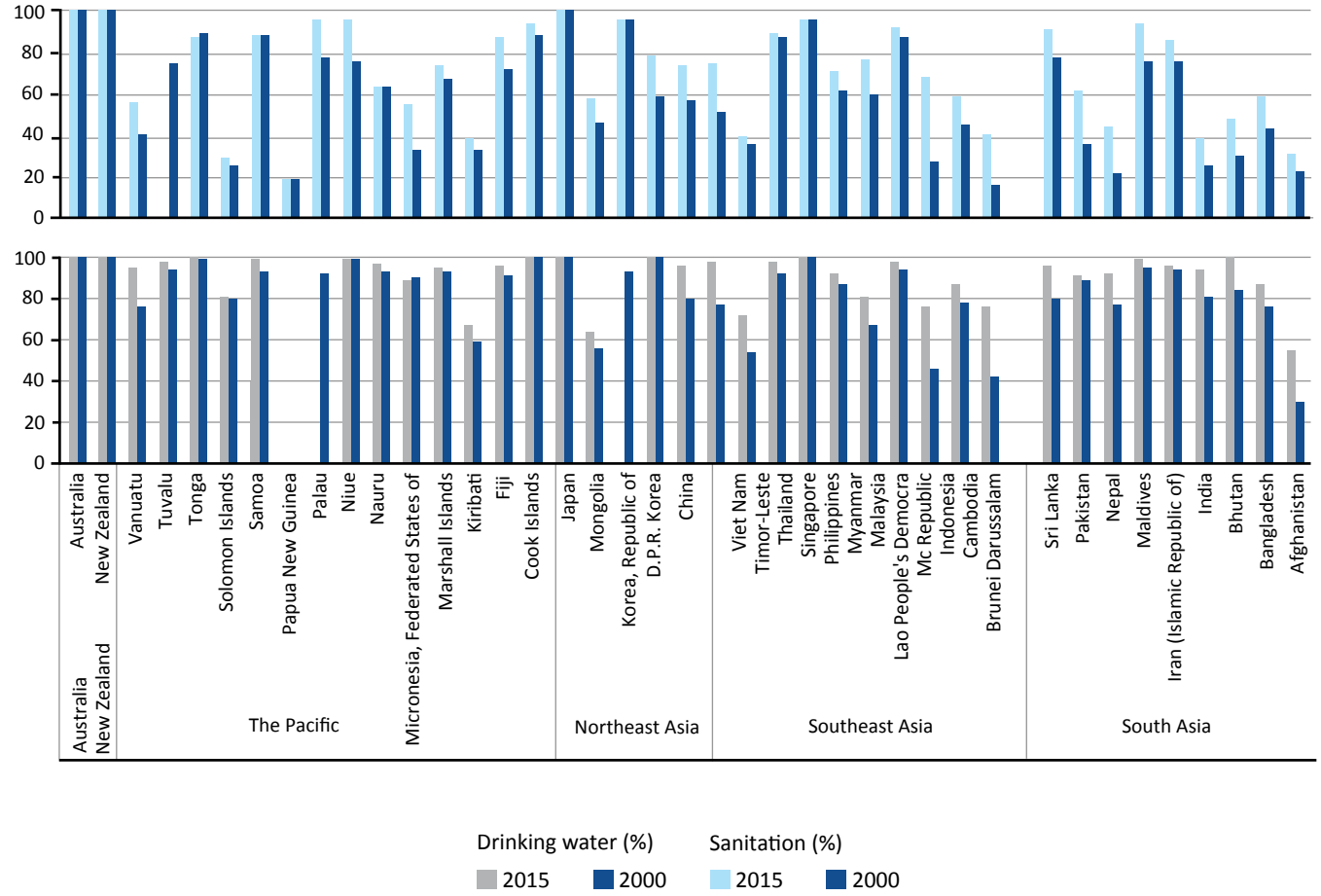


Source: UNDESA (no date)

still behind the regional average, Afghanistan, Cambodia and Lao PDR have made significant progress over the past 15 years.

In contrast, the sanitation target is severely off track (**Figure 3.1.8**) despite continued efforts made by the international community, governments, non-governmental

Figure 3.1.8: Asia and the Pacific, proportion of population with access to safe drinking water (bottom) and basic sanitation (top)



Source: UNDESA (no date)

organizations (NGOs), civil society, businesses and other stakeholders. Both drinking water and sanitation received an unprecedented response, and a huge amount of finance was diverted to achieve the targets. Funding agencies like the Asian Development Bank (ADB) and the World Bank have incorporated water and sanitation in their priority investment areas. Within the United Nations, a special advisory board on water and sanitation (UNSGAB) was established to give advice to the Secretary-General, and a Joint Monitoring Programme was entrusted with the compilation, analysis and dissemination of high-quality, up-to-date, consistent and statistically sound global, regional and country estimates of progress towards the targets (JMP 2015). Countries such as India have set up a separate ministries to address the

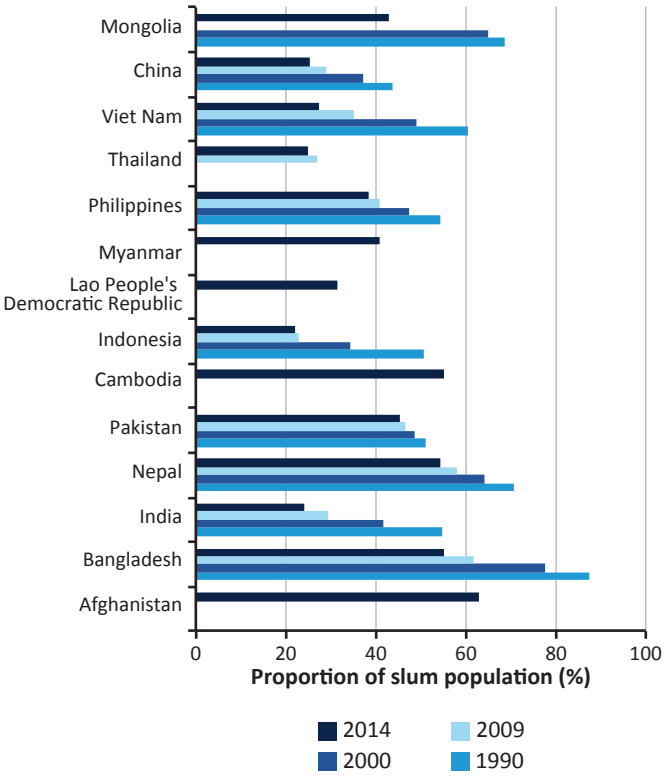
drinking water and sanitation challenges they face. Water supply and sanitation will undoubtedly continue to be high-priority issues of the post-2015 development agenda if unfinished tasks are to be completed, and there are further challenges that must be addressed to achieve environmental sustainability, such as hygiene, wastewater management (including reuse, resource recovery and greenhouse gas mitigation), pollution control and cleaning of polluted rivers.

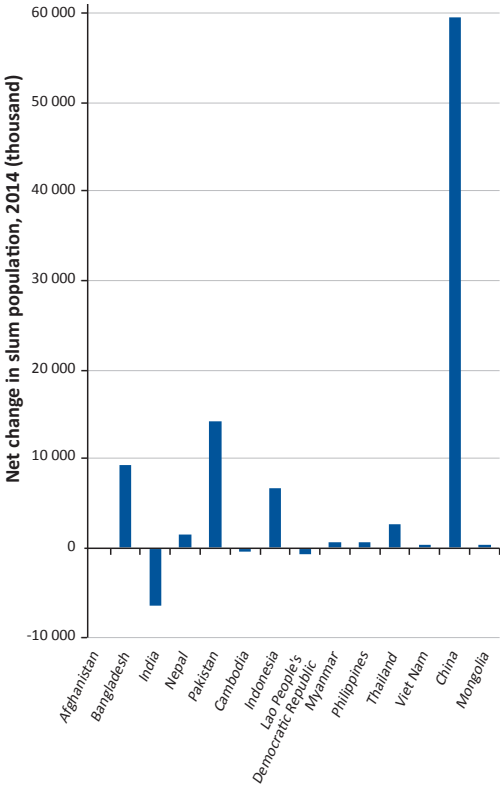
The target of achieving *a significant improvement in the lives of at least 100 million slum dwellers* by 2020 was achieved 10 years in advance. However, due to rapid urbanization and the rising rural-to-urban migration trend, the number of slum dwellers has actually increased in most countries, with some exceptions, including India, Cambodia and Lao PDR, where there has been a net decrease in the slum population (**Figure 3.1.9**). Additional efforts are needed to improve conditions for the growing numbers of slum dwellers, especially in the many countries that still lag behind (UN 2015).

3.1.4 Other cross-cutting agreements

In addition to the MDGs, significant regional initiatives are also critical in achieving environmental sustainability and for levelling the playing field for implementation of the SDGs in future.

Figure 3.1.9: Asia and the Pacific, proportion of slum population (left) and net change in slum population by 2014 (right)





Source: UNDESA (no date)

The *ASEAN Agreement on Transboundary Haze Pollution* is an agreement between Southeast Asian nations for cooperative action to bring the smoke haze caused by forest burning under control. One of the important features of the agreement is that it is based on deterrence and prevention through closer regional and bilateral cooperation and calling for greater transparency and accountability on the part of land owners and companies rather than punitive action. In 2015, Indonesia was the last ASEAN member to ratify the agreement. To address its increasing fire problems, the country has renewed its national forest moratorium, which prevents the granting of new licences to clear key forest areas.

These and other important programmes and agreements to deal with air quality issues in the region are highlighted in **Table 3.1.3.**

Implementation of these regional agreements and INDCs are essential not only for climate change mitigation but also to prevent damages to public health caused by the release of short-lived climate pollutants and other toxic pollutants such as mercury, polycyclic aromatic hydrocarbons.

Tripartite Environment Ministers Meeting (TEMM), Japan, China and the Republic of Korea, which was established in 1999, has played a key role as a regional high-level cooperation

Table 3.1.3: Northeast and Southeast Asia, selected existing regional air pollution cooperation frameworks

Agreements	Scope	Remarks
ABC	Atmospheric brown clouds • Global/regional	• Includes air and climate
EANET	Acid Deposition Monitoring Network in East Asia • Northeast and Southeast Asia	• Mainly monitoring • Narrow scope
Joint Forum	Joint Forum on the Atmospheric Environment in Asia and the Pacific • Asia-wide	• Network of networks (UNEP)
TEMM	Tripartite Environment Ministers Meeting Northeast Asia (China, Japan, Republic of Korea)	• Regular meeting • Collection of projects
LTP	Long Range Transboundary Air Pollutants in Northeast Asia • Northeast Asia (China, Japan, Republic of Korea)	• Research project • Broader scope (but not climate)
NEASPEC	Northeast Asia Subregional Programme for Environmental Cooperation • Northeast Asia (six countries)	• Secretariat services provided by the United Nations Economic and Social Commission for Asia and the Pacific Subregional Office (UN ESCAP-SRO) • Project based
CAA	Clean Air Asia (formerly CAI-Asia) • Asia-wide	• Multi-stakeholder partnership
AP-CAP	Asia and the Pacific Clean Air Partnership	• Network of networks (UNEP) • Scientific panel on air quality

Source: Elder and Zusman 2013

mechanism on the environment in North-East Asia. TEMM's first action plan was implemented between 2010 and 2014 and a new 5 year action plan was adopted in 2015 with nine priority areas such as air quality improvement, conservation of water and marine environment, climate change response.. There has been discussion on international cooperation towards the expansion of green markets and promotion of the green economy and environmentally sustainable cities. TEMM has carried out capacity-building projects that include ecological conservation in northwestern China, a joint environmental education project, a tripartite environmental education network, and a freshwater pollution prevention project.

The area of *resource use and efficiency* was missing from the MDGs and many relevant agreements such as the Basel, Stockholm and Rotterdam Conventions and UNFCCC. A lagging policy response on improving resource use and efficiency at the global level is caused by a complex set of factors. Among others, Asia and the Pacific's regional diversity is an important determinant because the bulk of production and consumption is concentrated in a handful of resource-hungry economies including Australia, China, India, Indonesia, Japan, Malaysia, Republic of Korea, Thailand and Viet Nam (UNEP 2013). Most of these countries have undertaken unilateral resource efficiency strategies and plans, for economic reasons, to minimize wastes and protect the environment within their territory.

Commitments to sustainable consumption and production in the 1992 United Nations Conference on Environment and Development's *Agenda 21* and the Johannesburg Plan of Implementation, and adoption of the 10-Year Framework of Programmes (10YFP) on sustainable consumption and production, can be considered a global recognition of the need for resource efficiency. Sustainable waste management, promotion of reduce, reuse and recycle (3Rs), adoption of sustainable lifestyles and a life-cycle approach are some of the policy tools being employed by various countries at different levels. In the aftermath of the 2008 economic crisis, pursuit of a green economy has become a spotlight of policy discussion and was a notable outcome of the Rio+20 United Nations Conference on Sustainable Development's *The Future We Want*. Increasing regional integration such as ASEAN+3, TEMM, the South Asian Association for Regional Cooperation (SAARC), Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), Greater Mekong Subregion (GMS), Pacific Islands Forum (PIF), Asia Pacific Economic Cooperation (APEC), Economic Cooperation Organization (ECO), and Trans-Pacific Partnership (TPP), can be used as formal mechanisms to strengthen the promotion of region-wide green integration.

In Asia and the Pacific, the green growth agenda is encouraging governments to shift unsustainable production and consumption patterns on to more sustainable pathways. These policies may appear in different forms, but in essence they signal a transformative change to reduce pressures on the environment and improve resource efficiency by promoting sustainable consumption and production, the 3Rs, sustainable energy for all, a low-carbon pathway, changing to low-impact lifestyles and leapfrogging to a circular economy. Examples that indicate shifting regional priorities towards a resource-efficient society include the 2010 Ministerial declaration on environment and development in Asia and the Pacific, the Sustainable 3R Goals for Asia and the Pacific for 2013–2023, the 2009 Manila Declaration on Green Industry in Asia, and the 2007 ASEAN Declaration on Environmental Sustainability.

A rapid transition from a traditional to a green economy requires all agreements to be respected and stronger policy instruments to be introduced. While the development of legal frameworks and international cooperation for improving resource efficiency in Asia and the Pacific are moving forward, challenges remain with respect to policy implementation and systems operation (IGES 2012). Resource efficiency aspects are conceptually well reflected in the national strategies of emerging economies such as Indonesia, Malaysia, Philippines, Thailand and Viet Nam, but concrete resource efficiency policies similar to those of China, Japan or the European Union (EU) Member States have not yet been developed (Aoki-Suzuki 2016). Green policies could provide incentives such as new market opportunities,

for example fuel-efficient vehicles, as well as disincentives for less resource-efficient production systems; and could minimize market risk, for example new kinds of taxes for non-compliance and restrictions on the abstraction and transport of particular raw materials. Further, the concept of a green economy could also encompass environmental and social considerations such as those related to sustainable consumption and production or corporate social responsibility.

Extreme events and disasters are on the rise across the region, and climate change is making all these extreme events the new normal. Alarmed by the increasing frequency and intensity of damaging natural disasters, policy-makers in the region have been formulating a high level of policy responses. Among them, the Hyogo Framework for Action 2005–2015 (HFA) aimed to establish more systematic action to identify disaster risks and build national and local resilience so as to decrease vulnerability.

The number of countries reporting on implementation increased during the term of the HFA to reach 36 in 2013. The growing interest and efforts of governments in the region to address vulnerability to natural hazards and extreme weather have resulted in significant progress with disaster risk reduction through the establishment of national and regional plans. Starting in 2015, the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNISDR 2015) and the SDGs will be a new driving force to implement disaster risk reduction measures. Disaster risk has also been receiving significant attention at UNFCCC processes. Building on previous COP decisions, adaptation and loss/damage are two crucial areas covered by the COP 21 Paris Agreement, aimed at strengthening the ability of countries to respectively deal with and recover from the adverse effects of climate change.

3.1.5 Transformative agenda for post-2015

Globalization, revolutions in information technology and mobility, and improved regional-level cooperation have enabled the cross-fertilization of ideas and approaches and their transfer from one territory to another. The region has benefited significantly from such improved connectivity to raise environmental awareness and take collective action. The region has seen major improvements in the formulation of environmental policies and plans, with most countries having dedicated ministries or departments to deal with environmental issues such as monitoring and conducting environmental impact assessments of development plans, and to establish regulations to prevent unwanted environmental problems. However, some countries, especially those in transition, have experienced a large gap between greater environmental awareness and efforts to address existing and new kinds of environmental problems.

Coordination and efficient mobilization of resources need to be given high priority post-2015, for which a reassessment of environmental goals and targets will be necessary, together with a forward-looking perspective based on integrated approaches that can become a basis for planning and implementation. Such an integrated mechanism should use, as far as possible, new concepts such as the green economy, ecosystem-based approaches, synergies between disaster risk reduction and climate change adaptation such as mitigating floods through groundwater recharge, low-carbon policies and enhanced regional cooperation on common environmental issues such as transboundary pollution of air and water, marine resource protection, biosafety regulations on the product development and trading of genetically modified (GM) crops and animals, resource efficiency across the supply chain, and the 3Rs.

A range of MEAs, sub-regional and national agreements and policies also address specific thematic issues on natural resources, for example the CBD and its Strategic Plan for Biodiversity 2011–2020, including the Aichi Biodiversity Targets, the 1986 Noumea Convention, the 2007 ASEAN Declaration on Environmental Sustainability, the Asia Pacific Water Forum, UNCCD, the 2002 ASEAN Agreement on Transboundary Haze Pollution, and UNFCCC. Countries party to these agreements generally have separate national policies and implementation mechanisms for the management of natural resources. Individual country abilities to mainstream their existing natural resource management

plans and strategies with the related SDGs and targets will be crucial for maximizing the impact of policies for achieving environmental sustainability. There is also a need to boost finances and resources significantly to develop environmental statistical capacity in the region, which has received less than 1 per cent of the allocated funds for developing statistical capacity across several areas. The role of national councils for sustainable development, the Network for Integrated Planning and Sustainable Development Strategies-Asia and Pacific (SDplanNet-AP) and similar bodies will also be crucial to boost capacity for successful implementation of the SDGs. The active role of United Nations bodies in the region, such as the UNEP Regional Office for Asia and the Pacific and UN ESCAP, will also be necessary for coherent, efficient and effective implementation of the SDGs. Further, citizens and the private sector should be mobilized by adequate space within government or in UN-led programmes and initiatives.

3.2 Success stories

The international and regional agreements outlined in Section 3.1 are extremely important as statements of collective policy intent in the region. Just as important, however, are the policies that have been adopted by individual countries. **Table 3.2.1** captures some effective policies and interventions for sustainable development that were initiated at the national level.

3.2.1 Improving access to basic services

Affordable health care can improve quality of life significantly. Thailand's Universal Coverage Health Scheme has successfully reduced individual health expenses, particularly among the poor, and increased coverage to 99 per cent of the population (UNDP 2012a). The share of public health-care expenditure in total government health expenditure increased from 56 per cent in 2001 to 80 per cent in 2013 (T. Mongkhonvanit *et al* 2016) (**Figure 3.2.1**).

The Malaysian government built up stakes in the commercial health-care sector in order to direct limited health-care resources to poorer citizens. The government subsidy was estimated at 55 per cent of total health-care spending (WHO 2013). India's National Rural Health Mission has been able to provide financial resources to local governments and strengthen *last-mile health* service delivery, train human

Key Messages

There are promising initiatives by countries in the region to address environmental challenges which also have the potential to be tailored, up scaled and replicated.

- Policy focus to meet the MDGs in South and Southeast Asia has been the provision of improved and affordable health care, improve food security and thereby reducing extreme hunger and malnutrition.
- Resource use efficiency has been achieved through policies through various policies and initiatives.
- There has been increase in application of market based instruments with in addressing various environmental challenges.
- Joint forest management committees and community-based forest management have successfully restored forest ecosystems while maintaining the livelihoods of the poor and marginalized.
- Local awareness raising and capacity building for disaster risk reduction is common.

Sustainability of the success stories is contingent to the nexus of innovative developmental policies and environmental health of the region.

Table 3.2.1: Asia and the Pacific, select list of policies and interventions for sustainable development

Country/region	Sector	Name of policy/program	Impact/success
Bangladesh	Food	National Food Security Policy	Increased yield, reduced import dependency
Cambodia	Health and sanitation (rural)	Community-led Total Sanitation	Reduction in open defecation
China	Energy and environment	Circular Economy Promotion Law	Reduction in energy intensity, industrial water consumption per unit of production, increased industrial solid waste recycling rate
India	Forest	Forest Conservation Act, 1980	Reduced deforestation
India	Renewable energy	Jawaharlal Nehru National Solar Mission	Substantial increase in solar power generation capacity
Pacific islands	Environment	South Pacific Applied Geoscience Commission	Increased technical understanding, improved disaster risk finance and insurance
Republic of Korea	Energy and environment	Framework Act on Low Carbon Green Growth	Reduction in energy intensity, increased investments in green technology
Singapore	Building and construction	Green Building Masterplan	30% of buildings achieving green mark
Thailand	Health	Universal Coverage Health Scheme	Increased coverage, reduction in out-of-pocket expenses

Source: UNEP

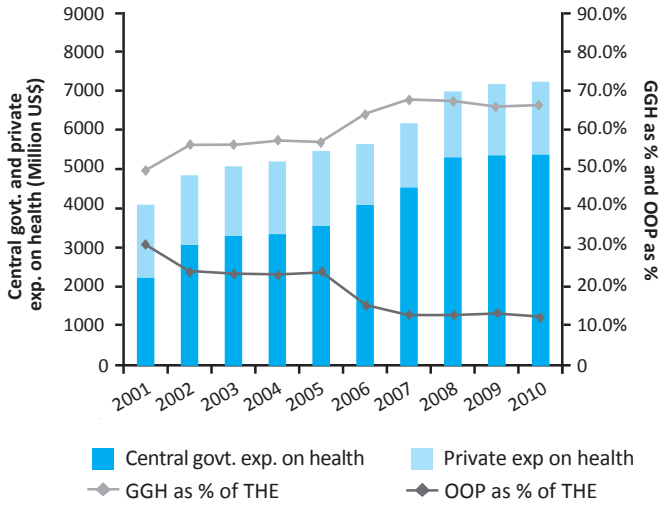
resources, and adopt innovative interventions to address state-specific health needs.

Bhutan's national health policy holds a prominent place in the country's economic development, with health expenditure at 7–11 per cent of total government expenditure. The policy aims to improve the delivery of health services and supply of related human resources, health research and information, affordable access to medical products, vaccines and technologies, health financing and leadership and governance (Bhutan, Ministry of Health 2012). Lao PDR introduced four different health financing schemes, including a social security organization scheme for salaried professionals working in the private sector, state authority for social security for civil servants, community-based health insurance for people working in the informal sector, and a health equity fund for the poor (WHO 2014).

Cambodia, through a community-led total sanitation initiative, has motivated citizens to construct their own sanitation infrastructure without depending on support from external sources (UNDP 2012a). In the Philippines, Family-based Actions for Children and their Environs in the Slums identified targets and actions that helped provide sanitation solutions to families at community and city levels. More than 600 children living in 15 slums in the Philippines were direct beneficiaries and the improvement in their quality of life ranged from 20 to 80 per cent. This project was replicated in 86 villages and 16 additional cities in 2009 (UNDP 2012b).

The Metropolitan Manila Development Authority's *Lingap sa Barangay* programme aims to improve ecological balance in various communities within its jurisdiction, in coordination with local government units (ANMC 2015). Bangladesh's pro-poor and gender-sensitive food policy has helped to

Figure 3.2.1: Thailand, general government expenditure on health and total health expenditure



GGH = general government expenditure on health. OOP = out-of-pocket. THE = total health expenditure. GGH and other in constant 2005 USD.
Source: Hanvoravongchai 2013

eradicate extreme poverty. Bangladesh also developed an investment plan for the promotion of agriculture to address food and nutritional security (UNDP 2013).

Bangladesh introduced the National Policy for Women's Advancement 2011 to improve gender parity through human development for women (Bangladesh, Ministry of Planning 2012). Fiji's education ministry introduced a free bus-fare initiative to encourage parents from low-income groups to send their children to school. This scheme has benefited many children in remote areas, thus helping Fiji towards achieving universal education (Vainerere 2010).

3.2.2 Promoting the efficient use of resources

China, through the 11th Five-Year Plan for Social and Economic Development (FYP 2006–2010), embraced a growth that is more sustainable and promotes the efficient use of resources (World Bank 2009). The 11th FYP set a target of a 20 per cent reduction in energy intensity, 10 per cent reduction in annual sulphur dioxide and carbon dioxide emissions, 30 per cent reduction in water consumption per unit of industrial added value, and an increase in the recycling rate for industrial solid waste to 60 per cent. China continued and broadened these targets in its 12th FYP (2011–2015).

Japan has introduced a series of resource efficiency policies and laws in areas such as the 3Rs and the Fundamental Law for Establishing a Sound Material-Cycle Society (2003), Virtuous Circle for Environment and Economy in Japan 2025, and Japan's Strategy for a Sustainable Society 2007 (Bahn-Walkowiak *et al.* 2008).

For encouraging the design and construction of environmentally friendly buildings, the Singapore government has implemented its Green Building Masterplan – and launched the Green Mark Scheme in 2005. A national target has been set for 80 per cent of buildings to achieve the Green Mark by 2030. More than 30 per cent of buildings had already achieved Building and Construction Authority Green Mark standard by early 2016.

3.2.3 Improving environmental quality

India granted exemption from customs and excise duties on domestic production and import of capital goods for phasing-out the use of ozone-depleting substances in projects funded by the Multilateral Fund for the Implementation of the Montreal Protocol (MLF). Further, it extended the phase-out of ozone-depleting substances for projects that are not supported by the MLF (India, Ministry of Enviroment and Forests and Climate Change 2008).

Singapore introduced a multi-pronged approach for phasing out the consumption of ozone-depleting substances. Licences are required for the import and export of such controlled substances, and certain prohibited ones – including chlorofluorocarbons (CFCs), halons and hydrobromofluorocarbons (HBFCs) – can only be imported if they are meant for re-export (Singapore, National Environment Agency 2015).

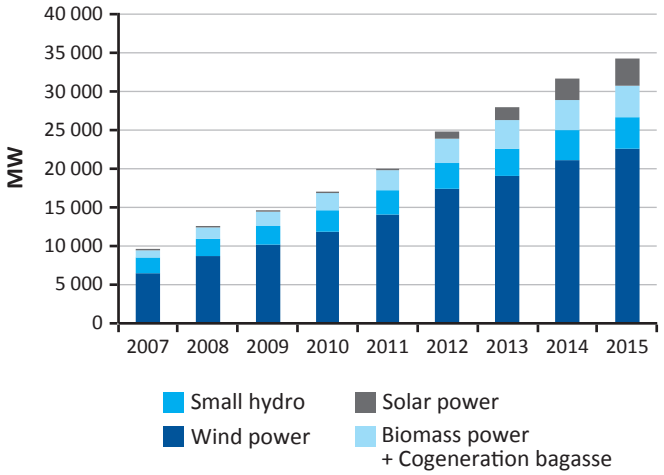
3.2.4 Market instruments

China set an ambitious goal to reduce carbon dioxide emissions per unit of GDP by 40–45 per cent below 2005 levels by 2020, and to increase forest cover by 40 million hectares. Between 2012 and 2015, Asia witnessed the establishment of nine new emissions trading systems (ICAP 2015). China's seven pilot emissions trading systems will help it to initiate a nation-wide emission trading system as early as 2016. (Andersen *et al.* 2012). The Republic of Korea's emissions trading system came into effect in January 2015, the world's biggest after the EU Emissions Trading System. The Maldives has planned to become carbon neutral by 2020 (Nachmany *el al* 2015). In 2010 Iran launched its targeted subsidy reform programme on fossil fuels, which reduced the subsidy bill by USD60 billion (10^{12}).

India launched the Jawaharlal Nehru National Solar Mission programme in 2010 with the aim of generating 20 gigawatts of solar power by 2022, further revised to 100 gigawatts in 2015. Also in 2010, the government introduced the National Clean Energy Fund for the promotion of renewable energy, imposing a levy of INR50 (USD0.8) per tonne on domestic production and import of coal, revised to INR200 (USD3.2) per tonne in 2015 (India, Ministry of Finance 2015) (**Figure 3.2.2**).

Asia and the Pacific countries are using integrated environmental performance measurement for creating sub-national environmental performance indicators (EPI) to improve tracking of policy implementation. Malaysia, for example, has developed two iterations of a state-level EPI.

Figure 3.2.2: India, annual growth in installed renewable energy generation capacity, 2007–2015



Source: India, Ministry of New and Renewable Energy 2015

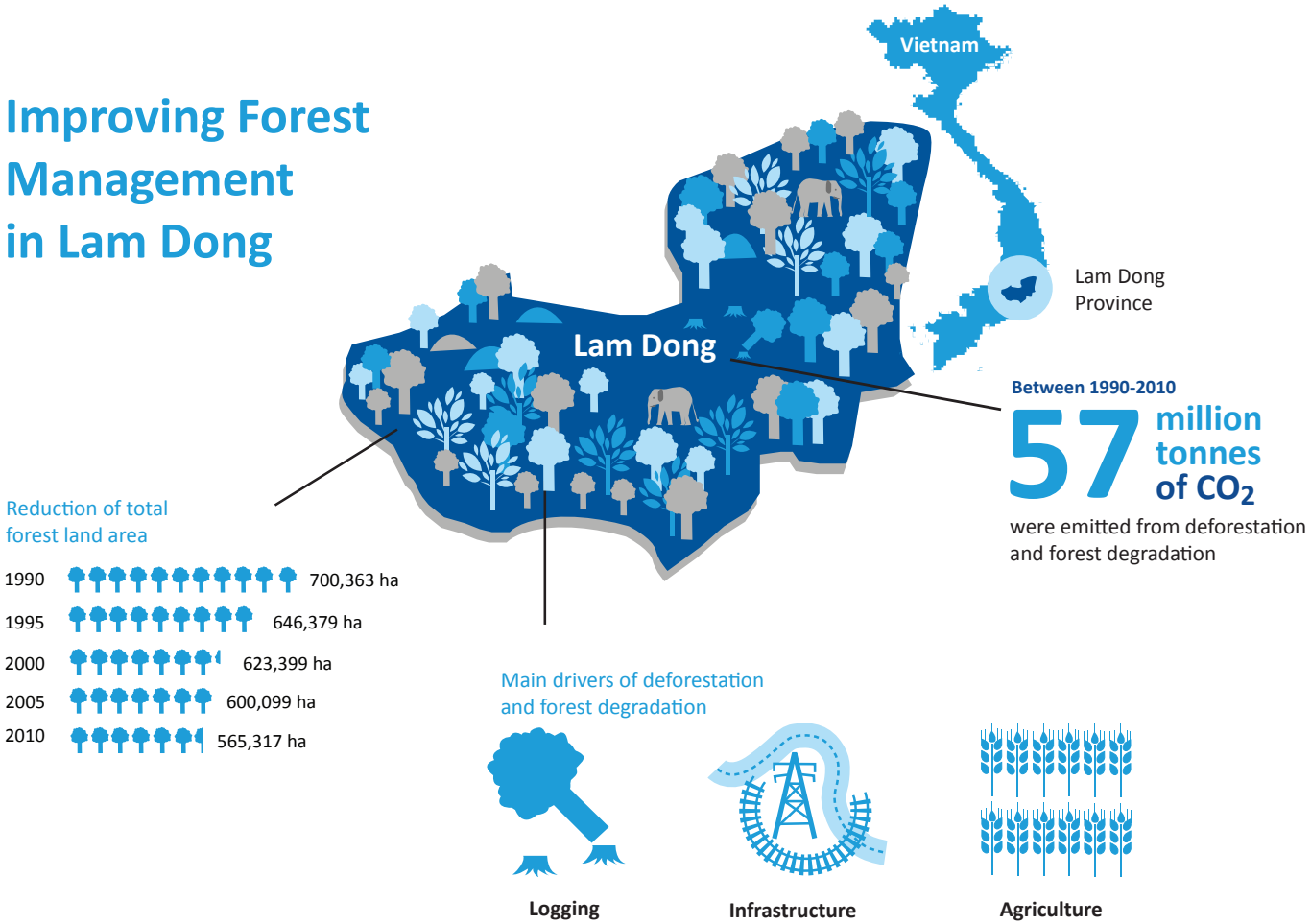
China and Viet Nam both completed feasibility assessments to identify gaps in existing measurement frameworks, monitoring systems and policies at the sub-national level (Hsu and Zomer 2015). In 2012, India's Planning Commission released its first national EPI report, a multi-indicator, state-by-state assessment of environmental quality and policy.

3.2.5 Conserving natural ecosystems

A number of countries, particularly in South and Southeast Asia, have established Joint Forest Management Committees and Community-based Forest Management and Forest User Groups for sustainable forest management, thereby decoupling forest ecosystem loss from economic development. The UN-REDD programme undertakes quantification, reports and verification that help smaller island nations to benefit from updated geographic information and data management systems, improve their capacity and have better access to multi-stakeholder networks addressing issues related to forests such as climate change.

In Viet Nam's Province of Lam Dong (**Figure 3.2.3**), forest-based ecosystem payment helped to improve the quality of life of more than 40 000 rural poor and helped to conserve more than 200 000 hectares of forest. The forest scheme charges operators and downstream utilities for upstream water regulation, soil conservation and landscape preservation. Successful replication of this scheme in other parts of Viet Nam would strengthen national plans to conserve forests and biodiversity, at the same time encouraging the participation of local communities (UNEP 2011).

Figure 3.2.3: Viet Nam, improving forest management in Lam Dong Province



Source: USAID 2015

The ecosystem approach to fisheries management of the Coral Triangle Initiative for Coral Reefs, Fisheries, and Food Security (CTI-CFF) helps protect a substantial area of ocean ecosystems in the Indo-Pacific and has strong political support from the relevant governments. Healthy coastal ecosystems are important for aquaculture, fisheries and forests and provide a source of income for coastal populations through eco-tourism and agriculture. They also act as potential buffer zones during extreme weather events, preventing coastal erosion and salt-water intrusion. The Green Coast Project is one such initiative implemented in India, Indonesia, Malaysia, Sri Lanka and Thailand, with the objective of restoring livelihoods and improving resilience to the impacts of climate change.

East Kolkata Wetlands was a threatened Ramsar site in Eastern India. Based on the Biorights model, the shrinking of the wetland has been reversed, with prevention of habitat loss (Dey 2010).

In 2007, Brunei, Indonesia and Malaysia launched the Heart of Borneo initiative with the objective of preserving the biodiversity of one of the largest islands in the world, accounting for almost 6 per cent of global biodiversity in tropical forests. The initiative benefited people relying on the tropical forest for their livelihoods, while helping sustainable management of forests and land use (WWF 2015).

The countries of the Greater Mekong sub-region launched a Core Environment Programme to address the increasing environmental pressure arising from economic growth. The Asian Development Bank administers the programme, but it is managed by the respective environment ministries, with a working group ensuring effective implementation of environmentally friendly and climate-resilient goals (ADB 2015). A Climate Change and Adaptation Initiative (CCAI) was established by the Mekong River Commission for strengthening and sharing adaptive capacity and resilience in the Mekong countries (Mekong River Commission 2015).

To promote the sustainable use of shared marine resources, eight countries (Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand), established the Bay of Bengal Large Marine Ecosystem project. It is supported by the Global Environment Facility (GEF) and the FAO, amongst other international organizations (BOBLME 2015).

Beginning in the 1970s, a long-term, massive afforestation programme, due to run to 2050, was initiated to prevent the expansion of the Gobi Desert and fight desertification in northern China. Despite the success of planting 36 million hectares of new forest across approximately 4 500 kilometres of northern China, however, positive effects are still in question due to the planting of non-native tree species, little abatement of yellow dust storms and overuse of groundwater in arid lands (O'Connor and Ford 2014; Wang *et al.* 2010).

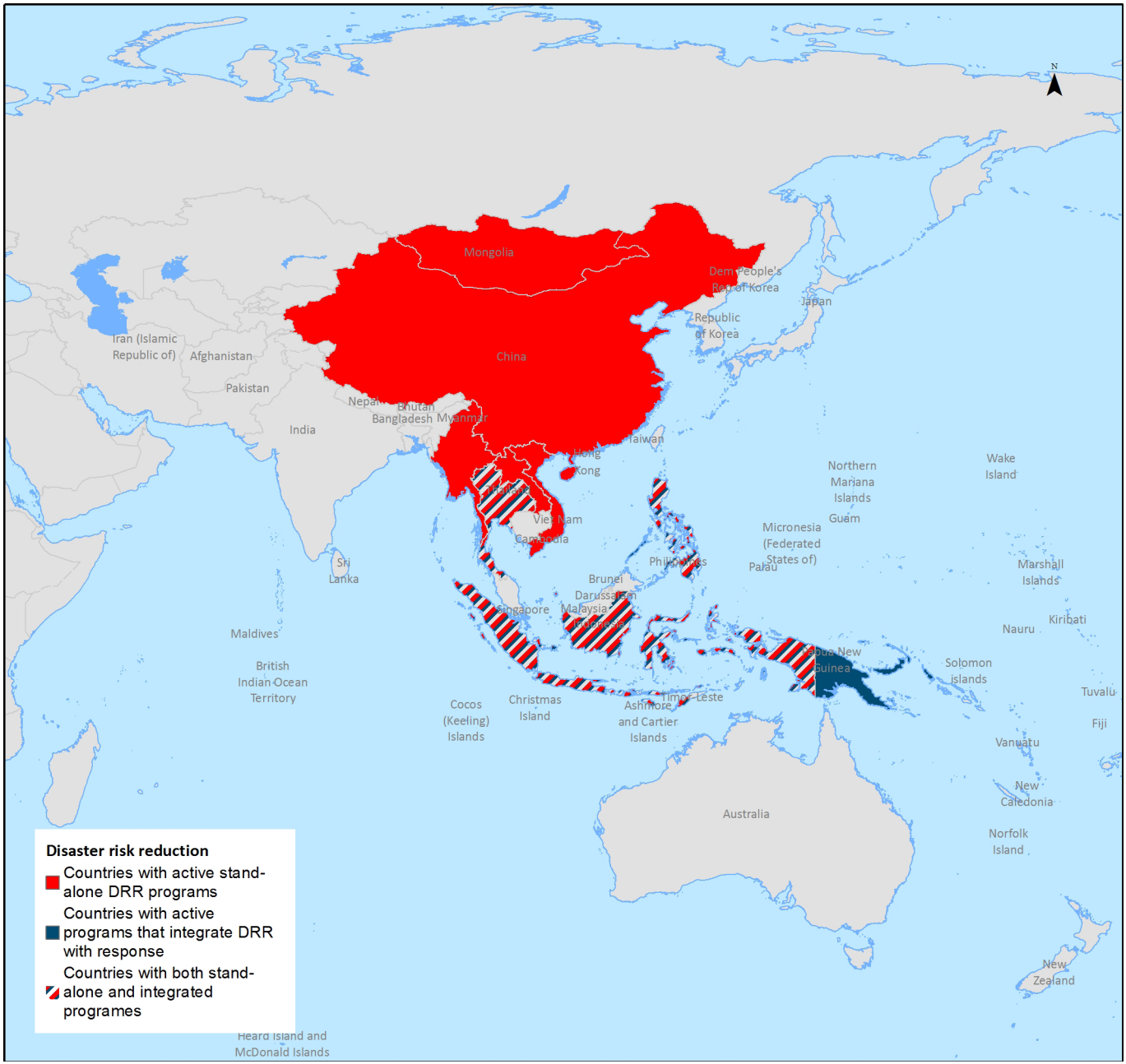
New agricultural practices that help retain water and soil nutrients and support biological soil processes in the Indo-Gangetic Plains of South Asia (which are relatively ecologically sound), are now being pushed by the state agricultural universities and departments. There is increased awareness among farmers of the benefits of zero-tillage and maintaining residue cover on the soil (Hobbs *et al.* 2006). Organic agriculture has had a strong response from farmers in India, as evident from the increase in the area under organic management from 42 000 hectares to more than 1 million hectares between 2003 and 2010 (India, Ministy of Agriculture and Famers Welfare 2015).

3.2.6 Addressing vulnerability

Spreading periodic national and local disaster risk reduction plans

Many countries in the region have successfully developed national frameworks and roadmaps for disaster risk reduction in light of the Sendai Framework for Disaster Risk Reduction 2015–2030 (**Figure 3.2.4**), and put substantial effort into multi-hazard management and public dissemination processes. Thailand, for instance, has developed a Master Plan for Prevention and Relief of Drought and a Strategic

Figure 3.2.4: Northeast Asia, Southeast Asia and the Pacific, disaster risk reduction



Source: USAID 2012

National Action Plan on Disaster Risk Reduction 2010–2019. Countries including China, India, Iran, Japan and Republic of Korea have incorporated the theme into the school curricula at all levels of educational systems.

3.2.7 Much closer attention to socio-economic damage

It is important to undertake local-level disaster initiatives since inputs from the local level will improve national disaster management policy. The Local Government Self-Assessment Tool (LG-SAT), launched in 2012, is a key tool to review and plan disaster risk reduction efforts (UNISDR 2013).

The United Nations Development Programme (UNDP) and the Secretariat of the International Strategy for Disaster Reduction have jointly undertaken a pilot exercise in selected Asian countries to identify indicators and illustrative disaster risk reduction targets. It has provided important insights into how targets and indicators can play a crucial role in ensuring that the SDGs and the post-2015 framework for disaster risk reduction are effectively aligned (WWF 2015).

3.2.8 Reducing environment-related health risks

The World Health Organization (WHO) has suggested the promotion of a health-in-all policy which has been successfully promoted in Thailand. It is an effective and efficient tool for addressing health issues linked to air pollution and pesticide contamination in agriculture, amongst other environmental problems (UNEP 2015).

To address future vulnerability to climate change, Cambodia introduced its National Adaptation Programme of Action to Climate Change in 2006. The key objective is to have a framework that will guide, coordinate and implement adaptation initiatives based on a participatory approach by ministries, departments and other stakeholders. It would also help in prioritizing projects. The National Health Strategy also aims to reduce the number of malaria cases and corresponding deaths (Cambodia, Ministry of Enviroment 2006).

The National Environmental Health Action Plan of the Philippines promotes collaboration between communities to improve environmental impacts on health. Key sectoral issues include solid waste, water and air pollution, use of toxic and hazardous substances and their impact, occupational health, food safety and sanitation (Philippines, Department of Health 2010).

Key Messages

The complex mix of geographic, environmental, political, economic and social issues across Asia and the Pacific has often generated tangled environmental issues, which require improved sub-regional cooperation.

- Many countries have successfully established adequate policies and governance frameworks, but the outcomes from policy implementation still need continual effort and capacity building at all levels.
- Sound scientific knowledge and analysis will support and provide collaborative mechanisms to solve shared problems.
- Strong governance and institutional capacity is another major condition for producing a well-implemented and inclusive framework.
- Efficient and comprehensive resource mobilization for trans-boundary issues should promote stronger collective action.

3.3 Enabling conditions

Led by China and India, the Asia and the Pacific region has recently become one of the fastest growing in the world, resulting in large-scale environmental impacts across various sectors. Rapid urbanization has raised concerns regarding air and water pollution, congestion in cities and degradation of land, forests and other natural resources. Sustainable long-term growth will be at risk unless countries are able to combat the environmental consequences of growth and reverse the trend towards increasing environmental impacts. Although adequate policies and governance mechanisms are being established in most countries, many challenges face their implementation.

The region has a great diversity of systems and mechanisms in its institutions for environmental governance, framing of laws and norms, and processes of public participation in decision making. Diverse political structures across countries in the region often lack a good balance between centralized and decentralized approaches and engagement of stakeholders in implementation, with often inadequate engagement of experts, and compartmentalized policies with limited or no flexibility. Performance of regional initiatives often fails to match intended outcomes, sometimes due to inadequate human resource capacity, lack of financial resources, poor implementation, and lack of mainstreaming into larger economic development and poverty alleviation policies and programmes. Short-term (two- to five-year) external funding of regional initiatives also constrains assistance in dealing with long-term goals and institutionalizing change.

Significant national variations with regard to the performance of a range of environmental, social and economic indicators urgently need to be addressed. Such disparities can be critical, with some countries lagging behind or making little progress. These gaps, including in developed countries in the region, can result in regional and environmental issues with important transboundary effects not being taken into account. Transboundary issues such as resource sharing, air pollution and water management need adequate attention from the countries in the region. Chronic issues, such as natural disasters, increasing vulnerability and climate change, will also create more challenges to all countries, and these call for effective policy tools and instruments to overcome threats to human life and livelihood, crops and livestock, private property and public infrastructure.

3.3.1 Encouraging climate change adaptation as a main pillar of sustainable development

Putting local climate change adaptation policy upfront

Despite the region's many successes in establishing climate change policies at the national level, the amount of carbon emissions is still increasing in most sub-regions as a result of rapid economic development and human activity (UN 2015). Many global and regional programmes such as the Green Economy Initiative, Clean Development Mechanism, Low-Carbon City, Kyoto Protocol and Montreal Protocol, aim to encourage low-carbon development to control emissions at mainly national levels, but extending these to develop climate change adaptation policies at the sub-regional or local level is a new challenge in the region.

For the successful establishment and adoption of such policies at the local level, a series of combined support mechanisms is needed in the form of effective policy, improved institutional capacity and governance mechanisms, financial incentives and scientific know-how. In most countries, the revision and establishment of legislation usually takes a long time, and the disparity of ministerial power across government structures often prevents environment and climate change issues from being incorporated into national and local development plans (Zhang 2015).

More targets to achieve in the SDGs; stronger institutional capacity required

Since many of the sustainable development goals have clear linkages to environmental sustainability, the future developmental policies to be coming up in the next 15 years

in the region will be a substantial driver towards addressing environmental challenges. Diverse and plentiful existing natural and human environments may hamper harmonized cooperation within some countries, so new or revised environmental programmes to establish collective efforts and meet the SDGs will be needed to improve environmental quality in the region (UNEP 2015).

3.3.2 Providing a platform for developing and sharing sound scientific knowledge and analysis

Better scientific base for identifying multi-risk hazards

Multi-risk hazards that affect people's well-being are getting more complex to manage. Limited national progress reports under the Hyogo Framework for Action 2005–2015 addressed multi-risks hazards, but insufficiently for the local level. As the impacts of disasters are mostly felt locally, there must be a stronger focus on how to better understand and address mainstreaming at the neighbourhood level. Local disaster offices, collaborating with the national disaster office, continuously need to capture local conditions and develop their own plan, taking complex local situations into account. National offices also need to capture this information more accurately for lessons learned and best practice, and share it with all stakeholders and other countries. Coordination and partnerships between stakeholders – governmental and non-governmental, including UN agencies, NGOs, donors and the private sector – also need to be strengthened to avoid gaps, duplication and ad hoc decision-making to maximize the impact of mainstreaming. The Hyogo Framework for Action substantially incorporated considerations related to the potential impacts of multiple hazards, including natural and human-induced disasters and industrial accidents and conflicts, in mainstreaming climate change agreements on adaptation, disaster risk reduction and sustainable development. In the post-2015 agenda, implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 and the SDGs with a holistic approach encompassing both natural and human-induced disasters would provide countries with a more effective way to address the risks faced by communities and build resilience to withstand and recover from shocks.

Incorporated or total management of risk management policy tools

Natural disasters often transcend national borders and overwhelm the capacities of individual countries to manage them. Most countries in the region have limited financial resources and physical resilience (UNISDR 2014). Furthermore, the level of preparedness and prevention varies from country to country and regional cooperation does not exist to the extent necessary. Because of this high vulnerability and the relatively small size of many Asia and the Pacific countries, particularly in Southeast Asia, it would be more efficient and economically prudent for countries to cooperate in the areas of civil protection and disaster preparedness and prevention. With the aim of reducing the sub-region's vulnerability to disasters, the World Bank and United Nations International Strategy for Disaster Reduction, through the Global Facility for Disaster Risk Reduction and in collaboration with other international partners, have started support for implementing the ASEAN Agreement for Disaster Management Emergency Response (AADMER) to promote sustainable development in the ASEAN region. The AADMER is a regional legally binding agreement that binds ASEAN Member States together to promote regional cooperation and collaboration in reducing disaster losses and intensifying joint emergency response.

3.3.3 Ensuring governance coherence across different levels of government

Promote and support cross-sectoral and integrated land-use management

As pressures on deforestation been increased in the last decade, the region needs to improve cross-sectoral and integrated land-use management at all levels. Few countries

Credit: Shutterstock/ De Visu

have adequate institutional capacity or financial and human resources to improve cross-sectoral land-use planning, and most of the developing and least developed countries in the region need to address growing land-related conflict. Integrated land-use policies need to be developed to resolve such conflict, which is driven by factors such as the desire to improve living conditions in the face of poverty and uncertain food supply and fuel security, the need to achieve economic development, illegal logging and land conversion, and the need to promote sustainable resource use.

A collective and inclusive approach to major environmental issues

Since economic activities have direct and indirect impacts on various natural resources and the environment, most environmental elements are tightly inter-related and involve dynamic human components. Policies that are particularly cross-sectoral and able to address natural resource degradation will play a very important role in the region (UN-REDD 2011).

The Green Economy Initiative is a collective and inclusive economic development approach that aims to generate growth and human well-being through sound resource use and energy efficiency. However, few collective green economy programmes reach down to the national or local level.

Poor air quality seriously affects human health in the region, requiring more effort to achieve substantial improvement through collective and inclusive policy instruments. Consistent and systematic monitoring and evaluation of air quality is needed, together with proper and applicable guidelines linked to building material controls and land-use regulations for indoor air, while proper transport planning

and fuel management policy need to be incorporated into the management of outdoor air quality. In most cases, air-quality monitoring and evaluation are cross-sectional and regional, so regionally cooperative plans to reduce air pollutants in the sub-regions should be encouraged and integrated with other closely related sectors.

In order to address climate change and air quality, renewable energy technology, in both innovation and policy, must be sought tirelessly across the region and adequately backed by policies and incentives. The development of an enabling entrepreneurial climate and of replicable cost-competitive technologies is desirable. The development and sustainable application of smart grids for sustainable cities and communities is one of the most promising trends in the Asia and the Pacific region, led by a number of countries including Australia, Japan, New Zealand, Republic of Korea and Singapore. It is imperative to actively promote these good examples with international collaboration and joint efforts to halt the rising trend in air pollution and reduce the impacts of climate change.

Comprehensive and systematic local management tools to reduce water resource stress

Good governance in water management is critical to securing water resources, quality and efficient use. Policies in the water sector do not solely apply to water demand and supply; policy tools must be integrated with other sectors including land-use planning, agriculture and energy. Localized water quality and pollution management needs to ensure the sustainable use of water resources, and a high level of participation by stakeholders and decision makers is expected to empower sustainable water use (WWWAP 2012).

Important regional bodies such as UN-Water, UN ESCAP, the Asia Pacific Water Forum, Asian Development Bank (ADB), UNEP, Global Water Partnership, Network of Asian River Basin Organizations and Water Environment Partnership in Asia can assist countries to achieve water security by promoting access to safer freshwater resources and sanitation, conservation, reuse, recycling, rainwater harvesting, sustainable groundwater extraction, improved technology for wastewater management and restoring and enhancing ecosystem services through regional cooperation (including transboundary initiatives and interagency working groups), use of traditional knowledge, and management with community participation. The water-food-energy nexus, highlighting synergies and trade-offs between each resource, is a useful approach to their management. Linking climate change and natural disaster policy is particularly important for countries that share water resources across boundaries and experience frequent flood damage (Middleton and Dore 2015; ADB 2012). Policy tools to encourage legal dialogue and capacity building to form regional conventions are needed to provide a common management system with transparency and security (Brander et al. 2012).

The complex mix of geographic, environmental, political, economic and social issues across Asia and the Pacific has often generated tangled environmental issues, which require improved sub-regional cooperation. Various multilateral environmental goals have identified the need to act in a more focussed manner. The responses towards addressing those goals have been mixed and the countries have faced implementation challenges. However the new agreements and the success stories create lot of opportunities and directions for the countries to minimize the widening gap between policies and their implementation. Sustainability of the success stories is contingent to the nexus of innovative developmental policies and environmental health of the region.

Globalization, revolutions in information technology, mobility and improving regional-level cooperation have enabled cross-fertilization of ideas, approaches, and policy tools and enabled their transfer from one territory to another. The mobilization of resources should not be limited to financial funds, but should incorporate technology, skills and know-how (IGES 2012; SPREP 2012). In the past the region has benefited significantly from improved connectivity to enhance environmental awareness and undertake collective action and the momentum needs to continue with renewed vigour in the future.

See references for Chapter 3

Credit: Shutterstock /Vaclav Volrab ▶

Chapter 4

Megatrends, Emerging Issues and Outlooks

As with past *Global Environment Outlooks* (GEOs), once the current state of the environment and policy response is assessed, it is important to look at possible policy pathways to a more sustainable future. With recent developments at the international level in late 2015, namely the adoption of the Sustainable Development Goals (SDGs) and the Paris Agreement, this sustainable future is more easily defined.

The GEO series became more quantitative as it evolved from GEO-1 through GEO-4; GEO-5 was the first to include regional assessments focusing on policies; and GEO-6 is the first to include a regional outlook. This outlook uses a qualitative approach, similar to that of GEO-5, but at the regional scale.

This chapter has four main parts. Section 4.1 reviews previous similar outlooks. Section 4.2 provides a macro-level discussion of pressures and outlooks for elements such as population, natural capital, infrastructure development, and natural disasters and risks. Section 4.3 surveys important emerging issues. Section 4.4 reviews regional and sub-regional outlooks, and finally the last section 4.5 discusses transformative pathways and the SDGs.

4.1 Review of major regional outlooks

The review of major outlooks relevant to the region indicates that economic factors are the principal drivers of environmental outcomes. The Asian Development Bank's (ADB) Asian Century outlook has two pathways: (i) Asian century, which assumes that the fast-growing economies that are already converging with best global practice will continue on this trajectory, while the more modest-growth economies will become "convergers" by 2020; and (ii) the middle-income trap, in which the fast-growing converging economies become economically trapped in the next 5–10 years, essentially following the pattern of Latin America, either stuck at low growth rates or having bursts of growth followed by periods of stagnation or even decline.

Food security has five scenarios: improved agricultural productivity; increased rice self-sufficiency; increased rice self-sufficiency alongside improved agricultural productivity; increased rice self-sufficiency accompanied by retaliatory tariffs from a key rice exporter; and natural disasters harming land productivity (Strutt and Nelgen 2013).

Key Messages

- Asia and the Pacific countries are increasingly aware of the importance of a healthy environment for the sustainable development of their economies and societies.
- However, accelerating environmental degradation and natural resource depletion are undermining the region's potential to achieve this ambition.
- The region's great diversity offers an opportunity to address these problems, build resilience and create sustainable prosperity for today's populations and future generations.
- These opportunities include solutions based on smart cities, renewable energy, the data revolution, and a more holistic and integrated approach based on the SDGs.

◄ Credit: Shutterstock/ Ozphotoguy

Trade agreement outlooks and the environment

Several outlooks have studied the impacts of trade agreements and greater regional integration in Asia and the Pacific. For example, Zenn (2015) recently looked at future scenarios for China's New Silk Road. Kenichi (2014) analysed various regional trade agreements being negotiated in the region, with six trade-liberalizing scenarios finding large income gains for Asia and the Pacific Economic Cooperation (APEC) economies. The National Institute for Environmental Studies (NIES) of Japan uses the Asia and the Pacific Integrated Model (AIM) to examine the impacts of alternative policy responses in Asia. Most of these scenarios suggest that the region should integrate sustainable production and low-carbon lifestyle features into trade to safeguard the environment.

Security outlooks and the environment

Security outlooks have also been developed for the region. The Institute for Defence Studies and Analyses (IDSA 2010) developed three scenarios: cloudburst, a sudden rise in tension; rainbow, multilateral cooperation neutralizing conflict; and dragon-fire, rapid changes as states become post-modern and open up borders. Swaine *et al.* (2013) posit five scenarios: limited conflict; mitigated threat; Asian cold war; Sino-centric Asia; and Sino-Japanese rivalry. These scenarios agree on the need to promote regional cooperation to address conflicts, including those arising from resources, and to safeguard the environment.

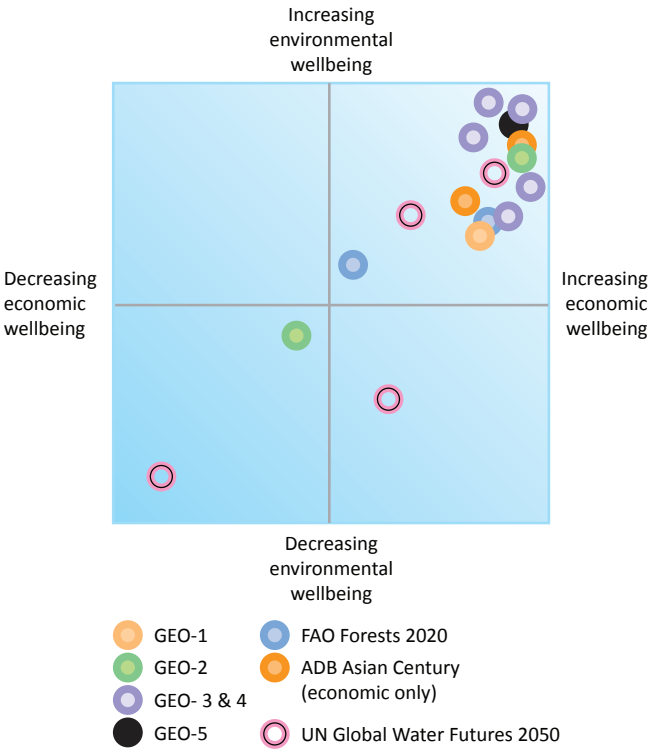
Energy outlooks and the environment

There are many global and regional scenario studies on energy and climate change. The International Energy Agency's assessment (IEA 2015) uses three scenarios: a scenario based on submitted intended nationally determined contributions (INDCs), which collectively represent 34 per cent of global carbon dioxide emissions; the 450 scenario, which limits temperature rise to 2°C above pre-industrial levels and peak carbon dioxide emissions of 450 parts per million; and a bridge scenario involving energy efficiency, reducing coal-fired power plants, increased investment in renewable energy, phase-out of fossil-fuel subsidies, and reduced methane emissions from oil and gas production. The APEC *Energy Overview 2014* (APEC 2015) refers to reducing energy intensity by at least 45 per cent by 2035 compared to 2005, and doubling the share of renewable energy in the APEC energy mix by 2030.

Environmental outlooks

The basic directions of eight major environmental outlooks are illustrated in **Figure 4.1.1**. These start with business-as-usual scenarios and then explore how sets of increasingly stronger policies or other interventions influence the

Figure 4.1.1: Overall direction of scenarios of selected environmental outlooks



Source:UNEP

economy and environment. **Figure 4.1.1** shows that business as usual (BAU) scenarios are considered negative for both the economy and environment in two cases, and in one case is positive for the economy but negative for the environment. In all cases, scenarios assess progressively stronger hypothetical interventions which improve both the economy and the environment. In other words, these scenarios suggest that strengthening environmental well-being will also strengthen economic well-being.

For example, GEO-2 identified two distinctive scenarios emerging from its analysis of trends: time is running out, and continued success. While the report recognized emerging environmental policy initiatives, these were found to be insufficient to arrest unhealthy trends in the areas of water, land degradation, forest destruction, loss of biodiversity and urban air pollution.

GEO-3 modelled four scenarios for 2002–2032 using quantitative work and qualitative narratives. Global and sub-regional implications for demographics, economy, atmosphere, human development, science and technology, governance, culture, environment, and so on, were presented. The implications were different for each sub-region. GEO-4 continued to use the scenarios introduced by GEO-3.

GEO-5 approached the scenarios with more qualitative discussion by reviewing the relevant published literature on drivers such as population and income, consumption, atmosphere, land, water and biodiversity. It emphasized enabling conditions such as shifting mind-sets, rules and incentives, and adaptive governance.

Climate change outlooks

The *Fourth Assessment Report* of the Intergovernmental Panel on Climate Change (IPCC) adopted several socio-economic scenarios. The A1 scenario is market-oriented and countries experience relatively fast economic growth, while the A2 scenario is characterized by regionally oriented economies that preserve local identities and experience the lowest per-person growth of the four scenarios. The B1 scenario is characterized by convergent and service-oriented economies while the B2 scenario utilizes local solutions with rapid technology development. These scenarios project rapid economic and population growth.

The IPCC *Fifth Assessment Report* uses representative concentration pathways (RCPs) to make projections and describes four different pathways of greenhouse gas emissions and atmospheric concentrations, air pollutant emissions and land use. The RCPs include a stringent mitigation scenario (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0) and one scenario with very high greenhouse gas emissions (RCP8.5). Scenario RCP2.6 aims to achieve the global target of keeping global temperature rise to 2°C above pre-industrial levels. All scenarios agree on a strong link between cumulative carbon dioxide emissions and global temperature rise and several scenarios agree with high confidence that global surface temperatures are likely to exceed a 1.5°C rise by the end of the century relative to 1850–1900 (IPCC 2014a).

Resource-use outlooks

A report by UNEP and the Commonwealth Scientific and Industrial Research Organisation (UNEP and CSIRO 2011) on resource efficiency concluded that a new industrial revolution is required, in which human needs are met with only about 20 per cent of the per person resource use of current systems. The UN World Water Assessment Programme developed five long-range global water scenarios where water stress appeared to be lowest in the global-consciousness scenario and highest in the conventional world-gone-sour scenario.

According to the Food and Agriculture Organization of the United Nations (FAO) report, *Asia Pacific Forests and Forestry to 2020,* forests will be negatively affected under a high-economic-growth-and-recovery scenario while net positive growth in the sector is possible in the social-and-ecological-stability scenario, mainly because of green economy measures and the UN's deforestation and forest degradation reduction programmes (REDD and REDD+). Several developed countries in the region have taken significant

steps towards a green-growth scenario by increasing investment in low-carbon technologies. Some developing countries have launched significant initiatives in this area too, focusing mainly on energy, and green and smart cities.

In conclusion, most outlooks and scenarios suggest that environmental conservation measures are essential and likely to lead to substantial economic and social benefits for the Asia and the Pacific region. While the outlooks and scenarios only reflect current thinking on possible futures, there is a need to closely examine the underlying assumptions and the actual policy interventions that may be needed to achieve the improved outcomes suggested by the advanced scenarios.

4.2 Megatrends

In the past few years, some important megatrends have become evident throughout Asia and the Pacific. Many of them are specific to the region but greatly affect other regions. Major megatrends were identified by regional experts at the UNEP regional scoping meeting, and were further prioritized and supplemented based on data analysis and literature review.

4.2.1 Rapid economic growth and urbanization

Asia and the Pacific's rapid ongoing economic growth may continue beyond 2030. Accelerated economic growth has shifted the global economic centre of gravity away from the North Atlantic, increasing the importance of Asia in world trade, and boosting South-South trade (ADB 2014). Developing Asian countries are projected to continue to lead gross domestic product (GDP) growth rates, and the share of South-South trade in global trade is projected to double from the present 13 per cent to 26 per cent by 2030.

The region's rapid economic growth has mainly been driven by global demand for industrial products, and the region has become the world's factory and warehouse. Global markets will probably remain the key driver of growth in the Asia and the Pacific economy in 2030. Meanwhile, domestic markets are expected to grow fast, poverty to decline, and the middle class to increase. Regional and sub-regional common

Key Messages

The megatrends are considered to be the big global trends that will influence future conditions in Asia and the Pacific. Many of them are specific to the region, but have considerable impacts on other regions.

- By 2030, the world is projected to have 41 megacities with 10 million inhabitants or more, with 70 per cent of the newcomers in Asia and the Pacific. Pressure on ecosystems and environmental quality will rise as urban areas expand.
- Spatially heterogeneous climate change has been observed over the region, compared to the global mean. The Asia and the Pacific region is among those experiencing significant increases in climate extremes, and the trend will probably continue for decades.
- There are increasing sub-regional connections and cumulative effects over various sectors in Asia and the Pacific, and local events increasingly have regional or even global consequences.
- Innovation in cost-efficient renewable energy technologies is increasing in the region, and mobile telecommunication technology and big data will lead a revolution in two-way transparency of environmental monitoring and interactions.

Blocks of tall apartments are replacing old houses in Chengdu, China, as millions of newcomers move here from small towns and villages
Credit: Gensuo Jia

Sky train mass transit in Bangkok, Thailand
Credit: Shutterstock/ladywewa

Pedestrians at Shibuya crossing on 20 November 2010 in Tokyo, Japan; the famous scramble crosswalk is used by more than 2.5 million people daily
Credit: Shutterstock/Thomas La Mela

markets are expected to advance, facilitated by stronger free-trade agreements. Consumer spending in developing Asian economies is projected to grow by 7.3 per cent per year in real terms between 2015 and 2030. Under pressure from growing global demand and domestic markets, greater future environmental impacts are expected. At the same time, as the region consolidates the economic gains and policy lessons of past decades, a brighter future of sustainable growth may be achievable.

Global urban populations could increase by 2.5 billion (10^9) by 2050, with nearly 90 per cent of the increase in Asia and Africa (World Bank 2015). Asia, despite its current lower level of urbanization, hosts 53 per cent of the world's urban population. In 2014, there were 28 megacities worldwide, home to 453 million people or about 12 per cent of the world's urban dwellers; 16 are in Asia. Tokyo, Japan, is the largest with nearly 38 million people, followed by Delhi, India, and Shanghai, China. By 2030, the world is projected to have 41 megacities with 10 million inhabitants or more, with 70 per cent of the newcomers in Asia and the Pacific.

This large-scale urban expansion is expected to have direct impacts on biodiversity, carbon budgets (Seto *et al.* 2012) and the region's climate (Jia *et al.* 2015). Proper planning of urban clusters and coordinated adaptation approaches are increasingly considered to be solutions for these emerging *megapolitan* regions (Georgescu *et al.* 2014). Providing public transport, as well as housing, electricity, water and sanitation, for a densely settled urban population is typically less costly and environmentally damaging than providing a similar level of services to a dispersed rural population. Therefore, future urbanization provides a good opportunity for Asia and the Pacific countries to better manage the environmental impacts of their economic growth and to move towards low-carbon and sustainable development.

4.2.2 Increasing pressure on ecosystems and natural capital

Increased use of Asia and the Pacific urban and agricultural land will continue to be driven by rapid economic growth and higher demand for land and natural resources. Properly planned urbanization can enhance land-use efficiency and may reduce pressure on natural ecosystems. In rural China, for example, millions of hectares of natural vegetation were re-established around newly abandoned villages and farmlands. Meanwhile, with a changing climate and increasing water use, major freshwater shortages may occur by 2050 as urban clusters continue to expand (McDonald *et al.* 2011). A total of 94 million people in Asia are projected to be living in cities with perennial water shortages in 2050.

The pressure on tropical forests is growing, and reducing carbon emissions by avoiding deforestation can be very costly. In Southeast Asia, the average area deforested annually is more than 1 million hectares, resulting in hundreds of millions of tonnes of carbon dioxide emissions per year between 2005 and 2015. The carbon price necessary to significantly reduce the region's deforestation by 2030 could be twice the global average because of high economic pressure on the region's tropical forest ecosystems (Kindermann *et al.* 2008).

Pressure on ecosystems and environmental quality will rise as urban areas expand. Meanwhile, environmental pressures have increased with economic globalization and displacement (Lambin *et al.* 2011). An urbanization mitigation wedge, corresponding especially to energy-efficient urbanization in Asia, might reduce urban energy use by more than 25 per cent compared to business as usual (Creutzig *et al.* 2015). Cities with GDP of less than USD10 000 per person use nearly three times less energy than those above this threshold, while most Asia and the Pacific developing countries are well below the threshold.

Increased consumption of natural resources and fossil fuels will put heavy pressure on natural capital. Rising consumption among the new middle class can have major environmental impacts, but these could be mitigated by various policy initiatives. The world's middle class is expanding rapidly, particularly in Asia developing countries that are now emerging economies. The global middle class population is expected to grow from less than 2 billion today to nearly 5 billion within two decades, largely from Asian emerging economies. The middle class is an important driver of economic growth due to its high income elasticity for durable goods and services, and the Organisation for Economic Co-operation and Development (OECD) predicts that its global spending may grow to USD56 trillion (10^{12}) by 2030 from USD21 trillion today. More than 80 per cent of this growth in demand is expected to come from Asia and the Pacific, putting heavier pressure on natural resources. Some evidence shows that the new middle class is often more environmentally conscious, and can sometimes lead local communities towards greener lifestyles, although this is far from certain.

Coastal areas and Pacific islands face the combined pressures of urbanization, sea-level rise and intensified extreme events such as disasters driven by climate change. Some islands are approaching a tipping point of major losses (Keener *et al.* 2013). Rising sea levels will increase the likelihood of coastal flooding, damaging coastal infrastructure, reducing habitat for endangered species and threatening shallow

reef systems. Extreme water levels will occur when sea-level rise related to longer-term climate change combines with seasonal high tides, inter-annual and inter-decadal sea-level variations, and storm-caused surges (Keener *et al.* 2013). Some megacities, such as Bangkok, Thailand, and Ho Chi Minh City, Viet Nam, are also reaching a tipping point of major consequences due to sea-level rise and sinking land.

4.2.3 Climate change and increasing disaster risk

Spatially heterogeneous climate change has been observed over the region, compared to the global mean. The Asia and the Pacific region is among those experiencing significant increases in climate extremes, and the trend will probably continue for decades (IPCC 2013). A rise in record-breaking precipitation events attributable to climate warming has been detected over Southeast and South Asia in the past three decades (Lehmann *et al.* 2015).

There is evidence across Asia and the Pacific of significant increases in the intensity and/or frequency of many extreme events such as heat waves, tropical cyclones, prolonged drought, intense rainfall, snow avalanches and severe dust storms. The region accounted for 91 per cent of the world's total deaths and 49 per cent of the world's total damage due to natural disasters in the last century. Most global and regional climate projections indicate highly differentiated climate change impacts across the sub-regions and different economic sectors of Asia and the Pacific by 2050 (IPCC 2014b).

Climate models project regional temperature increases of around 0.5–2°C by 2030, when the region is also projected to experience an increase in global sea level of approximately 3–16 centimetres, and the potential for more intense tropical cyclones and changes in important modes of climate variability such as El Niño-Southern Oscillation. The majority of the region's estimated 500 million rural poor are subsistence farmers occupying mainly rain-fed land. The impacts of such disasters range from hunger and susceptibility to disease to loss of life, income or livelihoods. Climate change is becoming the foremost development issue in the region (AASA 2012).

Extreme climate events are projected to become the new normal, with increasing frequency and intensity in the coming decades. Hurricanes and typhoons are migrating from the tropics towards the North and South poles, with tropical storms no longer peaking in the tropics as often as they did 30 years ago. Instead, storms are increasingly reaching their maximum strength at higher latitudes (Kossin *et al.* 2014), moving pole-wards at about 53 kilometres per decade in the northern hemisphere and 61 kilometres per decade in the southern hemisphere, a total shift of about 1° latitude per decade. The biggest moves have occurred in the Pacific and southern Indian Oceans. More typhoons and hurricanes reach above 40° north on the east coasts of Northeast Asia and North America. In summer 2015, three major typhoons hit northern China, Japan and Korea, moving north a record distance. Meanwhile, fire weather seasons have lengthened across 29.6 million square kilometres (25.3 per cent) of the Earth's vegetated surface, resulting in an 18.7 per cent increase in the length of the global mean fire weather season. Studies show a doubling (108.1 per cent increase) of global burnable area affected by long fire weather seasons (41 days above the historic mean) and an increase in their global frequency across 62.4 million square kilometres (53.4 per cent) during the second half of the study period (Jolly *et al.* 2015).

Disaster losses are multiplying due to increasing climate-driven risks and the exposure of a higher degree of urbanization and infrastructure. The Asia and the Pacific region has suffered more losses from disasters than other regions in the world. Of the ten worst disasters of the 21st century caused by natural events, seven occurred in Asia and the Pacific. This trend is expected to continue for the coming decades, accompanying demographic growth and socio-economic expansion. Disaster impacts are likely to increase with the rising population and rapid and unplanned urbanization, alongside climate variability and extremes food price fluctuations, financial shocks and weak governance systems (Alcantara-Ayala *et al.* 2015).

4.2.4 An inter-connected Asia and the Pacific region

Resource consumption and environmental pollution in different parts of the region may have very different consequences. There are increasing tele-connections and cumulative effects over various sectors in Asia and the Pacific, and local events increasingly have regional or even global consequences. Air pollutants from intensified point sources are becoming mixed and transported via atmospheric circulation, affecting societies and ecosystems far from the point of origin at much larger spatial scales. The impacts of air pollution and solid waste disposal are expanding from the local level to the sub-regional and even regional levels, driven partly by increasingly integrated economies and urbanization.

Many climate and environmental issues are closely interconnected, and these interconnections are increasing over time. One such regional issue is the spatial link between black carbon pollutants, alpine glacier retreat and downstream ecological and hydrological impacts. In South Asia, wood collection and damage to vegetation are related to their large-scale use as fuel in many rural communities. Such large-scale wood and charcoal burning could become a major contributor to black carbon emissions in the region, driving faster glacier melting in Asia's mountain areas. Changes in the hydrological regime and increased extreme events related to the retreat of glaciers, lead in turn to major impacts on crop yields and livelihoods in communities in the lowland areas of Asia's vast interior. Many similar links between ecosystem and climate issues can be identified across sub-regions. Without considering these connections, sectors and country-based climate change adaptation policies will probably fail. More coordinated or integrated adaptation strategies are needed across various sectors at sub-regional and regional scales.

Environmental pressures become highly regionalized as globalization and common markets continue to strengthen. The APEC countries are building an Asia and the Pacific partnership to create an open economy in the region featuring innovative development, interconnected growth and shared interests (APEC 2014).

Major advances in regional cooperation mechanisms and macro-scale transboundary infrastructure developments enhance capacity to address common regional and sub-regional environmental issues (ADB 2014). Rediscovery and development of the ancient inland and maritime silk roads connecting most of Asia with Europe and Africa will probably lead to major infrastructure improvements in the region and beyond.

The Association of Southeast Asian Nations (ASEAN) Economic Community (AEC), established in 2015, envisages a region fully integrated into the global economy. The AEC's areas of cooperation include human resources development and capacity building; recognition of professional qualifications; closer consultation on macroeconomic and financial policies; trade financing measures; enhanced infrastructure and communications connectivity; development of electronic transactions through e-ASEAN; integrating industries across the region to promote regional sourcing; and enhancing private-sector involvement in building the AEC. The AEC is intended to transform the ASEAN region into one with free movement of goods, services, investment and skilled labour, and freer flow of capital.

4.2.5 New solutions from collaboration and emerging technologies

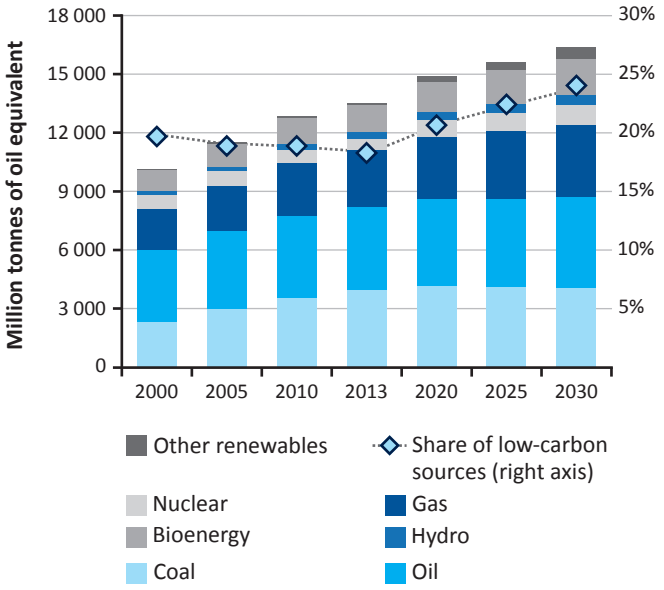
Asia and the Pacific countries are showing stronger willingness to cooperate on better solutions for major common sub-regional and regional environmental issues. Important political agreements and financial mechanisms are on the horizon and are expected to accelerate multilateral collaboration to solve the region's critical environmental problems in the next 10–20 years. Meanwhile, emerging new technologies, including cost-efficient renewable energy, mobile communication and big data, are further facilitating collaborative solutions.

Innovation in cost-efficient renewable energy technologies is increasing in the region. Global and regional energy systems are being transformed, with a growing share of renewable energy in various sectors (Dangerman *et al.* 2013). Asia accounted for about 60 per cent of global progress on energy access and clean-energy objectives during 2010–2012, well beyond its share of global energy consumption (World Bank 2015). Until 2050, Asia and the Pacific will face the greatest demand for low-carbon energy supply, and key policy options include technology transfer to manage demand growth and greater social acceptance of changing energy supply sources (IEA 2015).

The share of renewable technologies (excluding hydropower) in electricity generation worldwide is increasing, from 8.5 per cent in 2013 to 9.1 per cent in 2014, when renewables contributed 48 per cent of the world's newly added generating capacity. By 2030, global consumption of fossil fuels could decline to about 50 per cent of the 2014 level, with more than a 60 per cent reduction in coal consumption. Meanwhile, the use of clean energy will probably be double the level of 2014, with the largest share being solar energy (IEA 2015). The Asia and the Pacific region is expected to lead this structural shift in energy consumption by 2030. Still, at the current rate of increase of about 0.6–0.7 per cent per year, the share of renewables in total electricity generation would still only reach 20 per cent by 2030 (***Figure 4.2.1***). The speed of change is inhibited by several difficulties related to financing, inadequate energy market regulatory reform to enable larger-scale integration of intermittent renewables into electricity systems, continuing fossil-fuel subsidies, and weak or absent carbon prices.

Mobile telecommunication technology and big data will lead a revolution in two-way transparency of environmental monitoring and interactions, for example cell-phone-based public reporting, early warning and monitoring of pollution events. Satellite-based Earth observation has been combined with big data to track and predict illegal logging and hunting in Southeast Asian tropical forests. Drones are becoming widely used to monitor biomass burning and land-use conversion. A small solar-powered battery and a tiny computer have already transformed remote Indian villages. This *big bang* of information and education, is improving human lives (Mahbubani 2012).

Figure 4.2.1: Global primary energy demand by type in the intended nationally determined contributions scenario



Notes: 'Other renewables' includes wind, solar (photovoltaic and concentrating solar power), geothermal and marine energy source.
Source: IEA 2015

4.3 Emerging issues

4.3.1 Sustainable consumption and production

Despite increasing environmental pressures, general patterns of consumption and production in the region have become increasingly based on local knowledge and possibly more sustainable (AASA 2012). Expansion of the middle class has accelerated in the past five years, and is likely to continue on the same path until at least 2030. The size of the global middle class is projected to increase from 1.8 billion (10^9) in 2009 to 3.2 billion by 2020 and 4.9 billion by 2030. Most of this growth will come from Asia, which will then represent 66 per cent of the global middle-class population and 59 per cent of middle-class consumption, compared to 28 per cent and 23 per cent respectively in 2009 (OECD 2012).

The developing world's emerging middle class is a critical economic and social actor because of its potential as an engine of growth, particularly in the largest developing countries such as China and India (Kerschner and Huq 2011). Asia is almost entirely responsible for this emerging middle class, which is projected to triple in these countries to 1.7 billion by 2020. By 2030, Asia would be the home of 3 billion middle-class people. This will be ten times more than North America and five times more than Europe. The new global middle class is likely to demand better environmental protection and more transparency in how governments operate on major environmental issues, although social views and personal behaviour may vary. The world is reaching a tipping point, with the middle class expected to expand dramatically over the coming years. This is one of the most important features of today's global economic landscape.

Integrated life-cycle assessment of electricity supply scenarios confirms that the large-scale use of wind, photovoltaic (PV) and concentrated solar power (CSP) could reduce pollution-related environmental impacts of electricity production such as greenhouse gas emissions, freshwater contamination, eutrophication and exposure to particulate matter. The pollution caused by the higher material requirements of these technologies is small compared to the direct emissions of fossil-fuel power plants. Bulk material requirements appear manageable if not negligible compared to current production rates for these materials (Hertwich *et al.* 2015).

E-commerce and purchasing have expanded rapidly into rural areas and small towns, and even among the older generation, with potential impacts on energy use and environmental footprints (ADB 2014). Local knowledge-based industrial innovation is emerging in many Asian developing countries (Reardon *et al.* 2012). The supermarket revolution in Asia has been driven by the same factors

Key Messages

- The region has begun to suffer from new and emerging surprises in climate extremes, which are frequently exceeding historical records, and climate-driven mega-disasters are emerging in new areas and new time periods and season.
- Air and water pollution, once a local phenomenon, is rapidly going beyond the boundaries of cities, countries and sub-regions.
- A revolution in environmental governance is being driven by extensive use of mobile communication, information technology and big data.
- Larger and smarter cities are emerging in the region, with increasing green urban transport and construction, as well as urban green areas.

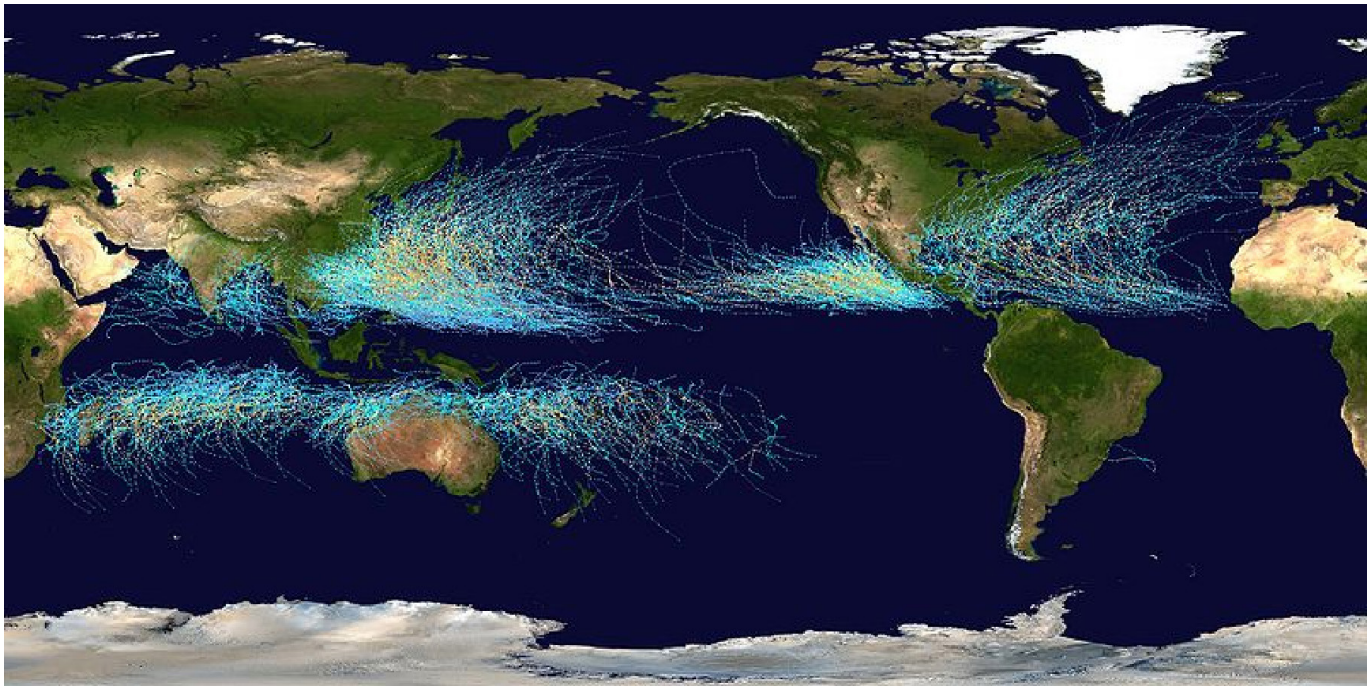
Rapid development of wind energy in Asia
Credit: Gensuo Jia

as in other regions: income growth, urbanization, direct foreign investment, diversification to meet the needs of a range of consumers, competitive domestic investments, and modernized procurement systems to reduce costs. However, in Asia, these trends have been more intense and rapid. Several approaches are being tried to connect small-scale producers with supermarkets. Some are unique to Asia, for example government-sponsored interfaces and services that link farmers to modern markets. This model has been demonstrated to be environmentally friendly and eco-efficient. Other emerging production and consumption patterns include the sharing economy and the rental of luxury goods, spreading quickly in major cities. On the production side, 3D printing could make large-scale factories outdated, although relevant life-cycle assessment has not been conducted.

4.3.2 Shifting patterns of extreme climate and disasters

The region has begun to suffer from new and emerging surprises in climate extremes, for example unprecedented snow storms in tropical regions, multi-year severe droughts in humid regions, and long-lasting heat waves in northern

Figure 4.3.1: Tropical storm tracks such as these have been moving pole-wards in recent decades, as monitored from multiple Earth observation satellites



Source: NASA 2013

high latitudes. Clearly, there is an emerging shift of extreme climate patterns and related disasters in space and time over the globe, and especially in Asia and the Pacific (AASA 2012), which could be a new normal.

Extreme climate events are exceeding historical records. The number of record-breaking rainfall events increased by 12 per cent globally in the period 1981–2010 compared to the previous 80 years, with the largest rise in Southeast Asia, at 56 per cent. These record-breaking rainfall events are consistent with rising temperatures (Lehmann *et al.* 2015). Fires in Western Australia, declared a national disaster, burned more than 80 000 hectares in February 2015. In 2013, China, Japan and the Republic of Korea experienced extremely hot summers. Extreme heat waves hit India and Pakistan in summer 2015. Studies of these events concluded that human-caused climate change made these heat waves more likely, although tying any particular extreme event to climate change remains problematic. Monsoon-like atmospheric circulation arrived early in June, causing heavy precipitation in northern India of a kind considered a once-in-a-century event. However, analyses of observed and simulated June precipitation indicated that human-caused climate change has increased the likelihood of such events (Kossin *et al.* 2014).

Changes in settlement patterns, urbanization and socio-economic status in Asia have influenced observed trends in vulnerability and exposure to climate extremes. In many coastal areas, growing urban settlements have also

affected the ability of natural coastal systems to respond effectively to extreme climate events, rendering them more vulnerable. Some countries, such as China, India and Thailand, are projected to face increased future exposure to extremes, especially in highly urbanized areas, as a result of rapid urbanization and economic growth. Guangzhou and Shanghai in China, Dhaka in Bangladesh, Mumbai and Kolkata in India, Yangon in Myanmar, Bangkok, Thailand, and Ho Chi Minh City and Hai Phòng, Viet Nam, are projected to have the largest population exposure to coastal flooding in 2070. Many of these cities are already exposed to coastal flooding, but have limited capacity to adapt due to their fixed location.

Climate-driven mega-disasters are emerging in new areas and new time periods and seasons (Kelly *et al.* 2013). Consequently, governments and citizens are often unprepared and find it difficult to deal with these entirely new phenomena.

4.3.3 Transboundary issues: infrastructure and common market development

Air pollution, once a local phenomenon, is rapidly going beyond the boundaries of cities, countries and sub-regions. Residual biomass burning in many Southeast Asian countries during the harvest season is causing worsening, persistent haze over the entire region for many weeks each year, leading to major health problems (Marlier *et al.* 2013). Forest fires in Indonesia in 2015 had multiple impacts on air quality, human health, climate and biodiversity. Meanwhile, scientists recently discovered that black carbon released by biomass burning in upwind areas is quickly accumulating on alpine glaciers in Asia, accelerating their melting (Xu *et al.* 2009).

New possible regional environmental solutions are emerging, driven by multilateral geopolitical and financial mechanisms. Several regional and sub-regional environmental cooperation platforms have recently been strengthened, including APEC, ASEAN+3, the South Asia Cooperative Environment Programme (SACEP), the North-East Asian Sub-regional Programme for Environmental Cooperation (NEASPEC), the Tripartite Environment Ministers Meeting involving China, Japan, and the Republic of Korea (TEMM), the Asian Network for Prevention of Illegal Transboundary Movement of Hazardous Wastes, the Northwest Pacific Action Plan (NOWPAP), and the Secretariat of the Pacific Regional Environment Programme (SPREP).

4.3.4 Environmental governance: large data-enhanced systems

A potential solution to environmental governance issues involves coordinated adaptation to climate change and disaster risk across sectors and geographical boundaries, including Earth-system approaches and stronger science-policy interfaces together with coordinated assessments and adaptation efforts. Climate change and disaster risk are often closely linked, while many disaster-related losses are caused by extreme climate events. Global adaptation efforts and financial resources, and coordination between those targeting climate change and disaster risk, are often lacking, but this may change under the post-2015 SDG framework and the Paris Agreement. Meanwhile, focusing climate change mitigation efforts on fossil fuels often results in little notice being paid to the large amount of carbon released by increasing disasters such as wildfires and drought. Mitigation of disaster risk can be an important part of mitigating climate change, and more effective coordination is emerging. There are potential co-benefits between United Nations conventions on climate change and air pollution, biodiversity and carbon-sink targets. More coordination and better governance across these conventions are expected at global and regional scales in the future.

A revolution of environmental governance is being driven by extensive use of mobile communication, information technology and big data. Rapid development of such technologies in the past several years has provided innovative technical solutions for new environmental disaster early-warning systems. People directly threatened by an approaching disaster event can now be precisely targeted by integrating large data capacities and the mobile devices of vulnerable individuals. Whole new generations of

early-warning systems are emerging from the integration of information technology with natural and social sciences.

The values of limited natural capital and ecosystem services are increasingly being recognized by governments and citizens, and in some cases economic values are being assigned to ecosystem services. Geo-engineering is increasingly being proposed as a climate change mitigation tool; however, its large-scale environmental consequences are not yet well understood. Earth-system assessment of its potential environmental impacts is necessary before developments in geo-engineering can be fully considered as practical solutions.

4.3.5 Larger and smarter cities

The much larger scale of today's urban clusters is having new climatic and ecological impacts in Asia and the Pacific. The urban heat-island effect was once widely considered to be a local phenomenon. However, many city clusters are merging into each other, with a gradual blurring of boundaries. At the same time, wildlands and urban green spaces are becoming isolated patches between built-up areas. Therefore, urban climate effects may no longer be local but could expand far beyond city limits to sub-regional and regional scales (Jia *et al.* 2015).

Cities occupy just 2 per cent of the world's land area, consume 75 per cent of its resources and generate a similar percentage of waste. Greening the cities could therefore be a very efficient and effective way to reduce resource use and help protect the environment. High population densities can make the process of providing essential municipal services far more efficient and cost-effective. Still, if urban development is not sustainably managed, the growth of cities could catalyse sharp increases in air pollution, slum dwellings, widening economic and social inequalities, energy waste and environmental degradation. Unfortunately, the majority of Asia's cities are not currently managing growth sustainably. According to a recent World Health Organization (WHO) report, half of the world's most polluted cities are in Asia, mainly because of the high greenhouse gas emissions and other pollutants from fossil-fuel-powered vehicles and energy plants (WHO 2014).

Smart-city technology is a crucial element of the future development of cities in the region, with the potential to greatly improve living standards and reduce poverty. Many countries are creating policies that encourage smart-city technology. Some have aggressively invested in low-carbon urban transit systems, energy-efficient buildings and climate-resilient infrastructure, renewable energy, green space, recycling and other environmentally friendly measures.

Both developing and developed Asia and the Pacific cities are exploring a variety of non-traditional methods to solve the key problem of financing information technology and infrastructure improvements. The group of solution providers is also growing and diversifying, as Chinese and Indian firms adopt smart-city strategies and expand out of their home markets, joining technology firms from Japan, the Republic of Korea and beyond (Guan *et al.* 2014). Navigant Research forecasts that annual smart-city technology investment in Asia and the Pacific will almost quadruple by 2023, reaching USD11.3 billion.

Green urban transport and construction, as well as urban green areas, are emerging in many parts of the region. There has been very rapid development of hybrid and electric vehicles, especially those used for public transport, in many cities (Kennedy *et al.* 2014). Major car manufacturers are working with battery providers to push the innovation of hybrid and electric vehicles, which are expected to triple in number by 2030. Meanwhile, national and municipal governments are providing tax benefits and subsidies to green vehicles and accelerating the installation of recharge stations. One promising green transport project is an e-car-friendly highway corridor between Beijing and Shanghai in China, where recharge stations will be installed every 50 kilometres along this 1 400 kilometre highway by 2019. The Asian Development Bank (ADB) is providing USD300 million towards a project to replace 100 000 gasoline-burning tricycles in the Philippines with clean, energy-efficient

electric tricycles, or e-trikes, by the end of 2017. Meanwhile, city buses are increasingly fuelled by electricity across Asia and the Pacific, and some cities are approaching exclusive use of e-buses. A rapid scaling-up of investments in these types of green approaches is needed to reduce energy use in cities, as well as undesirable environmental impacts from dirty energy production. With recent innovation in high-capacity and low-cost batteries and increasing acceptance among governments and consumers, green transport is likely to become a region-wide norm by 2030.

4.4 Outlooks

4.4.1 Overview of regional and sub-regional outlooks

The Asia and the Pacific region is so diverse that one set of outlooks can be misleading. Here, outlooks are plausible futures extending through at least the SDG period (to 2030), and beyond to 2050. The region can be divided into five sub-regions:

(i) Northeast Asia: China, Democratic Peoples' Republic of Korea, Japan, Mongolia and Republic of Korea;
(ii) Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao Peoples' Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Timor-Leste, Thailand and Viet Nam;
(iii) South Asia: Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan and Sri Lanka;
(iv) the Pacific: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu;
(v) Australia and New Zealand.

For the sake of simplicity in examining the region's outlooks, this section draws on overall regional priorities to identify one overarching priority theme for each of three sub-regions – the Pacific combined with Australia and New Zealand, Northeast and Southeast Asia combined, and South Asia – while recognizing that there is still considerable diversity within them (**Table 4.4.1**). Each sub-region needs to make choices, and elaborating possible options through narrative scenarios may help to clarify their implications.

The defining future theme for the Pacific region, Australia and New Zealand is climate change, since sea-level rise, increased intensity and perhaps frequency of storms, ocean acidification and loss of fisheries, among other effects, are survival issues for many island countries. This theme is embedded in the regional priority area of increased vulnerability to natural hazards and extreme events. Australia and New Zealand, as major development partners and potential destinations for environmental refugees, provide significant assistance.

Key Messages

- The Asia and the Pacific region is very diverse so it is difficult to explore the specific regional implications or priorities of the SDGs.
- The environment will play a key role in achieving the SDGs in all sub-regions.
- Most of the issues raised by the SDG are deeply interlinked in the region, so they should be implemented using an integrated approach, especially for resource management.
- The means of implementation should be considered from a broad perspective, including not only finance, but also capacity building, technology, science-policy links and the data revolution. Stronger governance is essential for mobilizing all of the means of implementation.

Table 4.4.1: Review of scenarios for sub-regions

Sub-regional priority	Scenario 1 (business as usual)	Scenario 2 (alternative future-partial improvement)	Scenario 3 (alternative future-full improvement)	Scenario 4 (sustainable development)
Pacific, Australia and New Zealand): climate change	Sinking under the water	Depopulation as islanders move to safer ground	Socio-technological adaptation to climate change and extreme events	SAMOA Pathway, incorporating the blue-green economy, technology leapfrogging, island community cohesion and resilience, and reconnecting with nature
Southeast and Northeast Asia: accelerating environmental degradation	Unplanned urbanization and industrialization	Industrial ecology and partial regional cooperation	Compact, energy-efficient and safe urban and industrial zones	Inclusive, safe, resilient, and sustainable urbanization and sub-regional physical and economic connectivity
South Asia: health and access to basic services	Parched and unhealthy	Agricultural domination for water access	Industrial and urban domination for water access	Water and sanitation for all

Note: SAMOA = SIDS (Small Island Developing States) Accelerated Modalities of Action
Source: UNEP

For Southeast and Northeast Asia, the priority theme is accelerating environmental degradation driven partly by rising urbanization, industrialization, infrastructure development and inefficient resource use.

For South Asia, the combination of environment-related health risks and changing demography, lifestyles and access to basic services will define environmental outcomes.

For each sub-region, other cross-cutting regional priorities, such as governance, are built into the pathway narratives. For each sub-region, four possible scenarios are described qualitatively, with the time frame to 2030 (related to the SDGs' duration) and 2050. These scenarios illustrate some of the options or development choices; they are not rigorously developed quantitative scenarios.

These sub-regions are increasingly integrated economically. Land and sea bridges, intra-regional trade and increasing labour movement all have environmental consequences, which are often forgotten in the rush to achieve economic growth.

The divisions between the sub-regions are mainly political, and not closely related to environmental or ecological considerations. Moreover, in discussing the sub-regions, it is easy to overlook aspects of convergence between them that are also important, such as transboundary ecosystems.

4.4.2 The Pacific sub-region, including Australia and New Zealand

Scenario 1: Sinking under the water (loss of land, migration, loss of fish resources and a decline in tourism). The Pacific Islands Climate Change Science programme, funded by Australia, provides information on the likely impacts of climate change under a business-as-usual option (PCCSP 2015). The Pacific Islands Regional Climate Assessment (Pacific RISA 2012) projects that large numbers of climate refugees may be forced to migrate to Australia, New Zealand or elsewhere. Island economies will falter, with increasing poverty and food insecurity. Significant areas of land will disappear under the water or will be regularly hit by storm surges or the salinization of groundwater lenses.

Scenario 2: Depopulation as islanders move to safer ground. Several of the more exposed Pacific island countries are buying land elsewhere to move their populations (Blue and Green Tomorrow 2014). Other islands are experiencing an exodus of people to Australia, New Zealand and elsewhere. Under this scenario, population migration will accelerate, leaving some islands with insufficient population to sustain their economies effectively.

Scenario 3: Socio-technology driven adaptation to climate change and extreme events. Under this scenario, the population will remain in place and continue to grow. Climate will continue changing, although more slowly than for Scenario 1, but the Pacific communities will be assisted in adapting to these changes, with appropriate technologies such as salt-resistant food crops, stilt housing and climate-proof infrastructure. The Asia and the Pacific Adaptation Network's website (APAN 2015) lists potential adaptation technologies.

Scenario 4: SAMOA Pathway (UNDESA 2015), incorporating the blue-green economy (a sustainable economy based on careful stewardship of marine and coastal resources), technology leapfrogging, priority for island community cohesion and resilience, and reconnecting with nature. Combining the joint concerns of disaster risk reduction and climate change, the Pacific region has developed a Resilient Development Strategy (SPC Geoscience 2015) with three strategic goals: strengthened integrated risk management to enhance climate and disaster resilience; low-carbon development; and strengthened disaster preparedness, response and recovery. This pathway would contribute to achieving SDG 13 on climate change. Target 13.1 on resilience and adaptation is particularly relevant to this region.

4.4.3 Southeast and Northeast Asia sub-region

Scenario 1: Unplanned urbanization and industrialization. Under the Asian century scenario (ADB 2011), countries in Southeast and Northeast Asia will continue functioning as the world's factory. If Asia "*continues to follow its recent trajectory, by 2050 its per capita income could rise sixfold in purchasing power parity (PPP) terms to … make some 3 billion additional Asians affluent*" (Kohli *et al.* 2011). According to ADB research, "*Asia's cities lured more than a billion new residents between 1980 and 2010 and will draw a billion more by 2040*", with more than half of the world's megacities located in the region (AFP 2012). The environmental consequences of this untrammelled growth, however, are already obvious and will become even worse, especially in Asia's megacities.

Scenario 2: Industrial ecology and partial regional cooperation. Planned industrial development and regional cooperation, such as a coordinated regional trade in waste products, can make the most of factor endowments (land, labour, capital, and entrepreneurship) in the Asian region (Kojima and Michida 2013). This option is also described as industrial symbiosis (SWITCH-Asia 2015) and is a feature of a circular economy (Cheam 2015).

Scenario 3: Compact, energy-efficient, and safe urban and industrial zones. The ADB (ADB 2011) states that "by 2050, Asia will be transformed, as its urban population will nearly double from 1.6 billion to 3 billion. Asia's cities, which already account for more than 80 per cent of economic output, will be the centres of higher education, innovation, and technological development. The quality and efficiency of urban areas would determine Asia's long-term competitiveness and its social and political stability. Asia must take advantage of being early on its urbanization growth curve to promote compact, energy-efficient, and safe cities". However, the quality of Asia's cities is far from assured, so additional measures are needed.

Scenario 4: Inclusive, safe, resilient and sustainable urbanization and sub-regional physical and economic connectivity. The SDGs and their targets under this option include SDG 11 on cities, especially Target 11.6 on reducing their environmental impacts, and SDG 12 on sustainable consumption and production, especially Target 12.4 focusing on chemicals and wastes, and Target 12.5, which calls for reduced waste generation and advocates prevention, reduction, recycling and reuse (Lindfield and Steinberg 2012).

4.4.4 South Asia sub-region

Scenario 1: Parched and unhealthy. "In South Asia, home to nearly 1.6 billion people, cities are increasingly feeling the pressure of population growth and urbanization. It is estimated that 22 of 32 Indian cities face daily water shortages. In Nepal's capital, Kathmandu, many local residents have grown accustomed to waiting in queues for hours to obtain drinking water from the city's ancient, stone waterspouts. In Karachi, Pakistan, electricity and water shortages have led to protests and citywide unrest" (Surie 2015).

Scenario 2: Agricultural competition for water access. Under the conflict-world scenario of the Global Water Futures 2050, "agriculture expands and/or intensifies in all countries in an attempt to reach the maximum possible food self-sufficiency. The strong push to intensify/expand agriculture (including use of marginal and fragile lands) results in deforestation and encroachment of natural ecosystems and increases agrochemical pollution, affecting the quality of watercourses and contaminating aquifers. On the other hand, the growth rate of industrial pollution is contained because of the volatile trends in the general economy" (Gallopin 2012).

Scenario 3: Industrial and urban competition for water access. Groundwater elevation in Lahore, Pakistan's second largest city, fell by up to 45 metres between 2003 and 2011. "*The groundwater of Hyderabad has high concentrations of sulphates (>400 mg per litre) ..., and the concentration of fluoride in deeper groundwater at certain locations is beyond permissible limits*" (WWAP 2015b). Under the techno-world scenario of the Global Water Futures 2050, which pushes capitalism to its limits, "*water resources become increasingly the most insurmountable limiting factor for future economic growth. Withdrawals reach peak value; all practicably accessible water courses are managed, and groundwater is pumped out to the limit of sustainability. The realization that the level of generalized water stress is reaching unsustainability thresholds leads to placing high priority on water use efficiency; however, the accomplishments are not sufficient to sustain global economic growth*".

Scenario 4: Water and sanitation for all (efficient use of water through appropriate pricing and conservation). This relates to SDG 6 on water and sanitation. Target 6.1 on drinking water and Target 6.2 on sanitation are particularly relevant. All targets, however, are applicable to this sub-region's water quality, water-use efficiency, transboundary cooperation, ecosystem management and community participation (Asia Foundation 2015). "*Sustainability in the Asia and the Pacific region is intimately linked with progress in access to safe water and sanitation; meeting water demands across multiple uses and mitigating the concurrent pollution loads; improving groundwater management; and increasing resilience to water-related disasters*" (WWAP 2015a; UNDESA 2015).

4.4.5 The Sustainable Development Goals and Asia and the Pacific highlights

The environment will play a key role in achieving the SDGs in this region since it provides the resources needed to sustain the economy and human health. Without a healthy environment and ecosystems, it will be difficult to achieve the SDGs and improve human well-being. Specifically, the goals on climate change, terrestrial ecosystems, oceans, sustainable consumption and production, water and energy are directly related to the environment. Environmental protection is also essential for other goals, including poverty reduction and health improvements. An integrated approach is necessary to achieve all the SDGs.

The SDG's environment-related targets are shown in **Table 4.4.2** along with some illustrative (but not comprehensive or systematic) environmental issues pertinent to Asia and the Pacific.

The SDGs are integrated by various links between the goals. In particular, most non-environmental goals include some environment-related targets. References to pollution and ecosystem services are distributed throughout the SDGs and targets. This integration helps the SDG framework address the key pressures and drivers of environmental degradation and stimulate environmental sustainability at different scales.

Table 4.4.2: Environment-related targets in the SDGs, and Asia and the Pacific issues

SDG	Environment-related targets (direct and indirect)	Asia and the Pacific issues
1. Poverty	Access to land and natural resources (1.4); resilience to climate and environmental shocks and disasters (1.5)	Land degradation and desertification intensify poverty
2. Hunger and food	Sustainable food production systems (2.4); genetic diversity (2.5); agricultural trade (2.b); commodity markets (2.c)	Difficulty in buying safe food; health problems from chemical use; overfishing
3. Health	Deaths and illness from pollution (3.9); water-borne diseases (3.3)	Air, water, land pollution; waste and sanitation; e-waste
4. Education	Education for sustainable development (ESD) (4.7); scholarships (4.b)	Increasing prosperity and middle class; people can be influenced by ESD
5. Gender	Women's equal rights to economic resources, property and natural resources (5.a)	Gender and environment issues; indoor air pollution/cook stoves
6. Water and sanitation	Access to safe water (6.1) and sanitation (6.2); water quality (6.3); water-use efficiency and scarcity (6.4); integrated water management (6.5); ecosystems (6.6); capacity building (6.a); local participation (6.b)	Health impacts from water pollution; severe water scarcity; water-energy-food nexus
7. Energy	Renewable energy (7.2); energy efficiency (7.3) and related investment (7.a); infrastructure and technology (7.b)	Energy access; energy use; increased renewables and efficiency
8. Economic growth and jobs	Resource efficiency and decoupling economic growth from environmental degradation (8.4); sustainable tourism (8.9); aid for trade (8.a)	Resource efficiency is a priority; green jobs
9. Infrastructure and industry	Sustainable and resilient infrastructure (9.1); industrialization (9.2); sustainability upgrading and resource efficiency (9.4); research, technology and innovation (9.5)	Asia's large infrastructure needs should be addressed sustainably
10. Inequality	Migration (10.7) (which has environmental causes and effects)	Illegal trade in hazardous waste; impact of land degradation on poor people
11. Cities	Sustainable transport (11.2) and urbanization (11.3); safeguards against disasters and diseases (11.5); environmental issues (air pollution, waste) (11.6); green public spaces (11.7); urban and non-urban environmental planning links (11.a); integrated policies for resource efficiency, climate and disaster resilience (11.b); support to the least developed countries for sustainable and resilient buildings (11.c)	Asian megacities; severe urban air pollution; high priority for climate and disaster resilience; increasing leadership by cities
12. Sustainable consumption and production (SCP)	SCP 10-Year Framework of Programmes (10YFP) (12.1); sustainable management and use of natural resources (12.2); food waste (12.3); waste and chemicals management (12.4); waste prevention, reduce, recycle, reuse (12.5); corporate social responsibility (12.6); sustainable public procurement (12.7); awareness for sustainable development and lifestyles (12.8); scientific and technological capacity for SCP (12.a); sustainable tourism and local products (12.b); rationalization of fossil-fuel subsidies (12.c)	High priority for SCP; severe waste problem; high fossil-fuel subsidies; efforts towards clean production
13. Climate	Resilience to disasters and climate hazards (13.1); integration of climate in policies (13.2); education, awareness and human and institutional capacity (13.3); Green Climate Fund of USD100 billion per year (13.a)	High priority for small island developing states (SIDS); high priority for adaptation; sea-level rise
14. Oceans	Marine pollution (14.1); marine and coastal ecosystems (14.2); ocean acidification (14.3); fishing (14.4); conserve 10 per cent of coastal and marine areas (14.5); prohibit some fisheries subsidies (14.6); economic benefits from sustainable use and management for SIDS (14.7); science, research, technology transfer (14.a.); international law and regimes (14.c)	High priority for SIDS; increasing ocean garbage; impact of pollution on fish; coral reefs

SDG	Environment-related targets (direct and indirect)	Asia and the Pacific issues
15. Terrestrial Eco-systems.	Terrestrial, mountain, and inland freshwater ecosystems and services (15.1); forests (15.2); desertification (15.3); mountain ecosystems (15.4); natural habitats, biodiversity and endangered species (15.5); genetic resources (15.6); poaching and illegal wildlife products (15.7); invasive species (15.8); integration of ecosystem and biodiversity values in national and local planning (15.9); increase in financial resources (15.a, 15.b); action on poaching and trafficking, and capacity building and sustainable livelihoods (15.c)	Forests in Indonesia and the Mekong; desertification in China and Mongolia; mountains in Nepal; biodiversity in Southeast Asia and China; poaching (broadly regional)
16. Peace, justice	Rule of law and access to justice (16.3); illicit finance and arms flows (16.4); corruption and bribery (16.5); effective, accountable and transparent institutions (16.6); responsive, inclusive, participatory and representative decision making (16.7); access to information (16.10); non-discriminatory laws and policies for sustainable development (16.b.)	Conflicts over resources; governance issues
17. Means of implementation	Domestic resource mobilization (17.1); additional financial resources (17.2, 17.3); technology transfer (17.6, 17.7) and technology bank (17.8); capacity building for SDGs (17.9); policy coherence (17.14); partnerships (17.16, 17.17); data availability (17.18); measurement and beyond GDP (17.19)	All of these points are relevant to Asia and the Pacific

Source: UNEP

Exploring the specific regional implications or priorities of the SDGs for Asia and the Pacific is difficult because of the region's diversity, with some countries prioritizing certain SDGs. However, this could be counterproductive owing to the interlinked nature of the goals. For example, water is linked to poverty, hunger, energy, climate change, sustainable production and consumption, gender, cities, and so on. This complexity calls for the SDGs to be implemented in an integrated way.

Several cross-cutting issues could facilitate integrated implementation. First, the SDGs address four cross-cutting themes from an environmental perspective: pollution, ecosystem services, decarbonization and resilience. These themes are distributed throughout all the goals, although not systematically. Second, the economy could be reorganized around the principles of sustainable consumption and production. Third, integrated approaches to resource management are needed, including for land, water, energy and air. Fourth, education for sustainable development is not only a goal in itself, but also a key means of achieving other goals. Fifth, the means of implementation should be considered from a broad perspective, including not only finance, but also capacity building, technology, science-policy links and the data revolution. Finally, stronger governance is essential for mobilizing all the means of implementation.

The economy is particularly important since it connects the environment with human well-being by mobilizing people through jobs, transforming resources into products and services, and distributing products and services to people to make them prosperous. It is a means of achieving human development, not an end in itself. The economy's current organizational structure has not been fully successful in achieving human development, poverty reduction or improved health, while it has contributed to degrading the environmental foundations of human development. Moreover, equality as proposed in several SDGs, such as 5 and 10, and inclusive economies are prerequisites for a healthy environment and social well-being. Addressing equality-related objectives will make a significant contribution to achieving environmental goals.

Sustainable consumption and production (SDG 12) provides a central organizing concept for the economy. Changing how the economy is measured, going beyond GDP and focusing on natural capital, is key for changing overall ways of thinking. Resource efficiency, encompassing not just energy but also other essential resources such as water

and land, is a critical first step, but ultimately economic prosperity and human well-being should be decoupled from resource use. Sustainable economic practices such as labour-intensive recycling can provide more employment than capital-intensive resource extraction. In a more sustainable economy, people would be healthier because of less pollution.

4.5 Transformative pathways and the Sustainable Development Goals

4.5.1 Transformative and greener pathways

The first step towards transformative and greener pathways is to secure the means of implementation, not only of the SDGs but also for other environmental priorities and commitments. A range of means has been globally agreed, including finance, technology, capacity building and stronger science-policy linkage. A data revolution is planned to track the progress of SDG implementation, which will be monitored by the High-level Political Forum on sustainable development.

The Addis Ababa Action Agenda (AAAA) provides a new roadmap for financing sustainable development. It has little new financing but highlights that developed countries will continue to provide financial assistance to the least developed nations, and newly emphasizes the need to increase financing from domestic sources. In Asia and the Pacific, the economic success of many emerging economies enables them to increase domestic funds for sustainable development, and some have even become donors of development assistance. Eliminating environmentally harmful subsidies, especially for fossil fuels, after compensating the most needy, could free additional financial resources. Indonesia, for example, has already moved in this direction (IISD 2014).

Environmental considerations should be incorporated into existing government spending budgets. Funding requests could be assessed according to environmental and broader sustainability considerations. These ideas are related to green budgeting. Green public procurement is already practised by some countries in the region, and guidelines could be expanded more broadly to cover private-sector procurement. Environmental impact assessment of projects and strategic environmental assessments of plans, programmes and policies should be expanded.

Key Messages

- Transformative and greener pathways can be advanced through a wide range of basic environmental policies and means of implementation. Countries should strengthen and fully implement these policies, or adopt them if they are absent.
- The means of implementation for transformative pathways should be secured. This includes not only financing but also strengthened human and technical capacity, and a strengthened science-policy interface.
- SDGs and low-carbon strategies, and environmental considerations should be integrated into national budgets and development strategies.
- Low-carbon strategies and stronger environmental policies generate significant co-benefits such as energy security, resilience and health. The consideration of co-benefits significantly increases the cost-effectiveness of these measures.
- Sustainable consumption and production could be at the core of economic transformation. Investments should incorporate sustainability considerations from the beginning.

The co-benefits concept highlights that integrated approaches to environmental issues can be more cost-effective than current silo approaches (Global Commission on the Economy and Climate 2015), since many related environmental issues have common causes. Climate change and air pollution are a prominent example in the region. Many solutions, such as renewable energy and energy efficiency, directly address both issues simultaneously, thereby leading to cost synergies (ACP 2014). Other relevant areas include buildings, transport and waste (De Oliveira *et. al.* 2013).

Enhanced capacity is as important as financing. Many countries in the region, to varying degrees, lack sufficient capacity to expand domestic financing, strengthen relevant policies or implement existing policies to the extent that would be necessary to achieve the SDGs and address other environmental issues. Simply spending more money or transferring more technology will not be successful without sufficient capacity to use these assets effectively.

The SDGs themselves can be considered means of implementation because complementarity between goals enhances the potential of the SDG framework to deliver broader results for people and the planet. Each goal is a means of implementation for the others, directly or indirectly. For example, achieving the water goals and targets will reduce poverty and hunger, enhance health, reduce land degradation, facilitate gender equality, provide jobs, assist sustainable industrialization and make consumption and production more sustainable. In general, environmental protection is necessary for poverty reduction and improved health and well-being, while poverty reduction and greater prosperity in turn can help to reduce environmental degradation. Education is one SDG, but it is also a means to achieve the other SDGs. This includes environmental education more specifically, as well as education for sustainable development more broadly.

Moving along transformative pathways towards sustainable development is a matter of urgency. There is a wide range of basic environment-related policies that could be strengthened or adopted by the countries in the region, depending on their individual situations. An important first step towards transformational change should be for countries to strengthen and fully implement existing basic policies, or adopt them if they are absent. These encompass measures such as ambient and emission standards for various pollutants and other related policies in order to prevent and control pollution of air, water and land, including ensuring the sound management of chemicals and waste. Supporting biodiversity and maintaining the provision of ecosystem services that support human well-being are basic requirements. Decarbonizing economies is also a key priority, and there are many well-known measures to address this, such as renewable energy, energy efficiency and sustainable transport (UNEP 2015a). Individually, these basic measures are not necessarily transformational, but if all the countries in the region were to implement them consistently, it would make a significant difference.

Integrated approaches to resource management are a major implication of the SDGs. For example, water, land and air are needed in order to produce energy, and producing water for human applications uses significant amounts of energy. Reducing poverty and hunger requires agriculture, which also needs land, water, energy and air. Climate may also be considered a resource, and is related to all these other resources. It is clear that all resources are necessary to achieve the SDGs and human well-being. The environment provides critical ecosystem services which are being damaged by pollution and overuse. Without integrated management, resources will be degraded, shortages will occur, the SDGs will not be achievable, and human well-being and prosperity will suffer. Implementing such integration will not be easy, however, since it requires cooperation between different ministries in each country, so it will be necessary to consider how to do this.

Transforming the region's economy is a key to putting the region on transformative pathways. SDG 12 on sustainable consumption and production should be at the centre of economic transformation. Countries have already agreed

on the sustainable consumption and production 10-Year Framework of Programmes (10YFP). Greener measures of economic performance that go beyond GDP will be essential. Several countries in the region have developed new concepts, such as Japan's sound material cycle society, China's ecological civilization, Thailand's sufficiency economy, and Bhutan's gross national happiness (GNH). UNEP's Inquiry into the Design of a Sustainable Financial System identified ways to enhance the financial system's sustainability, for example sustainable banking (green credit), green bonds, and sustainability reporting-requirements for stocks (UNEP 2015b).

The region's economic dynamism will probably continue, and large infrastructure investments are expected, especially in emerging and developing economies. These investments should incorporate sustainability considerations from the beginning. Countries should avoid being locked into high-polluting resource-intensive investments for long periods. The region's emerging and developing economies should leapfrog outmoded and unsustainable development models.

Resilience is related to the SDGs although it is not a headline goal. There is mounting concern in the region about natural disasters, some related to climate change (SDG 13). These harm human well-being, including through poverty and hunger (SDGs 1 and 2). More emphasis is now being placed in the region on resilience to natural disasters, climate change and other environment-related shocks. Measures to maintain ecosystem services and address climate change will help to strengthen resilience.

These measures will require additional human and technical capacities in most countries. The capacities needed are not limited to the traditional areas of environmental monitoring, enforcement and assessment, and not only to environment ministries and authorities. Greening national budgeting and tax systems, as well as green public and private procurement, will need upgraded capacities in government as well as in business and civil society. Processes such as multi-stakeholder engagement are new to most citizens, let alone governments. Implementation and monitoring of the SDGs and other environmental policies will need enhanced overall institutional capacity.

The data revolution for implementing and monitoring the SDGs will also need a revolution in capacity building for data collection and management. This is a central element of capacity. A key challenge for many countries is collecting data on and tracking many development indicators, and data are often insufficient and irregular, with substantial gaps. Recent assessments indicate that the region has one of the lowest rates of data coverage for various development indicators, with relatively low reporting frequency (Sustainable Development Solutions Network 2014). The data requirements for assessing SDG progress are huge and well beyond the currently collected data. Another widespread concern is data reliability. Many countries lack sufficient capacity for many forms of data collection, such as household surveys or real-time information on crises.

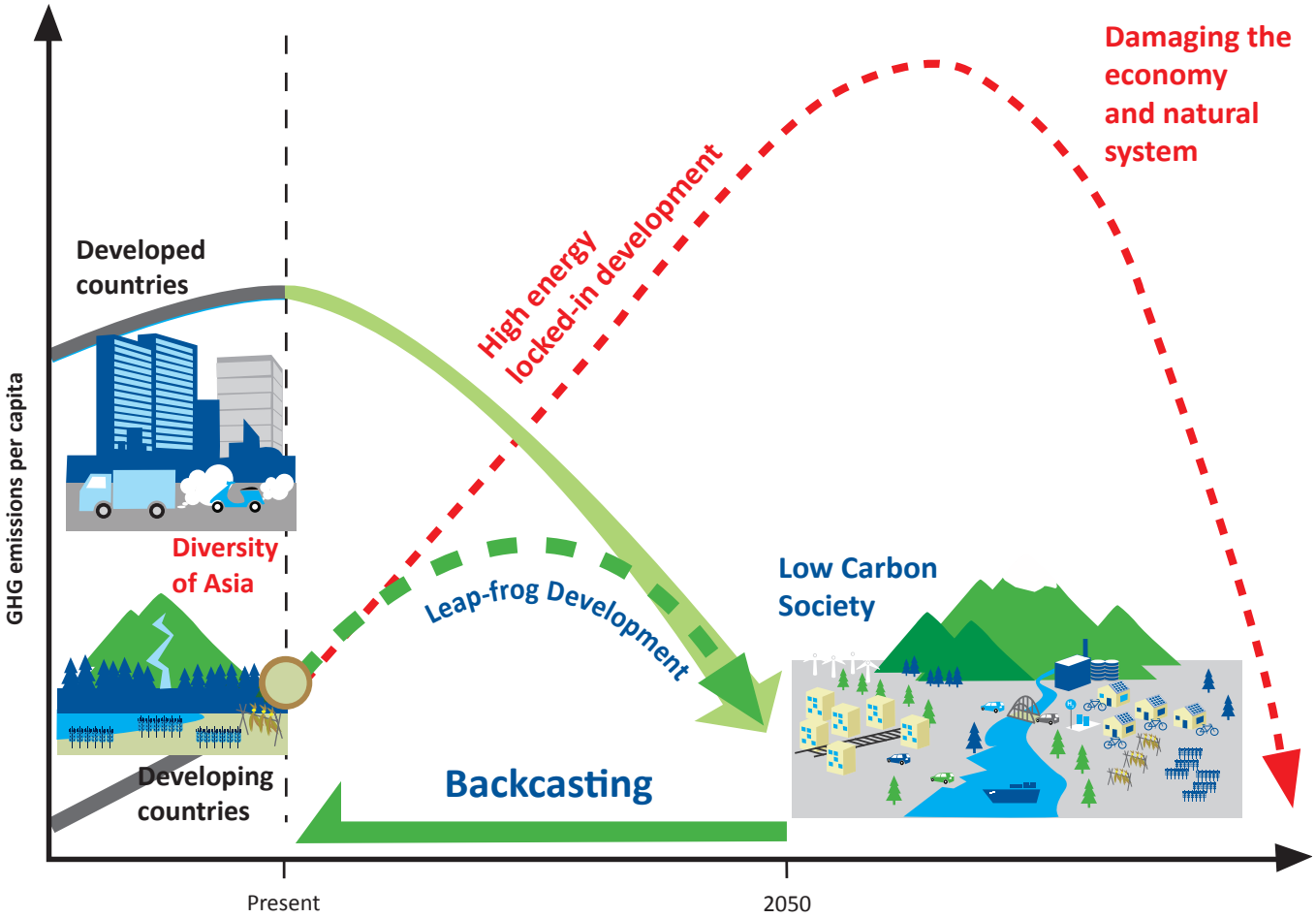
Better governance is necessary to mobilize all means of implementation for the SDGs. Common recommendations from governance research include greater stakeholder engagement, enhanced coordination and integration between different policy areas, and stronger monitoring and accountability mechanisms. Stakeholders also need better access to information to make their participation more effective.

Regional organizations should play a major role in implementing these transformative pathways. Regional SDG accountability frameworks could help to strengthen data and information collection, legal frameworks, and multi-stakeholder participation frameworks such as national councils for sustainable development. Civil-society organizations should be engaged at regional and national levels.

4.5.2 Transitions towards sustainable low-carbon development

Economic growth and increased energy use and intensity are the main drivers of the region's increasing greenhouse gas emissions. Reduced consumption of fossil fuels and related emissions are required in the long term to maintain global temperature rise below 2°C. To achieve this, highly ambitious policies are needed, such as increasing energy efficiency and decarbonizing energy systems. In the short and medium terms, as the region's rapid economic growth continues, natural gas may have an important role. Radical absolute reductions in the region's fossil-fuel-based energy use and emissions are required to achieve transformational change before 2050.

Figure 4.5.1: Leapfrog development scenarios towards a low-carbon Asia, to 2050 and beyond



Source: Japan, NIES 2014a

The region still needs strong environmental policy measures for reducing greenhouse gas emissions to achieve a low-carbon economy by 2050. The World Energy Council reported that investments in renewable energy supply in developing countries were USD131 billion in 2014 compared to USD139 billion in developed countries, with China investing USD83.3 billion (World Energy Council 2015). Although China has quickly expanded renewable energy recently, more effective energy efficiency and renewable energy policies in the region are still needed.

The Asia and the Pacific Integrated Model (AIM) has investigated leapfrogging and transformative pathways to promote low-carbon development in the region using quantitative methods with a reduction target of 50 per cent in global greenhouse gas emissions by 2050 from the 1990 level (**Figure 4.5.1**), using both bottom-up (AIM/Enduse) (Japan, NIES 2013) and top-down (AIM/CGE) (Japan, NIES 2012) approaches as modelled by the Asia and the Pacific Research Network (Japan, NIES 2014a). Several related locally tailored scenarios and policy roadmaps towards low-carbon development have been elaborated at the national level, for example in China, India, Indonesia, Malaysia, Republic of Korea, Thailand and Viet Nam, and at the local level in cooperation with policy-makers. The transformative pathways will need to consider the circumstances of different countries and implement concrete measures from now to 2050.

The Asia Sustainable Low Carbon Societies (Asia LCS) platform was created in 2004 (Japan, NIES 2014a) to contribute to comprehensive locally tailored scientific knowledge and roadmaps aligning low-carbon development with other national and global objectives and SDGs. The Asia LCS platform reported that low-carbon measures make it feasible to reduce Asia's greenhouse gas emissions by 69 per cent compared to the reference scenario in 2050 (**Figure 4.5.2**; Japan, NIES 2014b).

4.5.3 Low-emission development strategies

A United Nations Development Programme report stated that an overall 50 per cent reduction of world greenhouse gas emissions from 1990 levels by 2050 will be required for development to be sustainable (UNDP 2010). To achieve this, developed countries will have to cut emissions by at least 80 per cent by 2050 relative to 1990, with 20–30 per cent cuts by 2020. For the large developing country emitters, it recommends an emission trajectory peaking in 2020, followed by a 20 per cent reduction by 2050 relative to 1990.

Such transformational change will require a low-emission development strategy. However, each country has unique national circumstances and priorities, so it is therefore difficult to develop a single strategy for all countries.

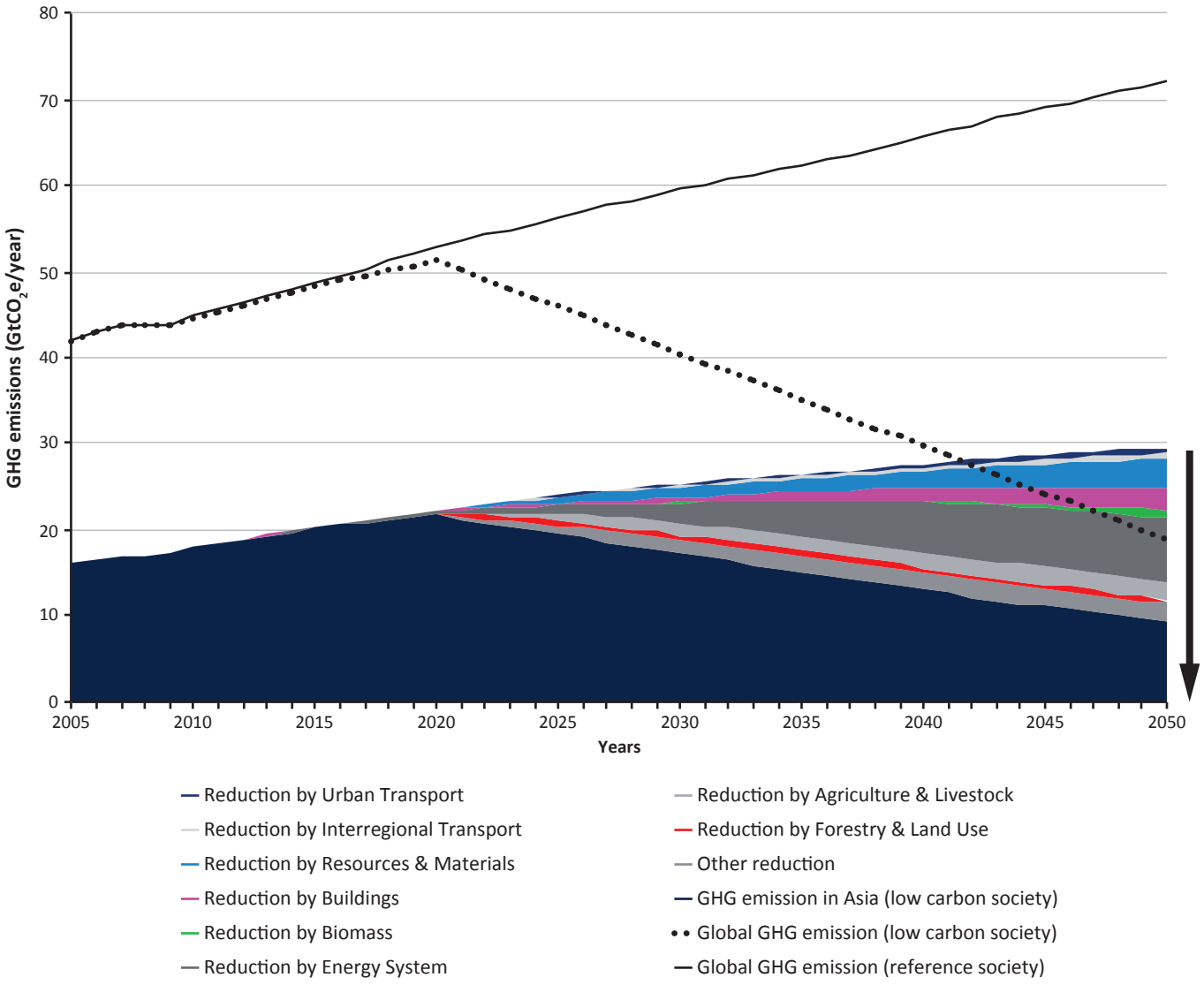
Low-emission development pathways contribute significant national co-benefits, such as improved energy security and resilience to energy price shocks, improved health due to lower local pollutant emissions, and increased agricultural and land-use productivity. Co-benefit analysis, therefore, is a prerequisite of a low-emission development strategy.

Effective international cooperation on low-emission development pathways would help mobilize financial and technological resources to support developing countries in mitigating and adapting to climate change.

Low-emission development strategies, such as nationally appropriate mitigation actions (NAMAs) and INDCs under the United Nations Framework Convention on Climate Change (UNFCCC), should be integrated into national development strategies (Boos *et al.* 2014; UNFCCC *et al* 2013). In order to achieve a low-carbon economy by 2050 and avoid locked-in emissions, the region should make early plans. One example is the Carbon and Cities Climate Registry (cCCR), a global mechanism developed for local governments by local governments (IISD 2014) that facilitates reporting of local climate action. **Figure 4.5.3** shows the cities that have reported the action they have taken.

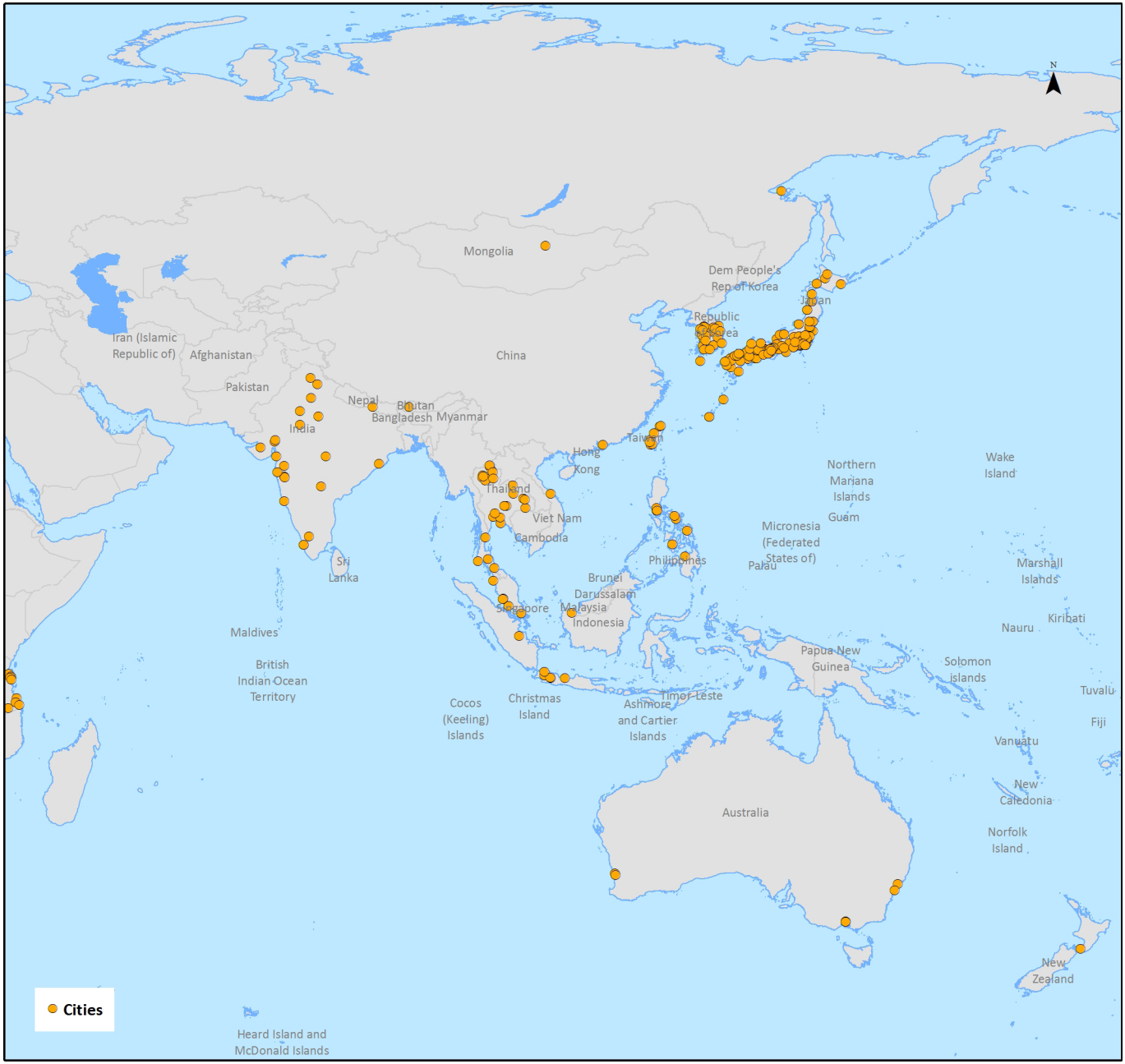
See references for Chapter 4

Figure 4.5.2: Greenhouse gas reduction scenarios in a low-carbon Asia, 2005–2050, (gigatonnes of carbon dioxide equivalent per year)



Source: Japan, NIES 2014b

Figure 4.5.3: Cities reporting climate action to the Carbon and Cities Climate Registry, 2014



Source: ICLEI 2015

Acronyms and Abbreviations

3Rs	reduce, reuse, recycle
AAAA	Addis Ababa Action Agenda
AADMER	ASEAN Agreement for Disaster Management Emergency Response
AASA	Association of Academics of Sciences in Asia
ABC	atmospheric brown cloud
ABNJ	Marine areas beyond national jurisdictions
ADB	Asian Development Bank
ADW	Alliance Development Works
AEC	Association of Southeast Asian Nations (ASEAN) Economic Community
AIDS	acquired immune deficiency syndrome
AIM	Asia-Pacific Integrated Model
AOD	aerosol optical depth
APAN	Asia-Pacific Adaptation Networks
APEC	Asia-Pacific Economic Cooperation
APO	Asian Productivity Organization
APWF	Asia Pacific Water Forum
ASEAN	Association of Southeast Asian Nations
Asia LCS	Asia Sustainable Low Carbon Societies
AQICN	Air Quality Instant-Cast and Now-Cast
BAU	business as usual
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BOBLME	Bay of Bengal Large Marine Ecosystem
BUVSs	benzotriazole ultraviolet stabilizers
CAEP	Chinese Academy for Environmental Planning, China
CAP	Clean Air Policy
CBD	Convention on Biological Diversity (UN)
CCAI	Climate Change and Adaptation Initiative
CCCR	Carbon and Cities Climate Registry
CDC	Climate Research Centre
CDM	Clean Development Mechanism
CEPA	Center for Poverty Analysis, Sri Lanka
CEPF	Critical Ecosystem Partnership Fund
CFC	chlorofluorocarbon
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CGIAR	Centre for Research on the Epidemiology of Disasters
CMS	Convention on Migratory Species
CNG	compressed natural gas
CO	Carbon Oxide
CO_2	Carbon Dioxide
COP	conference of the parties
CPCB	Central Pollution Control Board, India
CRED	Centre for Research on the Epidemiology of Disasters
CSP	concentrated solar power
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
CTI-CFF	Coral Triangle Initiative for Coral Reefs, Fisheries, and Food Security
DAC	Development Assistance Committee (OECD)

◄ Credit: Shutterstock/ West Coast Scapes

DCC	China Climate Change Info-Net; China Daily
DALY	disability adjusted life year
DDT	dichlorodiphenyltrichloroethane
DESA	Department of Economic and Social Affairs (UN)
DEWA	Division of Early Warning and Assessment (UNEP)
DMC	Domestic material consumption
DPSI	drivers, pressures, state and trends, and impacts
DPSIR	Driving Forces-Pressure-State-Impact-Response
ECO	Economic Cooperation Organization
EDF	Environmental Defense Fund
EEZs	exclusive economic zones
EF	energy footprint
EPI	1) Environmental Performance Index 2) environmental performance indicators
EQI	Environmental Quality Index
ETC	Erosion, Technology and Concentration, Canada
ETH Zurich	Swiss Federal Institute of Technology in Zurich
EU	European Union
EMDAT	Emergency Events Database
ENSO	El Niño-Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations (Statistics)
FYP	Five-Year Plan for Social and Economic Development
GCISC	Global Change Impact Studies Centre, Pakistan
GDI	Gender Development Index
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO	Global Environment Outlook
GESAMP	Group of Experts on Scientific Aspects of Marine Environmental Protection
GHG	Greenhouse gas
GJ	gigajoules
GLOBIO	Global Biodiversity Assessment model
GMS	Greater Mekong Subregion
GNH	gross national happiness
GOME	Global Ozone Monitoring Experiment
GOP	gross ocean products
HDR	Human Development Report
HBFCs	hydrobromofluorocarbons
HIV	human immunodeficiency virus
HFA	Hyogo Framework for Action 2005–2015
HFCs	hydrofluorocarbons
HLG	High Level Intergovernmental and Stakeholder Advisory Group for GEO-6
ICAP	International Carbon Action Partnership
ICIMOD	International Centre for Integrated Mountain Development, Nepal
IDMC	Internal Displacement Monitoring Centre
IEA	International Energy Agency, Paris
IETA	International Emissions Trading Association
IGES	Institute for Global Environmental Strategies, Japan
IGMS	Global Intergovernmental and Multi-stakeholder Consultation
IGRAC	International Groundwater Resources Assessment Centre

IISD	International Institute for Sustainable Development
ILO	International Labour Organization (UN)
IMD	India Meteorological Department
INDCs	intended nationally determined contributions
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency, Abu Dhabi, UAE
ISWA	International solid Waste Association
ISPONRE	Institute for Strategy and Policy on Natural Resources and Environment, Viet Nam
ITPS	Intergovernmental Technical Panel on Soils
IUCN	International Union for the Conservation of Nature
IUU	Illegal, unreported and unregulated
JMP	Joint Monitoring Programme
KEI	Korea Environment Institute
LADA	Land Degradation Assessment in Drylands
LG-SAT	Local Government Self-Assessment Tool
LPG	liquid petroleum gas
MARPOL	Convention for the Prevention of Pollution from Ships
MBT	mechanical biological treatment
MDG	Millennium Development Goal
METI	Ministry of Economy, Trade and Industry, Tokyo, Japan
MF	material footprint
MJ	megajoules
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MSA	mean species abundance
MSW	municipal solid waste
NAMAs	nationally appropriate mitigation actions
NASA	National Aeronautics and Space Administration, USA
NCDs	non-communicable diseases
NCO-P	Nepal Climate Observatory-Pyramid
NEASPEC	North-East Asian Sub-regional Programme for Environmental Cooperation
NIES	National Institute for Environmental Studies, Japan
NIDA	National Institute of Development Administration, Thailand
NMZ	National Manufacturing Zones
NO_2	nitrogen dioxide
NOWPAP	Northwest Pacific Action Plan
NRC	Norwegian Refugee Council
NSWAI	National Solid Waste Association of India
OCs	organochlorines
OECD	Organisation for Economic Co-operation and Development
OMI	Ozone Monitoring Instrument
PAHs	Polycyclic Aromatic Hydrocarbons
PBL	Netherlands Environmental Assessment Agency, The Hague
PBDEs	polybrominated diphenyl ethers
PCCSP	Pacific Climate Change Science Program
PIF	Pacific Islands Forum
PIRCA	Pacific Islands Regional Climate Assessment
PM	particulate matter
POPs	Persistent Organic Pollutants ,
PBDEs	polybrominated diphenyl ethers

PPM	parts per million
PPP	purchasing power parity
PRC	Peoples Republic of China
PV	photovoltaic
RCPs	representative concentration pathways
REEEP	Renewable Energy and Energy Efficiency Partnership
REMs	rare earth metals
REIN	Regional Environmental Information Network
SACEP	South Asia Cooperative Environment Programme
SAARC	South Asian Association for Regional Cooperation
SAP	Scientific Advisory Panel
Hong Kong SAR	Hong Kong Special Administrative Region
SAMOA Pathway	Small Island Developing States Accelerated Modalities of Action Pathway
SARS	severe acute respiratory syndrome
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Chartography
SDGs	Sustainable Development Goals
SDplanNet-AP	Network for Integrated Planning and Sustainable Development Strategies-Asia and Pacific
SEI	Stockholm Environment Institute
SEZ	Special Economic Zones
SIDS	Small Island Developing States
SIIT	Sirondhorn International Institute of Technology, Thailand
SLCPs	Short-lived climate pollutants
SNL	SNL Metals & Mining Financial
SO_2	sulphur dioxide
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
SRES	Special Report on Emissions Scenarios (IPCC)
SVTC	Silicon Valley Toxics Coalition
TFR	total fertility rate
TEMM	Tripartite Environment Ministers Meeting
TERI	The Energy and Resources Institute, India
TEQs	toxicity-equivalent concentrations
THE	total health espenditure
TPES	total primary energy supply
TPP	Trans-Pacific Partnership
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
ALM	Adaptation Learning Mechanism
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNEP ROAP	United Nations Environment Programme –Regional office for Asia and Pacific
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNHABITAT	United Nations Human Settlements Programme
UN-REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
UNSGAB	Special Advisory Board On Water and Sanitation

UNISDR	United Nations International Strategy for Disaster Reduction
UNU	United Nations University
UNWater	United Nations inter-agency coordination mechanism for all freshwater related issues, including sanitation
VOCs	volatile organic compounds
USA	United States of America
USGS	United States Geological Survey
UWEP	Urban Waste Expertise Program
WHO	World Health Organization (UN)
WHRC	Woods Hole Research Center
WMO	World Meteorological Organization (UN)
WRI	World Resources Institute
WWAP	World Water Assessment Programme
WWF	World Wildlife Fund

List of Figures

Figure 1.1.1:	Asia and the Pacific population density, 2015	6
Figure 1.1.2:	Annual population growth rate in Asia and the Pacific's sub-regions, 1961–2014	6
Figure 1.1.3:	Asia and the Pacific rural and urban population projection, 2010–2050	7
Figure 1.1.4:	Fertility rate in Asia and the Pacific's sub-regions, 1950–2050	8
Figure 1.1.5:	Asia Pacific and world's age structure, 1950–2050	10
Figure 1.1.6:	Human Development Index rankings for Asia and the Pacific countries, 2013	11
Figure 1.1.7:	Asia and the Pacific, access to basic services: improved drinking water and sanitation	13
Figure 1.2.1:	Asia and the Pacific and world, domestic material consumption, 1970–2015, million tonnes	15
Figure 1.2.2:	Asia and the Pacific, sub-regions and world, domestic material consumption, tonnes per person, 1970, 1990 and 2015	16
Figure 1.2.3:	Asia and the Pacific, sub-regions and world, material intensity of the economy, kilogram per USD, 1970–2015	17
Figure 1.2.4:	Asia and the Pacific, sub-regions and world, material intensity of economy, kilogram per USD, 1970, 1990 and 2015	17
Figure 1.2.5:	Asia and the Pacific and world, total primary energy supply, petajoules, 1970–2015	18
Figure 1.2.6:	Asia and the Pacific, sub-regions and world, total primary energy supply per person in Asia and the Pacific, its sub-regions and globally, gigajoules per person, 1970, 1990 and 2015	19
Figure 1.2.7:	Asia and the Pacific, sub-regions and world, energy intensity, megajoules per USD, 1970–2015	20
Figure 1.2.8:	Asia and the Pacific, sub-regions and world, energy intensity, megajoules per USD, 1970, 1990 and 2015	20
Figure 1.2.9:	Asia and the Pacific, total primary energy supply by energy carriers, Terajoules (10^{12} joules), 1970–2010	22
Figure 1.2.10:	Australia, China, India, Indonesia, and Japan, share of renewable energy (TPES), per cent, 1970, 1990, 2015	23
Figure 1.2.11:	Asia and the Pacific and world, water use, cubic kilometres, 1970–2015	23
Figure 1.2.12:	Asia and the Pacific, its sub-regions and world, water use per person, cubic metres per person, 1970, 1990 and 2015	24
Figure 1.2.13:	Asia Pacific, its sub-regions and world, water intensity of the economy, litres per US dollar of GDP, 1970–2015	24
Figure 1.2.14:	Asia and the Pacific, its sub-regions and world, water intensity of the economy, litres per USD of GDP, 1970, 1990 and 2015	25
Figure 1.2.15:	Asia and the Pacific, per person domestic material consumption (DMC), material footprint (MF) per person and material efficiency of the economy, tonnes per person and kilograms per USD, 1970–2015	26
Figure 1.2.16:	Asia and the Pacific, per person total primary energy supply (TPES), energy footprint (EF) per person, and energy efficiency, gigajoules (GJ) per person and megajoules (MJ) per USD 1970–2015	27
Figure 1.3.1:	Flood waters inundated the provinces of Phra Naknon Si Ayutthaya and Bangkok, Thailand, December 2011 (NASA)	28
Figure 1.3.2:	River floods in the Indian state of Bihar, October 2011 (NASA)	28
Figure 1.3.3:	Natural disaster events in Asia Pacific, 1970–2014	29
Figure 1.3.4:	Deaths caused by natural disasters in Asia and the Pacific by UNEP Sub-region, 1970-2014	30
Figure 1.3.5:	Development in China's Pearl River Delta (Zhu San Jiao), 1988–2014	31
Figure 1.3.6:	Economic exposure to tropical cyclones in Asia and the Pacific	31

Figure 1.3.7:	Physical exposure to tropical cyclones in Asia and the Pacific	31
Figure 1.3.8:	Physical exposure to floods in Asia and the Pacific	32
Figure 1.3.9:	Physical exposure to drought in Asia Pacific	32
Figure 1.4.1:	Asia Pacific, population and life expectancy, 1960–2012	35
Figure 2.1.1:	Global distribution of anthropogenic mercury emissions to the air, 2010	48
Figure 2.1.2:	Timeline of fuel quality standard evolution in Asia and the Pacific	49
Figure 2.1.3:	Diesel sulphur limits in Asia and the Pacific and globally	50
Figure 2.1.4:	Gasoline sulphur limits in Asia and the Pacific and globally	51
Figure 2.1.5:	Emission of sulphur dioxide and black carbon in selected Asian sub-regions, 1850–2010	52
Figure 2.1.6:	Sensitivity of modelled glacier volumes to temperature and precipitation anomalies, 2015–2100	53
Figure 2.1.7:	Land temperature anomalies over Asia, 1915–2015	54
Figure 2.1.8:	Annual average PM_{10} concentrations in cities of China, Japan, Republic of Korea and Thailand	55
Figure 2.1.9:	Top ranking of $PM_{2.5}$ for cities in Asia	56
Figure 2.1.10:	Trends in atmospheric ozone in Japan, 1990–2010 – TMA is Tokyo Metropolitan Area, NA is Nagoya Area, OKA is Osaka/Kyoto Area and FA is Fukuoka Area	57
Figure 2.2.1:	Asia and the Pacific, summary of drivers, pressures, state and trends, and impacts on land resources	58
Figure 2.2.2:	Asia and the Pacific, increase in human pressure on land resources	59
Figure 2.2.3:	Asia and the Pacific, tree cover, 2010	64
Figure 2.2.4:	Asia and the Pacific, change in cropland, 2001–2012	65
Figure 2.2.5:	Asia and Oceania, trends in Ramsar wetland sites, 1974-2016	66
Figure 2.3.1:	DPSIR indicators for ecosystems and biota in the Asia and the Pacific region	69
Figure 2.3.2:	Severity of coral bleaching Asia and the Pacific and areas of high thermal stress in the Asian and Pacific oceans, 1998–2006	72
Figure 2.3.3:	Change in carbon dioxide emissions from land-use change and forestry, million tonnes of carbon dioxide equivalent, 1990–2012	73
Figure 2.3.4:	Asia and the Pacific forest area, 1990 –2015 by sub-region	74
Figure 2.3.5:	Projected land-use system, 2030	75
Figure 2.3.6:	Red list categories for species in each region in 2015	76
Figure 2.3.7:	Pacific Ocean managed marine areas, 2015	79
Figure 2.4.1:	Asia and the Pacific, total renewable water resources per person, cubic metres per person per year, 2014	83
Figure 2.4.2:	Asia and the Pacific, nutrient pollution in river basins in 2015	85
Figure 2.5.1:	Asia, most vulnerable deltas	90
Figure 2.5.2:	Global, top ten cities ranked by asset exposure (USD billion) to coastal flooding, 2070's	91
Figure 2.5.3:	Pacific island states, economic losses due to tropical cyclones, earthquakes and tsunamis	91
Figure 2.5.4:	Deep sea minerals in Pacific	93
Figure 2.5.5:	Top ten sources of plastic waste	95
Figure 2.5.6:	Reefs at risk from integrated local threats, by area of reef in various sub-regions, square kilometres, 2012	96
Figure 2.6.1:	Municipal solid waste (MSW) generation projections in different regions of the world, tonnes per day, 2010–2100	100
Figure 2.6.2:	Municipal solid waste generation projections per person, by region, kilogrammes per person per day, 2010–2100	101
Figure 2.6.3:	Composition of municipal solid waste by country and income group	102

Figure 2.6.4: Estimated food loss, by country 103
Figure 2.6.5: Disaster waste generated at different locations across the world 103
Figure 2.6.6: Uncontrolled waste disposal worldwide 106
Figure 2.6.7: Greenhouse gas emissions GHG from the waste sector in Asia Pacific, thousand tonnes of carbon dioxide equivalent, 1990–2011 107
Figure 2.6.8: Greenhouse gas emissions from the waste sector of the region's four biggest emitters, million tonnes of carbon dioxide equivalent, 1990–2012 108
Figure 3.1.1: Asia and the Pacific, progress on development indicators, by country 113
Figure 3.1.2 a and b: Asia and the Pacific, carbon dioxide emissions, 1990–2011 114
Figure 3.1.3: Asia and the Pacific, reduction in ozone-depleting substances, 1990–2013 (ozone-depleting potential-weighted tonnes, ODP tonnes 118
Figure 3.1.4: Asia and the Pacific, change in proportion of land covered by forest percentage, 1990-2010 120
Figure 3.1.5: Asia and the Pacific, terrestrial and marine protected areas as a proportion of national territory 124
Figure 3.1.6: Asia and the Pacific, threatened species 126
Figure 3.1.7: Asia and the Pacific, water resource use in different countries, 1990–2015 127
Figure 3.1.8: Asia and the Pacific, proportion of population with access to safe drinking water (bottom) and basic sanitation (top) 128
Figure 3.1.9: Asia and the Pacific, proportion of slum population(left) and net change in slum population by 2014 (right) 129
Figure 3.2.1: Thailand, general government expenditure on health and total health expenditure 135
Figure 3.2.2: India, annual growth in installed renewable energy generation capacity, 2007–2015 136
Figure 3.2.3: Viet Nam, improving forest management in Lam Dong Province 137
Figure 3.2.4: Northeast Asia, Southeast Asia and the Pacific, disaster risk reduction 139
Figure 4.1.1: Overall direction of scenarios of selected environmental outlooks 148
Figure 4.2.1: Global primary energy demand by type in the intended nationally determined contributions scenario 155
Figure 4.3.1: Tropical storm tracks such as these have been moving pole-wards in recent decades, as monitored from multiple Earth observation satellites 158
Figure 4.5.1: Leapfrog development scenarios towards a low-carbon Asia, to 2050 and beyond 170
Figure 4.5.2: Greenhouse gas reduction scenarios in a low-carbon Asia, 2005–2050, gigatonnes of carbon dioxide equivalent per year 172
Figure 4.5.3: Cities reporting climate action to the Carbon and Cities Climate Registry, 2014 173

List of Tables

Table 1.2.1:	China, India, Indonesia, Australia and Japan, renewable energy supply and share of renewable energy in TPES, petajoules (10^{15} joules) and per cent	21
Table 1.3.1:	Disaster occurrence and damage in Asia and the Pacific Region due to droughts, floods, landslides, earthquakes, wildfires, and storms, 1970- August 2015	30
Table 1.3.2:	Parameters determining risk and vulnerability to disasters in different geographical settings	31
Table 1.3.3:	Key regional risks from climate change	33
Table 1.4.1:	Illustrative examples of environmental health issues affecting air, land, water, ecosystems and the ocean in Asia and the Pacific	37
Table 2.1.1:	Toxicity equivalent concentrations in Asia and the Pacific and Europe	49
Table 2.2.1:	Asia and the Pacific, sub-regional coverage of land-related state and trends	60
Table 2.3.1:	The amount and relative proportion of capture-fishery production in Asia and the Pacific countries	70
Table 2.4.1:	Water-related issues faced by countries in the Asia and the Pacific region	82
Table 2.5.1:	Asia and the Pacific: coastline length (>500 kilometres)	89
Table 2.5.2:	Asia and the Pacific: change in coastal populations within 100 kilmetres of the coast, 2000-2025	94
Table 3.1.1:	Asia and the Pacific, submission status of intended nationally determined contributions, 28 November 2015	116
Table 3.1.2:	Asia and the Pacific, status of international agreements related to fisheries	122
Table 3.1.3:	Northeast and Southeast Asia, selected existing regional air pollution cooperation frameworks	130
Table 3.2.1:	Asia and the Pacific, select list of policies and interventions for sustainable development	134
Table 4.4.1:	Review of scenarios for sub-regions	162
Table 4.4.2:	Environment-related targets in the SDGs, and Asia and the Pacific issues	165

List of Boxes

Box 1.4.1:	Dengue in Japan and Singapore	38
Box 2.3.1:	Projected mean species abundance (MSA), 2030	77
Box 2.4.1:	Emerging contamination by pharmaceutically active compounds and nanomaterials	86

References

Chapter 1

ADB (2012). Addressing climate change and migration in Asia and the Pacific. Asian Development Bank (ADB), Manila http://www.adb.org/sites/default/files/publication/29662/addressing-climate-change-migration.pdf

ADB (2013). Asian water development outlook 2013. Asian Development Bank (ADB), Manila http://adb.org/sites/default/files/pub/2013/asian-water-development-outlook-2013.pdf (Accessed: 23 February 2016)

ADW (2012). World risk report. Alliance Development Works, Berlin http://www.nature.org/ourinitiatives/habitats/oceanscoasts/howwework/world-risk-report-2012-pdf.pdf

Avishik, K., Yu, X. and Liu, J. (2012). 'Ecosystem management in Asia Pacific: Bridge science-policy gap'. Environmental Development 3, 77-90. doi: http://dx.doi.org/10.1016/j.envdev.2012.03.014 https://www.researchgate.net/publication/257742336_Ecosystem_management_in_Asia_Pacific_Bridging_science-policy_gap

Bain, R., Cronk, R., Hossain, R., Bonjour, S., Onda, K., Wright, J., Yang, H., Slaymaker, T., Hunter, P., Prüss-Ustün, A. et al. (2014). 'Global assessment of exposure to faecal contamination through drinking water based on a systematic review'. Tropical Medicine & International Health 19(8), 917-927. doi: 10.1111/tmi.12334 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4255778/

Barrett, J.R. (2014). 'Under the weather with ciguatera fish poisoning: Climate variables associated with increases in suspected cases.'. Environmental Health Perspectives 122(2014), 167 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4049702/

Beaglehole, R., Bonita, R., Horton, R., Adams, C., Alleyne, G., Asaria, P., Baugh, V., Bekedam, H., Billo, N., Casswell, S. et al. (2011). 'Priority actions for the non-communicable disease crisis '. The Lancet 377(29), 1438-1447. doi: http://dx.doi.org/10.1016/S0140-6736(11)60393-0 http://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2811%2960393-0/abstract

Berkhout, F., Verbong, G., Wieczorek, A.J., Raven, R., Lebel, L. and X., B. (2010). 'Sustainability experiments in Asia: Innovations shaping alternative development pathways'. Environmental Sciences and Policy 13, 261-271 http://www.sciencedirect.com/science/article/pii/S1462901110000286

Butler, C.D. (2014). Climate change and global health. Butler, C.D. (ed.), Wallingford http://www.amazon.co.uk/Climate-Change-Global-Health-Butler/dp/1780642652

Campbell, M., Cleland, J., Ezeh, A. and Prata, N. (2007). 'Return of the population growth factor'. Science Magazine, 315 1501-1502. AAAS http://www.sciencemag.org/content/315/5818/1501.full.pdf

Castles, S. and Miller, M.J. (2009). 'Migration in the Asia-Pacific region'. Migration Information Source, 9 July http://www.migrationpolicy.org/article/migration-asia-pacific-region/

Chan, E.Y., Wang, Z., Mark, C.K. and Da Liu, S. (2015). 'Industrial accidents in China: risk reduction and response'. The Lancet 386(10002), 1421-1422 http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(15)00424-9.pdf

Chen, Z., Peto, R., Zhou, M., Iona, A., Smith, M., Yang, L., Ling, G., Y., Chen, Y., Bian, Z., Lancaster, G. et al. (2015). 'Contrasting male and female trends in tobacco-attributed mortality in China: evidence from successive nationwide prospective cohort studies'. The Lancet 386, 1447-1456 http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736%2815%2900340-2.pdf

CSIRO (2015). Forecasts for indicators for a green and resource efficient Asia 2011–2015. Commonwealth Scientific and Industrial Research Organisation Canberra

EM-DAT (2015). Emergency Events Database. http://emdat.be/disaster_list/index.html (Accessed: 16 September 2015)

FAO (2015). Regional overview of food insecurity Asia and the Pacific: "Towards a food secure Asia and the Pacific". Food and Agricultural Organization (FAO), Bangkok http://www.fao.org/3/a-i4624e.pdf (Accessed: 12 August 2015)

Gao, Y. and Xia, J. (2011). 'Chromium contamination accident in China: Viewing environment policy of China'. Environmental Science and Technology 45, 8605-8606. doi: 10.1021/es203101f http://pubs.acs.org/doi/pdfplus/10.1021/es203101f

GBD DALYs (2013). 'Global, regional, and national disability-adjusted life years (DALYs) for 306 diseases and injuries and healthy life expectancy (HALE) for 188 countries, 1990–2013: Quantifying the epidemiological transition'. The Lancet 386(10009), 2145-2191. doi: 10.1016/S0140-6736(15)61340-X http://dx.doi.org/10.1016/S0140-6736(15)61340-X (Accessed: 14 September 2015)

Guan, N., Fan, Q., Ding, J., Zhao, Y., Lu, J., Ai, Y., Xu, G., Zhu, S., Yao, C., Jiang, L. et al. (2009). 'Melamine-contaminated powdered formula and urolithiasis in young children'. The New England Journal of Medicine 360(11), 1067-1074 http://www.nejm.org/doi/pdf/10.1056/NEJMoa0809550

Hsu, A., Emerson, J., Levy, M., de Sherbinin, A., Johnson, L., Malik, O., Schwartz, J. and Jaiteh, M. (2014). The 2014 environmental performance index. New Haven, CT http://www.epi.yale.edu (Accessed: 16 September 2015)

IDMC and NRC (2011). Internal displacement global overview of trends and developments in 2010 Internal Displacement Monitoring Centre and Norwegian Refugee Council, Geneva http://www.internal-displacement.org/assets/publications/2011/2011-global-overview-2010-global-en.pdf

http://www.internal-displacement.org/publications

IEA (2011). Technology roadmap: China wind energy development roadmap 2050. Organization for Economic Cooperation and Development, Paris https://www.iea.org/publications/freepublications/publication/china_wind.pdf

IEA (2014). World Energy Investment Outlook: Special report. International Energy Agency (IEA), Paris https://www.iea.org/publications/freepublications/publication/WEIO2014.pdf

IEA (2015). Energy balances of OECD and non-OECD countries 2015 [Data CD-ROM], International Energy Agency/OECD, Paris

IETA and CDC (2015). China: An emissions trading case study. International Emissions Trading Association (IETA) and CDC Climate Research Centre https://ieta.memberclicks.net/assets/CaseStudy2015/china-emissions-trading-case%20study_cdc_climat_ieta%20march_2015.pdf (Accessed: 16 September 2015)

IPCC (2012). Managing the risks of extreme events and disasters to advance climate change adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen et al. (eds.). Cambridge University Press, Cambridge https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf

IPCC (2014a). Climate change 2014: Synthesis report. Intergovernmental Panel on Climate Change, Geneva http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_All_Topics.pdf

IPCC (2014b). Summary for policymakers. Climate Change 2014: Impacts, adaptation, and vulnerability. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on Climate Change. Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C. et al. (eds.). Intergovernmental Panel on Climate Change, Cambridge http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

IPCC (2014c). Climate change 2014: Synthesis report. Contribution of working groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Pachauri, R.K. and Meyer, L.A. (eds.). Intergovernmental panel on Climate Change, Geneva

IRENA (2015). Renewable energy capacity statistics 2015. International Renewable Energy Agency, Abu Dhabi http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=36&CatID=141&SubcatID=604

Japan, METI (2011). Feed in tariff scheme for renewable energy. Japan Ministry of Economy, Trade and Industry (METI), Tokyo http://www.meti.go.jp/english/policy/energy_environment/renewable/pdf/summary201109.pdf (Accessed: September 15, 2015)

Jayachandran, S. (2009). 'Air quality and early-life mortality: Evidence from Indonesia's wildfires'. Journal of Human Resources 44, 916-954 http://www.nber.org/papers/w14011

Juan, D. (2014). 'New 5-year plan to raise goals for renewables'. China Daily USA, 9 October http://usa.chinadaily.com.cn/epaper/2014-10/09/content_18712330.htm

Kanbur, R., Rhee, C. and Zhuang, J. (eds.) (2014). Inequality in Asia and the Pacific: Trends, drivers, and policy implications. Asian Development Bank, Manila http://www.adb.org/sites/default/files/publication/41630/inequality-asia-and-pacific.pdf

Karagas, M., Choi, A.L., Oken, E., Horvat, M., Schoeny, R., Kamai, E., Cowell, W., Grandjean, P. and Korrick, S. (2012). 'Evidence on the human health effects of low level methylmercury exposure'. Environmental Health Perspectives 120, 799-806. doi: 10.1289/ehp.1104494 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3385440/

King, D., Schrag, D., Dadi, Z., Ye, Q. and Ghosh, A. (2015). Climate change: A risk assessment. Centre for Science and Policy http://www.csap.cam.ac.uk/projects/climate-change-risk-assessment/

King, M. (2015). 'REE: Rare earth elements and their uses'. Geology.com - Geoscience News and Information, http://geology.com/articles/rare-earth-elements/

Kutsuna, S., Kato, Y., Moi, M.L., Kotaki, A., Ota, M., Shinohara, K., Kobayashi, T., Yamamoto, K., Fujiya, Y., Mawatari, M. et al. (2015). 'Autochthonous dengue fever'. Emerging Infectious Diseases 21(3), 517-520 http://wwwnc.cdc.gov/eid/article/21/3/14-1662_article

Leal Filho, W. (2014). Handbook of climate change adaptation. Springer-Verlag, Berlin http://www.springer.com/la/book/9783642386695

Lelieveld, J., Evans, J.S., Fnais, M., Giannadaki, D. and Pozzer, A. (2015). 'The contribution of outdoor air pollution sources to premature mortality on a global scale'. Nature 525, 367-371 http://www.nature.com/nature/journal/v525/n7569/pdf/nature15371.pdf

Liu, Z., Guan, D., Moore, S., Lee, H., Su, J. and Q., Z. (2015). 'Climate policy: Steps to China's carbon peak'. Nature 522, 279–281 http://www.nature.com/news/climate-policy-steps-to-china-s-carbon-peak-1.17750

Malaysia, NRE and Universiti Teknologi Malaysia (2015). Malaysian environmental performance index. Malaysian Ministry of Natural Resources and Environment and Universiti Teknologi Malaysia http://www.epi.utm.my/v4/?page_id=305

Mandel, J.H., Wendt, C., Lo, C., Zhou, G., Hertz, M. and Ramachandran, G. (2015). 'Ambient air pollution and lung disease in China: health effects, study design approaches and future research'. Frontiers of medicine 9(3), 392-400 http://link.springer.com/content/pdf/10.1007/s11684-015-0397-8.pdf

Marlier, M.E., DeFries, R.S., Kim, P.S., Koplitz, S.N., Jacob, D.J., Mickley, L.J. and Myers, S.S. (2015). 'Fire emissions and regional air quality impacts from fires in oil palm, timber, and logging concessions in Indonesia '. Environmental Research Letters 10(2015), 9 http://iopscience.iop.org/article/10.1088/1748-9326/10/8/085005/pdf (Accessed: 12 August 2015)

Marlier, M.E., DeFries, R.S., Voulgarakis, A., Kinney, P.L., Randerson, J.T., Shindell, D.T., Chen, Y. and Faluvegi, G. (2013). 'El Nino and health risks from landscape fire emissions in Southeast Asia'. Nature Climate Change 3(2), 131-136. doi: 10.1038/nclimate1658 http://www.nature.com/nclimate/journal/v3/n2/full/nclimate1658.htm

McMichael, A.J. (1993). Planetary overload. Global environmental change and the health of the human species. Cambridge http://catdir.loc.gov/catdir/samples/cam031/92038292.pdf

McMichael, A.J. and Butler, C.D. (2011). 'Promoting global population health while constraining the environmental footprint '. Annual Review of Public Health 32, 179-197. doi: 10.1146/annurev-publhealth-031210-101203 http://www.annualreviews.org/doi/abs/10.1146/annurev-publhealth-031210-101203?url_ver=Z39.88-2003&rfr_dat=cr_pub%3Dpubmed&rfr_id=ori%3Arid%3Acrossref.org&journalCode=publhealth

McMichael, A.J., Zhou, Z.-N., Bradshaw, C., Butler, C.D., Gillespie, S., Guhl, F., Sulaiman, S.M., Trostle, J.A., Wilcox, B.A., Utzinger, J. et al. (2013). Research priorities for the environment, agriculture and infectious diseases of poverty. WHO Technical Report Series. World Health Organization, Geneva http://apps.who.int/iris/bitstream/10665/78129/1/WHO_TRS_976_eng.pdf

Millennium Ecosystem Assessment (2005). Ecosystems and human well-being: Synthesis. Island Press Washington, DC http://www.millenniumassessment.org/documents/document.356.aspx.pdf

Mohammad, N., Bin Mahmood, M.A., bin Abdul Wahab, N. and bin Idris Adam, A. (2011). Potentialities and constraints of the environmental law and policy in Malaysia to protect the environment: An empirical study for sustainable development. IEEE, Dalian http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=5996282&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D5996282

Ooi, E.-E., Goh, K.-T. and Gubler, D.J. (2006). 'Dengue prevention and 35 years of vector control in Singapore. '. Emerging Infectious Diseases 12(2006), 887-893 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3373041/

Oudin Åström, D., Bertil, F. and Joacim, R. (2011). 'Heat wave impact on morbidity and mortality in the elderly population: A review of recent studies'. Maturitas 69, 99-105 http://www.sciencedirect.com/science/article/pii/S0378512211000806

REEEP (2009). National policy, strategy and roadmap study for China: Small wind power industry development. Renewable Energy and Energy Efficiency Partnership http://www.reeep.org/national-policy-strategy-and-roadmap-study-china-small-wind-power-industry-development

Rodgers, Y.M.R. and Zveglich, J.E. (2014). Inclusive growth and gender inequality in Asia's labor markets. ADB Economics Working Paper Series No. 321. Kanbur, R., Rhee, C and Zhuang, J. (ed.). Asian Development Bank (ADB), Manila http://www.adb.org/sites/default/files/publication/30137/economics-wp321-inclusive-growth-gender-inequality.pdf

Schandl, H., Hatfield-Dodds, S., T., W., T., Geschke, A., Cai, Y., West, J., Newth, D., Baynes, T., Lenzen, M. and Owen, A. (2015). 'Decoupling global environmental pressure and economic growth: Scenarios for energy use, materials and carbon emissions'. Journal of Cleaner Production. doi: 10.1016/j.jclepro.2015.06.100 http://www.sciencedirect.com/science/article/pii/S0959652615008331 (Accessed: 21 July 2015)

School-UNEP, F. (2015). Global trends in renewable energy investment 2015. Frankfurt School-UNEP Collaborating Centre for Climate & Sustainable Energy Finance http://fs-unep-centre.org/publications/global-trends-renewable-energy-investment-2015 (Accessed: 16 September 2015)

Seetharam, K.S. (2012). 'Twenty-five years of transition in Asia's population and development: A review of progress and potential'. Asia-Pacific Population Journal 27(1), 13-22 http://ebac.unescap.org/sites/default/files/APPJ-Vol-27-No-1.pdf#page=19

Seligsohn, D. and Hsu, A. (2011). 'How does China's 12th five-year plan address energy and the environment?'. China FAQs: The Network for Climate and Energy Information, convened by the World Resources Institute (WRI), 7 March http://www.chinafaqs.org/blog-posts/how-does-chinas-12th-five-year-plan-address-energy-and-environment (Accessed: 16 September 2015)

Sharma, D.C. (2005). 'Bhopal: 20 years on'. The Lancet 365, 111-112. doi: http://dx.doi.org/10.1016/S0140-6736(05)17722-8 http://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2805%2917722-8/abstract

Smith, K.R., Bruce, N., Balakrishnan, K., Adair-Rohani, H., Balmes, J., Chafe, Z., Dherani, M., Hosgood, H.D., Mehta, S., Pope, D. et al. (2014). 'Millions dead: how do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution'. Annual Review of Public Health 35, 185-206. doi: 10.1146/annurev-publhealth-032013-182356 http://www.ncbi.nlm.nih.gov/pubmed/24641558

SPREP (2012). Pacific environment and climate change outlook. Secretariat of the Pacific Regional Environment Programme Apia http://www.unep.org/pdf/PEECO.pdf

SVTC (2014). 2014 Solar scorecard. Silicon Valley Toxics Coalition (SVTC) http://www.solarscorecard.com/2014/2014-SVTC-Solar-Scorecard.pdf (Accessed: September 15, 2015)

The White House (2014). U.S.-China joint announcement on climate change 11 November 2014 https://www.whitehouse.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change

UNDESA (2010). Trends in sustainable development: Small island developing states (SIDS). New York, NY https://sustainabledevelopment.un.org/content/documents/313Trends_in_Sustainable_Development_SIDS.pdf

UNDESA (2013). International migration 2013. United Nations Department of Economic and Social Affairs, New York http://www.un.org/en/development/desa/population/migration/publications/wallchart/docs/wallchart2013.pdf (Accessed: 1 August 2015)

UNDESA (2014). World urbanization prospects: The 2014 revision: Highlights. United Nations Department of Economic and Social Affairs, New York http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

UNDESA (2015). Monitoring global population trends. United Nations Department of Economic and Social Affairs http:/www.un.org/esa/population/

UNDP (2014). HDI rankings in Asia and the Pacific in 2013: Human development report 2014. United Nations Development Programme (UNDP) http://hdr.undp.org/en/content/human-development-report-2014

UNEP (2010). Resource efficiency. United Nations Environment Programme, Paris http://www.unep.org/pdf/brochures/ResourceEfficiency.pdf (Downloaded: September 16, 2015)

UNEP (2011). UNEP Year book 2011: Emerging issues in our global environment. United Nations Environment Programme

Nairobi http://www.unep.org/yearbook/2011/pdfs/UNEP_YEARBOOK_Fullreport.pdf

UNEP (2012). GEO5: Global Environment Outlook: Environment for the future we want. United Nations Environment Programme http://www.unep.org/geo/geo5.asp

UNEP (2013a). Keeping track of our changing environment in Asia and the Pacific: From Rio to Rio+20 (1992-2012). United Nations Environment Programme Nairobi http://environmentportal.in/files/file/Keeping%20track%20of%20our%20changing%20environment%20in%20Asia%20and%20the%20Pacific-2013.pdf

UNEP (2013b). Global risk data platform http://preview.grid.unep.ch/index.php?preview=map&lang=eng

UNEP (2014). Emerging issues for small island developing states: Results of the UNEP foresight process. United Nations Environment Programme, Nairobi http://www.unep.org/pdf/Emerging_issues_for_small_island_developing_states.pdf

UNEP (2015). Indicators for a resource efficient and green Asia and the Pacific: Measuring progress of sustainable consumption and production, green economy and resource efficiency policies in the Asia-Pacific region. United Nations Environment Programme (UNEP), Paris http://greeninfo.asia/Publications/Indicator-for-a-RE%28Low-resolution%29.pdf

UNESCAP (2014). Statistical yearbook for Asia and the Pacific 2014 (No. ST/ESCAP/2704). United Nations Economic and Social Commission for Asia and the Pacific Virigina http://www.unescap.org/sites/default/files/ESCAP-SYB2014_0.pdf

UNESCAP (2015). Economic and social survey of Asia and the Pacific - Part I: Making growth more inclusive for sustainable development. United Nations Economic and Social Commission for Asia and the Pacific, Bangkok http://www.unescap.org/sites/default/files/Economic%20and%20Social%20Survey%20of%20Asia%20and%20the%20Pacific%202015.pdf

UNESCAP (2016). Disasters in Asia and the Pacific: 2015 year in review United Nations Economic and Social Commission for Asia and the Pacific, Bangkok http://www.unescap.org/resources/disasters-asia-and-pacific-2015-year-review

UNESCAP, ADB and UNDP (2010). Paths to 2030: MDG priorities in Asia and the Pacific. United Nations Economic and Social Commission for Asia and the Pacific http://www.aidsdatahub.org/sites/default/files/documents/mdg-paths-to-2015.pdf

UNFPA (2014). The power of 1.8 billion adolescents, youth and the transformation of the future. United Nations Population Fund, New York, NY https://www.unfpa.org/sites/default/files/pub-pdf/EN-SWOP14-Report_FINAL-web.pdf

Wang, J. (2010). 'The changes of China's environmental policy in the latest 30 years'. Proceda Environmental Sciences 2, 1206-1212 http://www.sciencedirect.com/science/article/pii/S1878029610001647

Watts, N., Adger, W.N., Agnolucci, P., Blackstock, J., Byass, P., Cai, W., Chaytor, S., Colbourn, T., Collins, M., Cooper, A. et al. (2015). 'Health and climate change: policy responses to protect public health'. The Lancet 386(10006), 1861-1914 http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736%2815%2960854-6.pdf

Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A.G., de Souza Dias, B.F., Ezeh, A., Frumkin, H., Gong, P., Head, P. et al. (2015). 'Safeguarding human health in the Anthropocene epoch: Report of The Rockefeller Foundation–Lancet Commission on Planetary Health'. The Lancet Commissions 386(10007), 56. doi: 10.1016/S0140-6736(15)60901-1 http://www.thelancet.com/commissions/planetary-health

WHO (2013). World health statistics: Obesity and overweight. World Health Organization http://www.who.int/mediacentre/factsheets/fs311/en/

WHO and UNICEF (2014). Progress on drinking water and sanitation: 2014 update. World Health Organization and the United Nations Children's Emergency Fund, Geneva http://www.who.int/water_sanitation_health/publications/2014/jmp-report/en/

World Bank (2013). East Asia Pacific region urban sanitation review: A call for action. https://openknowledge.worldbank.org/bitstream/handle/10986/17616/840460WP0EAP0U0Box0382094B00PUBLIC0.pdf?sequence=1&isAllowed=y

World Bank (2015). Data: Mortality rate, under-5 (per 1,000) http://data.worldbank.org/indicator/SH.DYN.MORT?display=default (Accessed: 19 November 2015)

WRI (2015). The Access Initiative (TAI): Ensuring that citizens have the right and ability to influence decisions about their natural resources. World Resources Institute http://www.wri.org/our-work/project/access-initiative-tai/commissions

Wubbeke, J. (2014). 'The three-year battle for China's new environmental law'. Chinadialogue: China and the World Discuss the Environment, 25 April https://www.chinadialogue.net/article/show/single/en/6938-The-three-year-battle-for-China-s-new-environmental-law

WWAP (2014). The United Nations world water development report 2014: Water and energy. United Nations Educational, Scientific and Cultural Organization Paris http://www.unesco.org/new/en/natural-sciences/environment/water/wwap/wwdr/2014-water-and-energy/

Zhang, Q.Q., Ying, G.G., Pan, C.G., Liu, Y.S. and Zhao, J.L. (2015). 'Comprehensive evaluation of antibiotics emission and fate in the river basins of China: Source analysis, multimedia modeling, and linkage to bacterial resistance'. Environmental Science & Technology 49(11), 6772-6782 doi: 10.1021/acs.est5b00729 http://pubs.acs.org/doi/abs/10.1021/acs.est.5b00729

Zhang, Z. (2008). 'Asia energy and environmental policy: Promoting growth while preserving the environment'. Energy policy 36(10), 3905-3924 https://www.researchgate.net/publication/222528028_Asian_Energy_and_Environmental_Policy_Promoting_Growth_While_Preserving_the_Environment

Zomer, A. and Hsu, A. (2015). Four hurdles to getting data and science into the SDGs: Rigorous integration will ensure the goals inspire rather than deter commitment. http://www.scidev.net/global/data/opinion/four-hurdlesdatascience-sdgs.html (Accessed: 15 September 2015)

Chapter 2

ADB (2010). Key indicators for Asia and the Pacific: Special chapter: The Rise of Asia's middle class. Asian Development Bank, Manila http://www.adb.org/sites/default/files/publication/27726/key-indicators-2010.pdf

ADB (2012). Addressing climate change and migration in Asia and the Pacific. Graeme, H., Bardsley, D., Sharma, V., Tan, Y., Williams, M. and Bedford, R. (eds.). Asian Development Bank Manila http://espace.library.uq.edu.au/view/UQ:258003

ADB (2013a). Food security in Asia and the Pacific. Asian Development Bank Manila http://www.adb.org/publications/food-security-asia-and-pacific

ADB (2013b). Energy statistics in Asia and the Pacific (1990–2009) and energy outlook for Asia and the Pacific. Asian Development Bank (ADB), Manila http://www.adb.org/sites/default/files/publication/30286/energy-statistics-pamphlet.pdf (Accessed: 23 July 2015)

ADB (2013c). Asian Water Development Outlook 2013. Asian Development Bank, Manila http://adb.org/sites/default/files/pub/2013/asian-water-development-outlook-2013.pdf (Accessed: 23 February 2016)

ADB (2015). People's Republic of China: Construction and demolition waste management and recycling. Project Number: 48105-001 - Policy and Advisory Technical Assistance (PATA). Asian Development Bank, Manila http://www.adb.org/sites/default/files/project-document/161008/48105-001-tar.pdf (Accessed: June 2015)

Ahrends, A., Hollingsworth, P.M., Ziegler, A.D., Fox, J.M., Chen, H., Su, Y. and Xu, J. (2015). 'Current trends of rubber plantation expansion may threaten biodiversity and livelihoods'. Global Environmental Change 34(2015), 48-58. doi: http://dx.doi.org/10.1016/j.gloenvcha.2015.06.002 https://www.researchgate.net/profile/Jianchu_Xu2/publication/281799254_Current_trends_of_rubber_plantation_expansion_may_threaten_biodiversity_and_livelihoods/links/55fd746108aec948c4d07879.pdf

Akimoto, H., Mori, Y., Sasaki, K., Nakashimi, H., Ohizumi, T. and Itano, Y. (2015). 'Analysis of monitoring ground-level ozone in Japan for long-term trend during 1990 – 2010: Causes of temporal and spatial variation'. Atmospheric Environment 102, 302-310. doi: 10.1016/j.atmosenv.2014.12.001 https://www.researchgate.net/profile/Hajime_Akimoto3/publication/272391770_Analysis_of_monitoring_data_of_ground-level_ozone_in_Japan_for_long-term_trend_during_1990-2010_Causes_of_temporal_and_spatial_variation/links/561c6b4908aea80367243f93.pdf

Alkemade, R., van Oorschot, M., Miles, L., Nellemann, C., Bakkenes, M. and Ten Brink, B. (2009). 'GLOBIO3: A Framework to investigate options for reducing global terrestrial biodiversity loss'. Ecosystems 12(3), 374-390. doi: 10.1007/s10021-009-9229-5 http://link.springer.com/article/10.1007/s10021-009-9229-5/fulltext.html

Amini, M., Mueller, K., Abbaspour, K.C., Rosenberg, T., Afyuni, M., Møller, K.N., Sarr, M. and Johnson, C.A. (2008). 'Statistical modeling of global geogenic fluoride contamination in groundwaters'. Environmental Science & Technology 42(10), 3662-3668 http://pubs.acs.org/doi/pdf/10.1021/es071958y

Anand, P.B. (2012). Climate change and water: Impacts to human health and consumption. Asia-Pacific Human Development Report Background Papers Series 2012/15. United Nations Development Programme http://www.asia-pacific.undp.org/content/dam/rbap/docs/Research%20&%20Publications/human_development/aphdr-2012-tbp/RBAP-HDR-2012-APHDR-TBP-15.pdf (Accessed: 23 July2015)

Anschütz, J. (1996). Community based solid waste management and water supply projects: Problem and Solution compared: A Survey of literature. Urban Waste Expertise Programme: UWEP Working Document 2 Urban Waste Expertise Program (UWEP) http://www.ilo.int/wcmsp5/groups/public/---ed_emp/---emp_policy/---invest/documents/publication/wcms_asist_5125.pdf (Accessed: 24 November 2015)

APEC (2014). APEC marine sustainable development report. Asia-Pacific Economic Cooperation http://publications.apec.org/publication-detail.php?pub_id=1552 (Accessed: 20 August 2015)

APO (2006). Postharvest management of fruit and vegetables in the Asia-Pacific Region. Reports of the APO seminar on Reduction of Postharvest Losses of Fruit and Vegetables, and Marketing and Food Safety: Challenges in Postharvest Management of Agricultural/Horticultural Products. India and Islamic Republic of Iran, 5–11 October 2004 and 23–28 July 2005, Asian Productivity Organization and Food and Agriculture Organization of the United Nations http://www.apo-tokyo.org/00e-books/AG-18_PostHarvest/AG-18_PostHarvest.pdf

Arunakumara, K., Walpola, B.C. and Yoon, M.-H. (2013). 'Current status of heavy metal contamination in Asia's rice lands'. Reviews in Environmental Science and Bio/Technology 12(4), 355-377 http://link.springer.com/article/10.1007/s11157-013-9323-1/fulltext.html

Baharuddin, M.F.T., Taib, S., Hashim, R., Abidin, M.H.Z. and Rahman, N.I. (2013). 'Assessment of seawater intrusion to the agricultural sustainability at the coastal area of Carey Island, Selangor, Malaysia. '. Arabian Journal of Geosciences 6(10), 3909–3928. doi: 10.1007/s12517-012-0651-1 http://link.springer.com/article/10.1007%2Fs12517-012-0651-1#/page-1

Bai, Z., Dent, D., Olsson, L. and Schaepman, M. (2008). Global assessment of land degradation and improvement 1: identification by remote sensing. Report 2008/01, FAO/ISRIC-Rome/Wageningen. World Soil Information, Wageningen http://isric.eu/sites/default/files/Report%202008_01_GLADA%20international_REV_Nov%202008.pdf

Baldé, C.P., Wang, F., Kuehr, R. and Huisman, J. (2015). The Global e-waste monitor 2014: Quantitites, flows and resources. United Nations University, IAS – SCYCLE, Bonn http://i.unu.edu/media/unu.edu/news/52624/UNU-1stGlobal-E-Waste-Monitor-2014-small.pdf

Baldwin, R.F. (2010). 'Identifying keystone threats to biological diversity '. In Landscape-scale Conservation Planning. Trombulak, S.C. and Baldwin, R.F. (eds.). Springer, Netherlands, chapter 2, 17-32 www.springer.com/978-90-481-9574-9

Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, chapter 30, 1655-1731 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap30_FINAL.pdf

Bappenas (1999). Planning for fire prevention and drought management project: Final report Annex 1: Causes, extent, impact and costs of 1997/98 fires and drought. ADB TA 2999-INO July 1998 - March 1999. Asian Development Bank http://s3.amazonaws.com/zanran_storage/www.adb.org/ContentPages/82475717.pdf (Accessed: 24th December 2014)

Benjakul, R. (2009). Impact of climate change on coastal aquifers in metropolis Cebu (Philippines). Michigan Technological University, Department of Geological and Mining Engineering and Sciences http://www.mtcws.mtu.edu/Education/2009_Posters/Benjakul-Rungroj_poster.pdf (Accessed: 3 July 2015)

Bergqvist, A., Holmgren, K.E. and Rylander, P. (2012). Impacts of saline water intrusion on the daily lives in the Mekong Delta Viet Nam. Degree project in Environmental Science / Minor Field Study, Biology and Environmental Science - Bachelor's Programme, Swedish University of Agricultural Sciences http://stud.epsilon.slu.se/3934/2/bergqvist_a_eitrem_holmgren_k_rylander_p_120227.pdf

Berthe, L., Seng, D.C. and Asora, L. (2014). ' Multiple stresses, veiled threat: Saltwater intrusion in Samoa'. Samoa Conference III: Opportunities and challenges for a sustainable cultural and natural environment. Apia, Samoa 25-29 August 2014. National University of Samoa http://samoanstudies.ws/wp-content/uploads/2015/03/Leo-Berthe-Dennis-Chang-Seng-and-Lameko-Asora.pdf

Biogas Asia Pacific Forum (2013). Biogas gain ground in South East Asia: Report on the Biogas Asia Pacific Forum 2013. https://dl.dropboxusercontent.com/u/76410251/PSR%20-%20Biogas%20AP%202013.pdf (Accessed: 18 February, 2016)

BirdLife International (2008). Invasive alien species have been implicated in nearly half of recent bird extinctions. http://www.birdlife.org/datazone/sowb/casestudy/127

Blanco, G., Gerlagh, R., Suh, S., Barrett, J.R., de Coninck, H.C., Diaz Morejon, C.F., Mathur, R., Nakicenovic, N., Ofosu Ahenkora, A., Pan, J. et al. (2014). 'Drivers, trends and mitigation'. In Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Edenhofer, O., Pichs-Madruga, R., Y. Sokona, Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P. et al. (eds.). Cambridge University Press, Cambridge, chapter 5, 351 https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter5.pdf

Bolch, T., Kulkarni, A., Kääb, A., Huggel, C., Paul, F., Cogley, J.G., Frey, H., Kargel, J.S., Fujita, K., Scheel, M. et al. (2012). 'The State and Fate of Himalayan Glaciers'. Science 336(6079), 310-314. doi: 10.1126/science.1215828 http://www.sciencemag.org/content/336/6079/310.full.pdf

Bonasoni, P., Laj, P., Angelini, F., Arduini, J., Bonafe, U., Calzolari, F., Cristofanelli, P., Decesari, S., Facchini, M. and Fuzzi, S. (2008). 'The ABC-Pyramid Atmospheric Research Observatory in Himalaya for aerosol, ozone and halocarbon measurements'. Science of the Total Environment 391(2), 252-261. doi: 10.1016/j.scitotenv.2007.10.024 http://earthjustice.org/sites/default/files/black-carbon/bonasoni-et-al-2008.pdf

Boucher, D., Elias, P., Lininger, K., May-Tobin, C., Roquemore, S. and Saxon, E. (2011). The root of the problem: What is driving tropical deforestation today? . Union of Concerned Scientists. Citizens and Scientists for Environmental Solutions, Cambridge http://www.ucsusa.org/sites/default/files/legacy/assets/documents/global_warming/UCS_RootoftheProblem_DriversofDeforestation_FullReport.pdf

Bruce, N., Dherani, M., Liu, R., III, H.D.H., Sapkota, A., Smith, K.R., Straif, K., Lan, Q. and Pope, D. (2015). 'Does household use of biomass fuel cause lung cancer? A systematic review and evaluation of the evidence for the GBD 2010 study'. Thorax 70(2015), 433–441. doi: 10.1136/thoraxjnl-2014-206625 http://ehsdiv.sph.berkeley.edu/krsmith/publications/2015/Thorax-2015-Bruce.pdf

Burke, L., Reytar, K., Spalding, M. and Perry, A. (2012). Reefs at risk revisited in the Coral Triangle. World Resources Report. World Resources Institute Washington DC http://www.wri.org/sites/default/files/pdf/reefs_at_risk_revisited_coral_triangle.pdf

Burke, L., Selig, E. and Spalding, M. (2002). Reefs at risk in Southeast Asia. World Resources Institute, Washington, DC http://www.wri.org/sites/default/files/pdf/rrseasia_full.pdf

CAI Asia Center (2010). Clean Air Initiative for Asian Cities Center http://www.pciaonline.org/node/114

Cai, W.-J., Hu, X., Huang, W.-J., Murrell, M.C., Lehrter, J.C., Lohrenz, S.E., Chou, W.-C., Zhai, W., Hollibaugh, J.T. and Wang, Y. (2011). 'Acidification of subsurface coastal waters enhanced by eutrophication'. Nature Geoscience 4(11), 766-770 http://mel.xmu.edu.cn/upload_paper/2012101595652-VxnmFR.pdf

CEPF (2015). The biodiversity hotspots maps. Critical Ecosystem Partnership Fund http://www.cepf.net/resources/hotspots/Pages/default.aspx

Certini, G. (2005). 'Effects of fire on properties of forest soils: A Review'. Oecologia 143(1), 1-10. doi: 10.1007/s00442-004-1788-8 https://pdfs.semanticscholar.org/4918/11b26f736b116e079166fe8bbec865fcf5d1.pdf

Chen and al, e. (2011). 'Rapid range shifts of species associated with high levels of climate warming'. Science 333 (2011), 1024-1026 https://www.sciencemag.org/content/333/6045/1024.full.pdf

Chun, J.M. (2015). Planned relocations In The Mekong Delta: A Successful model for climate change adaptation, a cautionary tale, or both? Brookings-LSE Project on Internal Displacement. Brookings Institution, Washington, D.C. http://www.brookings.edu/~/media/research/files/papers/2015/06/planned-relocations-climate-change/brookings-planned-relocations-case-studyjane-chun-vietnam-case-study-june-2015.pdf

CIA (2016). The World Factbook 2016-17. United States Central Intelligence Agency https://www.cia.gov/library/publications/the-world-factbook/index.html

CITES (2013). Consideration of proposals for amendment of appendices I and II. Sixteenth Meeting of the Conference of the Parties, Resolution Conf. 10.9 https://cites.org/eng/res/10/10-09.php

Colchester, M. and Chao, S. (eds.) (2011). Oil palm expansion in South East Asia: Trends and implications for local communities and indigenous peoples. Forest Peoples Programme and SawitWatch http://www.forestpeoples.org/sites/fpp/files/publication/2011/11/oil-palm-expansion-south-east-asia-final.pdf

Collins, K. (2011). 'Land use'. In Resource Efficiency: Economics and Outlook for Asia and the Pacific. UNEP and CSIRO, 103-137 http://www.unep.org/roap/Portals/96/REEO_AP_Key.pdf

Conservation International (2010). New 'Pacific Oceanscape' makes history 8 August http://www.conservation.org/NewsRoom/pressreleases/Pages/Pacific_Oceanscape_creation.aspx

Convention, U.-S. (2015). Global Monitoring Plan for persistent organic pollutants: under the Stockholm Convention Article 16 on effectiveness evaluation: Second regional monitoring report: Asia-Pacific Region. Stockholm Convention http://chm.pops.int/Implementation/GlobalMonitoringPlan/MonitoringReports/tabid/525/Default.aspx

Costanza, R., Kubiszewski, I., Roman, J. and Sutton, P. (2011). Changes in ecosystem services and migration in low-lying coastal areas over the next 50 years. Migration and Global Environmental Change. UK Government Office for Science, London https://www.uvm.edu/giee/pubpdfs/Costanza_2011_Migration_and_Global_Environmental_Change.pdf

CPCB (2012). Status of water quality in India-2012. Monitoring of Indian National Aquatic Resources Series: MINARS/36 /2013-14. Central Pollution Control Board, Ministry of Environment & Forests http://www.cpcb.nic.in/WQ_Status_Report2012.pdf (Accessed: 14 July 2015)

Cramb, R. and Curry, G.N. (2012). 'Oil palm and rural livelihoods in the Asia–Pacific region: An overview'. Asia Pacific Viewpoint 53(3), 223-239. doi: 10.1111/j.1467-8373.2012.01495.x https://www.researchgate.net/publication/264401019_Oil_palm_and_rural_livelihoods_in_the_Asia-Pacific_region_An_overview

CRED (2015). The Human cost of natural disasters: A Global perspective. Centre for Research on the Epidemiology of Disasters, Brussels http://reliefweb.int/sites/reliefweb.int/files/resources/PAND_report.pdf

Dasgupta, S., Kamal, F.A., Khan, Z.H., Choudhury, S. and Nishat, A. (2014). River salinity and climate change evidence from coastal Bangladesh. World Bank Policy Research Working Paper. World Bank http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2416607

Davis, S.W., Dennis, N.A., Buchler, N.G., White, L.E., Madden, D.J. and Cabeza, R. (2009). 'Assessing the effects of age on long white matter tracts using diffusion tensor tractography'. Neuroimage 46(2), 530-541. doi: 10.1016/j.neuroimage.2009.01.068 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2775533/pdf/nihms96333.pdf

De Mitcheson, Y.S., Cornish, A., Domeier, M., Colin, P.L., Russell, M. and Lindeman, K.C. (2008). 'A global baseline for spawning aggregations of reef fishes'. Conservation Biology 22(5), 1233-1244. doi: 10.1111/j.1523-1739.2008.01020.x https://www.researchgate.net/profile/Michael_Domeier/publication/23184825_A_global_baseline_for_spawning_aggregations_of_reef_fishes/links/0deec528510e97bbc6000000.pdf

Deltares (2015). Sinking cities: An integrated approach towards solutions. https://www.deltares.nl/app/uploads/2015/09/Sinking-cities.pdf (Downloaded: 28 July 2015)

Dentener, F., Keating, T. and Akimoto, H. (2010). Hemispheric transport of air pollution 2010 Part A: Ozone and particulate matter. Air Pollution Studies No. 17. Economic Commission for Europe http://www.htap.org/publications/2010_report/2010_Final_Report/HTAP%202010%20Part%20A%20110407.pdf

Devaraju, N., Bala, G. and Modak, A. (2015). 'Effects of large-scale deforestation on precipitation in the monsoon regions: remote versus local effects'. Proceedings of the National Academy of Sciences 112(11), 3257–3262. doi: 10.1073/pnas.1423439112 http://www.pnas.org/content/112/11/3257.full.pdf

DiMiceli, C.M., Carroll, M.L., Sohlberg, R.A., Huang, C., Hansen, M.C. and Townshend, J.R.G. (2011). Annual Global Automated MODIS Vegetation Continuous Fields (MOD44B) at 250 m Spatial Resolution for Data Years Beginning Day 65, 2000 - 2010, Collection 5 Percent Tree Cover. University of Maryland, College Park, Maryland, MD http://glcf.umd.edu/data/vcf/

Dlugokencky, E. and Tans, P. (2015). Global Greenhouse Gas Reference Network. NOAA/ESRL www.esrl.noaa.gov/gmd/ccgg/trends/ (Accessed: 27 November 2015)

EANET (2015). EANET Data on the acid deposition in the East Asia Region http://www.eanet.asia/product/ (Accessed: November 2015

Ebarvia, M. and M., C. (2016). 'Economic assessment of oceans for sustainable blue economy development'. Journal of Ocean and Coastal Economics 2(2), 7. doi: http://dx.doi.org/10.15351/2373-8456.1051 http://cbe.miis.edu/cgi/viewcontent.cgi?article=1051&context=joce

Ebinghaus, R., Dommergue, A., Jaffe, D., Keeler, G.J., Kock, H.H., Pirrone, N., Schmeltz, D. and Sprovieri, F. (2010). 'Observations'. In Hemispheric Transport of Air Pollution 2010 Part B Mercury. Pirrone, N. and Keating, T. (eds.). UNECE, Geneva, chapter 2, 27-74 http://www.unece.org/fileadmin/DAM/env/lrtap/Publications/11-22145-Part-B.pdf

Eitelberg, D.A., Vliet, J. and Verburg, P.H. (2015). 'A review of global potentially available cropland estimates and their consequences for model-based assessments'. Global Change Biology 21(3), 1236-1248 http://dare.ubvu.vu.nl/bitstream/handle/1871/52447/Eitelberg_et_al-2014-Global_Change_Biology.pdf?sequence=1

Elder, M., Sivapuram, P., Romero, J. and Matsumoto, N. (2008). 'Prospects and challenges of biofuels in Asia: Policy implications'. In Climate Change Policies in the Asia-Pacific. Institute for Global Environmental Strategies Hayama, chapter 5, 105-132 http://www.isn.ethz.ch/Digital-Library/Publications/Detail/?lang=en&id=57251

Eriksson, M., Jianchu, X., Shrestha, A.B., Vaidya, R.A., Nepal. S. and Sandström, K. (2009). The changing Himalayas: Impact of climate change on water resources and livelihoods in the Greater Himalaya. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu http://www.preventionweb.net/files/11621_icimodthechanginghimalayas1.pdf

Esty, D.C., Levy, M.A., Kim, C.H., de Sherbinin, A. and Mara, V. (2008). 2008 Environmental Performance Index. Yale Center for Environmental Law and Policy, New Haven http://www.yale.edu/epi/files/2008EPI_Text.pdf

Faneca Sanchez, M., Bashar, K., Janssen, G.M.C.M., Vogels, M., Snel, J., Zhou, Y., Stuurman, R. and Dude Essink, G.H.P. (2015). SWIBANGLA: Managing salt water intrusion impacts in coastal groundwater systems of Bangladesh: Final report. Deltares report number: 1207671-000-BGS-0016. Deltares, UNESCO-IHE and Jahangirnagar University https://www.deltares.nl/app/uploads/2015/04/1207671-000-BGS-0016-r-SWIBANGLA-def.pdf (Accessed: January 2015)

FAO (2006). Understanding forest tenure in South and Southeast Asia. Food and Agriculture Organization, Rome http://www.fao.org/docrep/009/j8167e/j8167e00.htm (Accessed: 17 September 2015)

FAO (2009). How to feed the world in 2050. Food and Agriculture Organization of the United Nations, Rome http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf (Accessed: 15 September 2015)

FAO (2010). Global Forest Resources Assessment 2010. FAO Forestry Paper 163. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy http://www.fao.org/docrep/013/i1757e/i1757e.pdf

FAO (2011a). Mapping supply and demand for animal-source foods to 2030. FAO Animal Production and Health Working Paper. Food and Agriculture Organization of the United Nations, Rome http://www.fao.org/docrep/014/i2425e/i2425e00.pdf

FAO (2011b). The Save Food Asia-Pacific Campaign Food and Agriculture Organization of the United Nations, Bangkok http://in.one.un.org/img/uploads/SaveFood_Brochure.pdf

FAO (2014). FAO Statistical Yearbook 2014. Asia and the Pacific food and agriculture. Food and Agriculture Organization of the United Nations Rome http://www.fao.org/3/a-i3590e.pdf (Accessed: 19 September 2015)

FAO (2014a). Freshwater Availability: Precipitation and Internal Renewable Water Resources (IRWR). http://www.fao.org/nr/water/aquastat/tables/WorldData-IRWR_eng.pdf (Accessed: 20 February 2016)

FAO (2014b). FAOSTAT Nations, F.a.A.O.o.t.U., http://faostat3.fao.org/home/E (Accessed 17 July 2015)

FAO (2015a). Global forest resources assessment 2015: Desk reference. Food and Agriculture Organization of the United Nations (FAO), Rome http://www.fao.org/3/a-i4808e.pdf (Accessed: 17 September 2015)

FAO (2015b). Global forest resources assessment 2015: How are the world's forests changing? Food and Agriculture Organization of the United Nations (FAO), Rome, Italy http://www.fao.org/3/a-i4868e.pdf (Accessed: 17 September 2015)

FAO (2015c). FAOSTAT: Forest land. Food and Agriculture Organization of the United Nations. http://faostat3.fao.org/browse/G2/GF/E

FAO (2015d). AQUASTAT. http://www.fao.org/nr/water/aquastat/main/index.stm

FAO (2015e). Country factsheets. Food and Agriculture Organization of the United Nations. http://www.fao.org/nr/water/aquastat/countries_regions/ (Accessed: 5 September 2015)

FAO (2016). FAO gender and land rights database. Food and Agriculture Organization of the United Nations. http://www.fao.org/gender-landrights-database/en/

FAO and ITPS (2015). Status of the World's Soil Resources (SWSR) – Main Report. Food and Agriculture Organization of the United Nations and and Intergovernmental Technical Panel on Soils, Rome http://www.fao.org/3/a-i5199e.pdf

Fischlin, A., Midgley, G.F., Hughs, L., Price, J., Leemans, R., Gopal, B., Turley, C., Rounsevell, M., Dube, P. and Tarazona, J. (2007). 'Ecosystems, their properties, goods, and services'. In Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M.L., O.F. Canziani, Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. (eds.). Cambridge University Press, Cambridge, chapter 4, 211-272 http://www.researchonline.mq.edu.au/vital/access/services/Download/mq:7542/DS01

Fong-Sum, Y., Kuo, C.S., Shi, L., Tse, P.-K., Wacaster, S. and Wilburn, D.R. (2014). The mineral industries of Asia and Pacific. 2012 Minerals Yearbook: Asia and the Pacific. United States Geological Survey http://minerals.usgs.gov/minerals/pubs/country/2012/myb3-sum-2012-asia-pacific.pdf (Accessed: 16 September 2015)

Foresight: Migration and Global Environmental Change (2011). Final Project Report. The Government Office for Science, London https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/287717/11-1116-migration-and-global-environmental-change.pdf

Frenken, K.E. (2012). Irrigation in Southern and Eastern Asia in figures: AQUASTAT Survey – 2011 FAO Water Report 37. Food and Agricultural Organization of the United Nations, Rome http://www.fao.org/docrep/016/i2809e/i2809e.pdf

Friedl, M.A., Sulla-Menashe, D., B. Tan, A.S., Ramankutty, N., Sibley, A. and Huang, X. (2010). MODIS Collection 5 global land cover: Algorithm refinements and characterization of new datasets, 2001-2012, Collection 5.1 IGBP Land Cover. Boston University. Boston, MA http://glcf.umd.edu/data/lc/

Funge-Smith, S., Briggs, M. and Miao, W. (2012). Regional overview of fisheries and aquaculture in Asia and the Pacific 2012. RAP Publication 2012/26. Asia-Pacific Fishery Commission and Food and Agriculture Organization of the United Nations Bangkok http://www.fao.org/docrep/017/i3185e/i3185e00.pdf

Gattuso, J.-P., Brewer, P.G., Hoegh-Guldberg, O., Kleypas, J.A., Pörtner, H.-O. and Schmidt, D.N. (2014a). 'Cross-chapter box on ocean acidification'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, 129-131 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-CCboxes_FINAL.pdf

Gattuso, J.-P., Hoegh-Guldberg, O. and Pörtner, H.-O. (2014b). 'Cross-chapter box on coral reefs'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability: Part A: Global and Sectoral Aspects: Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, 97-100 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-CCboxes_FINAL.pdf

Geldmann, J., Joppa, L.N. and Burgess, N.D. (2014). 'Mapping change in human pressure globally on land and within protected areas'. Conservation Biology 28(6), 1604-1616. doi: 10.1111/cobi.12332. https://www.researchgate.net/profile/Jonas_Geldmann/publication/264203159_Mapping_Change_in_Human_Pressure_Globally_on_Land_and_within_Protected_Areas/links/5492cd850cf2302e1d074227.pdf

GESAMP (2015). Sources, fate and effects of microplastics in the marine environment: a global assessment. IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Rep. Stud. GESAMP No. 90. Kershaw, P.J. (ed.). International Maritime Organization, Washington, DC http://ec.europa.eu/environment/marine/good-environmental-status/descriptor-10/pdf/GESAMP_microplastics%20full%20study.pdf

Ghatak, M. and Roy, S. (2007). 'Land reform and agricultural productivity in India: A review of evidence'. Oxford Review of Economic Policy 23(2), 251-269 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.539.5862&rep=rep1&type=pdf

Global Footprint Network (2015). Ecological footprint and biocapacity in 2011 http://www.footprintnetwork.org

Goddard, C. (2015). 'The Ocean business: The Rise and rhetoric of the blue economy'. The World in 2016, 2 November. The Economist http://www.theworldin.com/article/10625/ocean-business

Goldammer, J.G., Davidenko, E., Kondrashov, L. and Ezhov, N. Recent trends of forest fires in Central Asia and opportunities for regional cooperation in forest fire management. Regional Forest Congress "Forest Policy: Problems and Solutions. Bishkek, Kyrgyzstan, 25-27 November 2004 http://www.fire.uni-freiburg.de/GlobalNetworks/CentralAsia/GFMC-Kyrgisia-Congress-Nov-2004-Final.pdf

Gopal, B. (2013). 'Future of wetlands in tropical and subtropical Asia, especially in the face of climate change'. Aquatic Sciences 75(2013), 39-61. doi: 10.1007/s00027-011-0247-y http://link.springer.com/article/10.1007/s00027-011-0247-y/fulltext.html

Gottschalk, F. and Nowack, B. (2011). 'The release of engineered nanomaterials to the environment'. Journal of Environmental Monitoring 13(5), 1145-1155 https://www.researchgate.net/profile/Bernd_Nowack/publication/50349175_The_release_of_engineered_nanomaterials_to_the_environment/links/54c75fc30cf238bb7d0a7d1a.pdf

Halpern, B.S., Longo, C., Hardy, D., McLeod, K.L., Samhouri, J.F., Katona, S.K., Kleisner, K., Lester, S.E., O'Leary, J. and Ranelletti, M. (2012). 'An index to assess the health and benefits of the global ocean'. Nature 488(7413), 615-620. doi: 10.1038/nature11397 http://www.nature.com/nature/journal/v488/n7413/pdf/nature11397.pdf

Hansda, R. (2009). The outlook for non-wood forest products in Asia and the Pacific. Asia-Pacific Forestry Sector Outlook Study II Working Paper Series: Working Paper No. APFSOS II/WP/2009/18 Food and Agriculture Organization of the United Nations http://www.fao.org/fileadmin/templates/rap/files/APFSOS/2009-18NWFP.pdf

Harris, R.B. (2010). 'Rangeland degradation on the Qinghai-Tibetan plateau: a review of the evidence of its magnitude and causes'. Journal of Arid Environments 74(1), 1-12. doi: 10.1016/j.jaridenv.2009.06.014 https://www.researchgate.net/profile/Richard_Harris25/publication/222406023_Rangeland_Degradation_on_the_Qinghai-Tibetan_Plateau_A_Review_of_the_Evidence_of_its_Magnitude_and_Causes/links/557904b308ae752158703e83.pdf

Hart Energy (2016). International Fuel Quality Center http://www.hartenergy.com/Downstream/Research-And-Consulting/International-Fuel-Quality-Center/

He, T., Feng, X., Guo, Y., Qiu, G., Li, Z., Liang, L. and Lu, J. (2008). 'The impact of eutrophication on the biogeochemical cycling of mercury species in a reservoir: a case study from Hongfeng Reservoir, Guizhou, China'. Environmental Pollution 154(1), 56-67 https://www.researchgate.net/profile/Zhonggen_Li/publication/5691516_The_impact_of_eutrophication_on_the_biogeochemical_cycling_of_mercury_species_in_a_reservoir_A_case_study_from_Hongfeng_Reservoir_Guizhou_China/links/0a85e53416316c2de3000000.pdf

Heil, A. and Goldammer, J.G. (2001). 'Smoke-haze pollution: A review of the 1997 episode in Southeast Asia'. Regional Environmental Change 2(1), 24-37. doi: 10.1007/s101130100021 http://www.fire.uni-freiburg.de/vfe/Smoke-Haze%20in%20SE%20Asia%201997.pdf

Hijioka, Y., Lin, E., Pereira, J.J., Corlett, R.T., Cui, X., Insarov, G.E., Lasco, R.D., Lindgren, E. and Surjan, A. (2014). 'Asia'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Barros, V.R., Field, C.B., D.J. Dokken, M.D. Mastrandrea, K.J. Mach, Bilir, T.E., Chatterjee, M., K.L. Ebi, Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, chapter 24, 1327-1370 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap24_FINAL.pdf

Hoegh-Guldberg, O., Cai, R., Poloczanska, E.S., Brewer, P.G., Sundby, S., Hilmi, K., Fabry, V.J. and Jung, S. (2014). 'The Ocean'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

Hoekstra, A.Y., Mekonnen, M.M., Chapagain, A.K., Mathews, R.E. and Richter, B.D. (2012). 'Global monthly water scarcity: blue water footprints versus blue water availability'. PloS one 7(2), e32688 http://journals.plos.org/plosone/article/asset?id=10.1371%2Fjournal.pone.0032688.PDF

Huang, Q., Yang, Y. and Wang, Q. (2012). 'Potential for serious environmental threats from uncontrolled co-processing of wastes in cement kilns'. Environmental Science & Technology 46(2012), 13031–13032. doi: 10.1021/es3042274 http://pubs.acs.org/doi/pdf/10.1021/es3042274

ICAR and NAAS (2010). Degraded and wastelands of India: Status and spatial distribution. Indian Council of Agricultural Research and National Academy of Agricultural Sciences, New Delhi http://www.icar.org.in/files/Degraded-and-Wastelands.pdf

IEA (2012). World Energy Outlook 2012. International Energy Agency (IEA), Paris http://www.iea.org/publications/freepublications/publication/WEO2012_free.pdf

IGRAC (2010). Global Groundwater Information System (GGIS). International Groundwater Resources Assessment Centre http://www.un-igrac.org/publications/104

Immerzeel, W.W., van Beek, L.P.H. and Bierkens, M.F.P. (2010). 'Climate change will affect the Asian water towers'. Science 328(5984), 1382–1385. doi: 10.1126/science.1183188 http://www.futurewater.nl/wp-content/uploads/2011/05/Immerzeel_Science_11June2010.pdf

IPCC (2007). Climate change 2007: Impacts, adaptation and vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J. and Hanson, C.E. (eds.). Cambridge University Press, Cambridge https://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4_wg2_full_report.pdf

IPCC (2013). 'Summary for Policymakers'. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (eds.). Cambridge University Press, Cambridge http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf

IPCC (2014). Climate Change 2014: Synthesis report: Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Pachauri, R.K. and Meyer, L.A. (eds.). Intergovernmental Panel on Climate Change, Geneva https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf

Island Conservation, University of Auckland and Landcare Research New Zealand, University of California Santa Cruz and Coastal Conservation Action Laboratory (2014). Database of Islands and Invasive Species Eradications. http://diise.islandconservation.org/

ISWA (2013). Waste Atlas 2013 Report. http://www.iswa.org/fileadmin/galleries/News/WASTE_ATLAS_2013_REPORT.pdf (Accessed: 26 November 2015)

ISWA (2015). 'AcuComm's Waste Business Finder'. Waste Business Monitor, March 2015. International Solid Waste Association http://www.iswa.org/fileadmin/galleries/Blasts%202014/Waste%20industry%20sales%20monitor/Issue_7_Mar_2015_ISWA_.pdf

ww.acucomm.net (Accessed: April 2015)

IUCN (2015). IUCN Red List of Threatened Species Resources, I.U.f.C.o.N.a.N. (ed.), Gland https://cmsdata.iucn.org/downloads/iucn_redlist_brochure2.pdf

Ives, M. (2012). 'Melting glaciers may worsen Northwest China's water woes'. Yale Environment 360, 26 July http://e360.yale.edu/feature/melting_glaciers_may_worsen_china_water_woes_tarim_river/2556/

Jacks, G., Bhattacharya, P., Chaudhary, V. and Singh, K.P. (2005). 'Controls on the genesis of some high-fluoride groundwaters in India'. Applied Geochemistry 20, 221-228. doi: 10.1016/j.apgeochem.2004.07.002 http://www.researchgate.net/publication/223541978_Controls_on_the_genesis_of_some_high-fluoride_groundwater_in_India._Appl_Geochem

Jambeck, J.R., Geyer, R., Wilcox, C., Siegler, T.R., Perryman, M., Andrady, A., Narayan, R. and Law, K.L. (2015). 'Plastic waste inputs from land into the ocean'. Science 347(6226), 768-771 http://www.iswa.org/fileadmin/user_upload/Calendar_2011_03_AMERICANA/Science-2015-Jambeck-768-71__2_.pdf

Joshi, S. and Dudani, I. (2008). 'Environmental health effects of brick kilns in Kathmandu Valley'. Kathmandu University Medical Journal 6(1), 3-11 http://europepmc.org/abstract/med/18604107

Kanbur, R., Rhee, C. and Zhuang, J. (eds.) (2014). Inequality in Asia and the Pacific: Trends, drivers, and policy implications. Asian Development Bank, Manila http://www.adb.org/sites/default/files/publication/41630/inequality-asia-and-pacific.pdf

Katsigris, E., Bull, G., White, A., Barr, C., Barney, K., Bun, Y., Kahrl, F., King, T., Lankin, A., Lebedev, A. et al. (2004). 'The China forest products trade: overview of Asia-Pacific supplying countries, impacts and implications'. 6(3-4), 237-253 http://www.cifor.org/publications/pdf_files/articles/AKatsigris0401.pdf

Keller, A.A., McFerran, S., Lazareva, A. and Suh, S. (2013). 'Global life cycle releases of engineered nanomaterials'. Journal of Nanoparticle Research 15(6), 1-17. doi: 10.1007/s11051-013-1692-4 http://link.springer.com/article/10.1007/s11051-013-1692-4/fulltext.html

Kumar, S.V., Reichle, R.H., Peters-Lidard, C.D., Koster, R.D., Zhan, X., Crow, W.T., Eylander, J.B. and Houser, P.R. (2008). 'A land surface data assimilation framework using the land information system: Description and applications'. Advances in Water Resources 31(11), 1419-1432. doi: 10.1016/j.advwatres.2008.01.013 http://www.sciencedirect.com/science/article/pii/S0309170808000146/pdfft?md5=ce96dc8aa5fee2a6dd2c45a87282ofb7&pid=1-s2.0-S0309170808000146-main.pdf

Lalitaporn, P., Kurata, G., Matsuoka, Y., Thongboonchoo, N. and Surapipith, V. (2013). 'Long-term analysis of NO2, CO, and AOD seasonal variability using satellite observations over Asia and intercomparison with emission inventories and model'. Air Quality Atmosphere & Health 6(2013), 655-672. doi: 10.1007/s11869-013-0205-z https://www.researchgate.net/publication/271917161_Long-term_analysis_of_NO2_CO_and_AOD_seasonal_variability_using_satellite_observations_over_Asia_and_intercomparison_with_emission_inventories_and_model

Lan, Q.e.a. (2012). 'Genome-wide association analysis identifies new lung cancer susceptibility loci in never-smoking women in Asia'. Nature Genetic 44(2012), 1330-1337. doi: 10.1038/ng.2456 http://www.nature.com/ng/journal/v44/n12/full/ng.2456.html

Lara, R.J., Neogi, S.B., Islam, M.S., Mahmud, Z.H., Yamasaki, S. and Nair, G.B. (2009). 'Influence of catastrophic climatic events and human waste on vibrio distribution in the Karnaphuli Estuary, Bangladesh'. EcoHealth 6(2), 279-286 http://link.springer.com/article/10.1007/s10393-009-0257-6/fulltext.html

Lawry, S., Samii, C., Hall, R., Leopald, A., Hornby, D. and Mtero, F. (2014). 'The Impact of land property rights interventions on investments and agricultural productivity in developing countries: A Systematic review'. Campbell Systematic Reviews 1(2014), 104. doi: 10.4073/csr.2014.1 http://r4d.dfid.gov.uk/pdf/outputs/systematicreviews/Lawry_Land_Property_Rights_Review.pdf (Accessed: 17 September 2015)

Le, G.V., Takahashi, K., PARK, E.K., Delgermaa, V., Oak, C., Qureshi, A.M. and Aljunid, S.M. (2011). 'Asbestos use and asbestos-related diseases in Asia: past, present and future'. Respirology 16(5), 767-775 http://envepi.med.uoeh-u.ac.jp/toolkit/pdf/Bibliography/Giang_2011.pdf

Lehodey, P., Bertignac, M., Hampton, J., Lewis, A. and Picaut, J. (1997). 'El Niño Southern Oscillation and tuna in the western Pacific'. Nature 389(6652), 715-718. doi: 10.1038/39575 http://www.nature.com/nature/journal/v389/n6652/full/389715a0.html

Leong, S.L., Zainudin, R., Kazen-Allen, L. and Robinson, B.W. (2015). 'Asbestos in Asia'. Official Journal of the Aisan Pacific Society of Respirology 20(2015), 548–555. doi: 10.1111/resp.12517 http://onlinelibrary.wiley.com/doi/10.1111/resp.12517/epdf

Li, J., Han, Z. and Xie, Z. (2013). 'Model analysis of long-term trends of aerosol concentrations and direct radiative forcings over East Asia'. Tellus Series B: Chemical and Physical Meteorology 65(20410). doi: http://dx.doi.org/10.3402/tellusb.v65i0.20410 http://www.tellusb.net/index.php/tellusb/article/view/20410/30159

Lindenmayer, D., Cunningham, S. and Young, A. (2012). Land use intensification: Effects on agriculture, biodiversity and ecological processes. CSIRO PUBLISHING http://www.publish.csiro.au/pid/6808.htm

Loo, Y.Y., Billa, L. and Singh, A. (2014). 'Effect of climate change on seasonal monsoon in Asia and its impact on the variability of monsoon rainfall in Southeast Asia'. Geoscience Frontiers 6(2015), 817-823. doi: http://dx.doi.org/10.1016/j.gsf.2014.02.009 http://ac.els-cdn.com/S1674987114000036X/1-s2.0-S1674987114000036X-main.pdf?_tid=14eb75ee-1549-11e6-9e74-00000aabof6b&acdnat=1462731610_319cc1c78cb774297352ff3d2d7437ff

Lu, Y., Song, S., Wang, R., Liu, Z., Meng, J., Sweetman, A.J., Jenkins, A., Ferrier, R.C., Li, H. and Luo, W. (2015). 'Impacts of soil and water pollution on food safety and health risks in China'. Environment international 77(2015), 5-15. doi: 10.1016/j.envint.2014.12.010 https://www.researchgate.net/profile/Yonglong_Lu/publication/271058737_Impacts_of_Soil_and_Water_Pollution_on_Food_Safety_and_Health_Risks_in_China/links/54bcbf430cf29eocb04c2a1f.pdf

Lutz, A., Immerzeel, W., Shrestha, A. and Bierkens, M. (2014). 'Consistent increase in High Asia's runoff due to increasing glacier melt and precipitation'. Nature Climate Change 4(7), 587-592. doi: 10.1038/nclimate2237 https://www.researchgate.net/publication/262913479_Consistent_increase_in_High_Asia's_runoff_due_to_increasing_glacier_melt_and_precipitation

Lymer, D., Fung-Smith, S. and Miao, W. (2008). Status and potential of fisheries and aquaculture in Asia and Pacific 2008. RAP PUBLICATION 2008/15. FAO Regional Office for Asia and the Pacific, Bangkok ftp://ftp.fao.org/docrep/fao/011/i0433e/i0433e00.pdf

Lymer, D., Fung-Smith, S. and Miao, W. (2010). Status and potential of fisheries and aquaculture in Asia and Pacific 2010. RAP Publication 2010/17. FAO Regional Office for Asia and the Pacific http://www.fao.org/docrep/013/i1924e/i1924e00.pdf

Macusi, E.D., Katikiro, R.E., Deepananda, K., Jimenez, L.A., Conte, A.R. and Fadli, N. (2011). 'Human induced degradation of coastal resources in Asia Pacific and implications on management and food security'. Journal of Nature Studies 9(2), 13-28

Mazumder, M.N.H., Sultana, M.A. and Al-Mamun, A. (2013). 'Regional tourism development in Southeast Asia'. Transnational Corporations Review 5(2), 60-76. doi: 10.5148/tncr.2013.5205 https://www.researchgate.net/publication/237076711_Regional_Tourism_Development_in_Southeast_Asia

McClean, C.J., Lovett, J.C., Küper, W., Hannah, L., Sommer, J.H., Barthlott, W., Termansen, M., Smith, G.F., Tokumine, S. and Taplin, J.R. (2005). 'African plant diversity and climate change'. Annals of the Missouri Botanical Garden 92(2), 139-152 http://www.jstor.org/stable/3298511?seq=1#page_scan_tab_contents

McGranahan, G., Balk, D. and Anderson, B. (2007). 'The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones'. Environment and urbanization 19(1), 17-37. doi: 10.1177/0956247807076960

Mendelsohn, R. (2011). 'The impact of climate change on land. G. K. Ingram and Y.U. Hong (eds)'. In Climate Change and Land Policies Ingram, G.K. and Hong, Y.-H. (eds.). Lincoln Institute of Land Policy, Cambridge, 62-83 https://www.lincolninst.edu/pubs/dl/2035_1357_LP2010-ch04-The-Impact-of-Climate-Change-on-Land.pdf

Miles, L.J. (2002). The impact of global climate change on tropical forest biodiversity in Amazonia. PhD Dissertation PhD Dissertation, University of Leeds, Leeds, U.K. http://onlinelibrary.wiley.com/doi/10.1111/j.1466-822X.2004.00105.x/pdf

Ministry of Environmental Protection of PRC (2014). China's fifth national report on the implementation of the Convention on Biological Diversity. Ministry of Environmental Protection, Beijing https://www.cbd.int/doc/world/cn/cn-nr-05-en.pdf

Morgan, L.K., Werner, A.D., Ivkovic, K.M., Carey, H. and Sundaram, B. (2013). A national-scale vulnerability assessment of seawater intrusion: First-order assessment of seawater intrusion for Australian case study sites. Record 2013/19. Geoscience Australia, Canberra, and National Centre for Groundwater Research and Training, Adelaide http://www.ga.gov.au/corporate_data/74959/Rec2013_019.pdf

MRC (2015). Vulnerability report volume 2: Basin-wide climate change impact and vulnerability assessment for wetland dependent livelihoods and eco-services. Mekong River Commission, Vientiane

Mukherjee, A., Sengupta, M.K., Hossain, M.A., Ahamed, S., Das, B., Nayak, B., Lodh, D., Rahman, M.M. and Chakraborti, D. (2006). 'Arsenic contamination in groundwater: a global perspective with emphasis on the Asian scenario'. Journal of Health, Population and Nutrition 24(2), 142-163 http://citeseerx.ist.psu.edu/viewdoc/download;jsessionid=AF82119D6A956EA6BADC7A1FA80F8CD2?doi=10.1.1.161.1323&rep=rep1&type=pdf

Mutiyar, P.K. and Mittal, A.K. (2014). 'Occurrences and fate of selected human antibiotics in influents and effluents of sewage treatment plant and effluent-receiving river Yamuna in Delhi (India)'. Environmental Monitoring and Assessment 186, 541-557. doi: 10.1007/s10006-013-3398-6 http://link.springer.com/article/10.1007/s10661-013-3398-6

Nakata, H., Shinohara, R., Nakazawa, Y., Isobe, T., Sudaryanto, A., Subramanian, A., Tanabe, S., Zakaria, M.P., Zheng, G.J., Lam, P.K. et al. (2012). 'Asia–Pacific mussel watch for emerging pollutants: Distribution of synthetic musks and benzotriazole UV stabilizers in Asian and US coastal waters'. Marine pollution bulletin 64, 2211–2218. doi: 10.1016/j.marpolbu.2012.07.049 http://www.sciencedirect.com/science/article/pii/S0025326X12003700

NCAR (2015). Atmospheric Composition and the Asian Monsoon (ACAM). National Center for Atmospheric Research https://www2.acom.ucar.edu/acam

Newbold, T., Hudson, L.N., Hill, S.L., Contu, S., Lysenko, I., Senior, R.A., Börger, L., Bennett, D.J., Choimes, A. and Collen, B. (2015). 'Global effects of land use on local terrestrial biodiversity'. Nature 520(7545), 45-50. doi: 10.1038/nature14324 http://www.nature.com/nature/journal/v520/n7545/pdf/nature14324.pdf

Nicholls, R.J., Hanson, S., Herweijer, P., C.N., Hallegatte, S., Corfee-Morlot, J., Château, J. and Muir-Wood, R. (2008). Ranking port cities with high exposure and vulnerability to climate extremes: Exposure estimates. OECD Environment Working Papers, No. 1. Organization for Economic Cooperation and Development http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aias076737.pdf

Nilsson, C., Reidy, C.A., Dynesius, M. and Revenga, C. (2005). 'Fragmentation and flow regulation of the world's large river systems'. Science 308(5720), 405-408. doi: 10.1126/science.1107887 http://courses.washington.edu/efuture/NilsonRiversScience2005.pdf

Nkonya, E., Mirzabaev, A. and von Braun, J. (eds.) (2016). Economics of land degradation and improvement: A Global assessment for sustainable development. Springer, Berlin http://link.springer.com/content/pdf/10.1007%2F978-3-319-19168-3.pdf

NOAA (2015). Climate at a glance. National Oceanic and Atmosphere Administration https://www.ncdc.noaa.gov/cag/time-series/global/asia/land/ytd/1/1910-2015

Novotny, V., Wang, X., Englande Jr, A.J., Bedoya, D., Promakasikorn, L. and Tirado, R. (2010). 'Comparative assessment of pollution by the use of industrial agricultural fertilizers in four rapidly developing Asian countries'. Environment, development and sustainability 12(4), 491-509. doi: 10.1007/s10668-009-9207-2

NSWAI (2015). Air Pollution due to improper waste management - Open burning and landfill fires in Mumbai. National Solid Waste Association of India (NSWAI), http://www.nswaienvis.nic.in/Facts_figures/pdf/Air%20Pollution%20due%20to%20Improper%20Waste%20Management-Mumbai.pdf

Nurse, L.A., McLean, R.F., Agard, J., Briguglio, L.P., Duvat-Magnan, V., Pelesikoti, N., Tompkins, E. and Webb, A. (2014). 'Small islands'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects: Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, chapter 29, 1613-1654 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap29_FINAL.pdf

O'neil, J., Davis, T.W., Burford, M.A. and Gobler, C. (2012). 'The rise of harmful cyanobacteria blooms: The potential roles of eutrophication and climate change'. Harmful Algae 14, 313-334 https://www.researchgate.net/profile/Timothy_Davis2/publication/251694423_The_rise_of_harmful_cyanobacteria_blooms_The_potential_roles_of_eutrophication_and_climate_change_Harmful_Algae_Elsevier_BV_14/links/0046352c58cda947bc000000.pdf

Ogata, Y., Takada, H., Mizukawa, K., Hirai, H., Iwasa, S., Endo, S., Mato, Y., Saha, M., Okuda, K. and Nakashima, A. (2009). 'International Pellet Watch: Global monitoring of persistent organic pollutants (POPs) in coastal waters. 1. Initial phase data on PCBs, DDTs, and HCHs'. Marine pollution bulletin 58(10), 1437-1446. doi: 10.1016/j.marpolbul.2009.06.014 http://ac.els-cdn.com/S0025326X09002690/1-s2.0-S0025326X09002690-main.pdf?_tid=52937c36-1682-11e6-9b4b-00000aabof6b&acdnat=1462866146_48dce05e8d56a8ea2819cf6e035e60ff

Olsson, L., Opondo, M., Tschakert, P., Agrawal, A., Eriksen, S.H., S., M., L.N., P. and Zakieldeen, S.A. (2014). 'Livelihoods and poverty'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, chapter 13, 793-832 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap13_FINAL.pdf

Oswell, A.H. (2010). The big cat trade in Myanmar and Thailand. A Traffic Southeast Asia Report. Traffic Southeast Asia Office, Petaling Jaya www.traffic.org/species-reports/traffic_species_mammals61.pdf

Pacific Institute (2010). World water quality facts and statistics. http://www.pacinst.org/wp-content/uploads/sites/21/2013/02/water_quality_facts_and_stats3.pdf (Downloaded: 21 August 2015)

Pariatamby, A. and Tanaka, M. (2014). Municipal solid waste management in Asia and the Pacific Islands: Challenges and Strategic Solutions. Springer-Verlag, Singapore http://link.springer.com/book/10.1007%2F978-981-4451-73-4

Parker, L. (2015). 'Eight million tons of plastic dumped in ocean every year'. National Geographic, 13 February http://news.nationalgeographic.com/news/2015/02/150212-ocean-debris-plastic-garbage-patches-science/

PBL (2015). Trends in global CO2 emissions: 2015 Report. PBL Netherlands Environmental Assessment Agency (PBL), The Hague http://edgar.jrc.ec.europa.eu/news_docs/jrc-2015-trends-in-global-co2-emissions-2015-report-98184.pdf

Pentamwa, P. and Kim Oanh, N.T. (2008). 'Air quality in Southern Thailand during haze episode in relation to air mass trajectory'. Songklanakarin Journal of Science and Technology 30(539-546) http://rdo.psu.ac.th/sjstweb/journal/30-4/0125-3395-30-4-539-546.pdf

Pippard, H. (2009). The Pacific islands: An analysis of the status of species as listed on the 2008 IUCN Red List of Threatened Species. Suva: IUCN http://cmsdata.iucn.org/downloads/the_pacific_islands_an_analysis_of_the_status_of_species_as_listed_on_the_2008_iucn_r.pdf

Pitman, M.G. and Läuchli, A. (2002). 'Global impact of salinity and agricultural ecosystems'. In Salinity: environment-plants-molecules. Springer, chapter 1, 3-20 http://xa.yimg.com/kq/groups/21666630/914623393/name/Ch1-2-salinity+Environ+Plants+Molecules.pdf

Pongpiachan, S., Tipmanee, D., Khumsup, C., Kittikoon, I. and Hirunyatrakul, P. (2015). 'Assessing risks to adults and preschool children posed by PM2.5-bound polycyclic aromatic hydrocarbons (PAHs) during a biomass burning episode in Northern Thailand'. Science of the Total Environment 508, 435-444. doi: http://dx.doi.org/10.1016/j.scitotenv.2014.12.019

Pörtner, H.-O., Karl, D.M., Boyd, P.W., Cheung, W.W.L., Lluch-Cota, S.E., Nojiri, Y., Schmidt, D.N. and Zavialov, P.O. (2014). 'Ocean systems'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Field, C.B., Barros, V.R., Dokken, D.J., K.J. Mach, M.D. Mastrandrea, Bilir, T.E., Chatterjee, M., K.L. Ebi, Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, chapter 6, 411-484 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap6_FINAL.pdf

Qu, J. and Fan, M. (2010). 'The current state of water quality and technology development for water pollution control in China'. Critical Reviews in Environmental Science and Technology 40, 519-560. doi: 10.1080/10643380802451953 http://www.researchgate.net/publication/233288276_The_Current_State_of_Water_Quality_and_Technology_Development_for_Water_Pollution_Control_in_China

Rahman, M.M., Naidu, R. and Bhattacharya, P. (2009). 'Arsenic contamination in groundwater in the Southeast Asia region'. Environmental Geochemistry and Health 31(1), 9-21 http://download.springer.com/static/pdf/633/art%253A10.1007%252Fs10653-008-9233-2.pdf?originUrl=http%3A%2F%2Flink.springer.com%2Farticle%2F10.1007%2Fs10653-008-9233-2&token2=exp=1462868777~acl=%2Fstatic%2Fpdf%2F633%2Fart%25253A10.1007%25252Fs10653-008-9233-2.pdf%3ForiginUrl%3Dhttp%253A%252F%252Flink.springer.com%252Farticle%252F10.1007%252Fs10653-008-9233-2*~hmac=864fe00ad75ead216f1426f50d4b59208068b5459f0b2f39c518e5cac15f905c

Ramsar Convention Secretariat (2010). Wise use of wetlands Handbook 1: Wise use of wetlands. 4th edn. Ramsar Convention Secretariat, Gland http://www.ramsar.org/sites/default/files/documents/library/hbk4-01.pdf

Ramu, K., Kajiwara, N., Sudaryanto, A., Isobe, T., Takahashi, S., Subramanian, A., Ueno, D., Zheng, G.J., Lam, P.K. and Takada, H. (2007). 'Asian mussel watch program: contamination status of polybrominated diphenyl ethers and organochlorines in coastal waters of Asian countries'. Environmental Science & Technology 41(13), 4580-4586 http://tintuc.vnu.edu.vn/upload/scopus/578.pdf

Rashki, A., Kaskaoutis, D.G., Francois, P., Kosmopoulos, P.G. and Legrand, M. (2015). 'Dust-storm dynamics over Sistan region, Iran: Seasonality, transport characteristics and affected areas'. Aeolian Research 16(2015), 35-48 http://www.researchgate.net/publication/268524395_Dust-storm_dynamics_over_Sistan_region_Iran_Seasonality_transport_characteristics_and_affected_areas

Ravindranath, N.H., Joshi, N.V., Sukumar, R. and Saxena, A. (2006). 'Impact of climate change on forest in India'. Current Science 90(3), 354-361 http://www.currentscience.ac.in/Downloads/article_id_090_03_0354_0361_0.pdf

Reading, R.P., Bedunah, D.J. and Amgalanbaatar, S. (2006). 'Conserving biodiversity on Mongolian rangelands: Implications for protected area development and pastoral uses'. In Rangelands of Central Asia: Proceedings of the Conference on Transformations, Issues, and Future Challenges. Bedunah, D.J., McArthur, E.D. and Fernandez-Gimenez, M. (eds.). USDA Forest Service Proceedings RMRS-P-39, Salt Lake City, UT: Rocky Mountain Research Station. , 127 http://www.fs.fed.us/rm/pubs/rmrs_p039/rmrs_p039_001_017.pdf

Reef Base (2014). Global information system for coral reefs: GIS & Maps http://www.reefbase.org/gis_maps/datasets.aspx

Reisinger, A., Kitching, R.L., Chiew, F., Hughes, L., Newton, P.C.D., Schuster, S.S., Tait, A. and P.Whetton (2014). 'Australasia'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects: Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Bilir, T.E., Chatterjee, M., K.L. Ebi, Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, chapter 25, 1371-1438 https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap25_FINAL.pdf

Republic of Indonesia, Ministry of Environment (2014). Indonesia State of Environment Report 2013. https://newberkeley.files.wordpress.com/2014/09/slhi-2013.pdf

Richey, A.S., Thomas, B.F., Lo, M.H., Reager, J.T., Famiglietti, J.S., Voss, K., Swenson, S. and Rodell, M. (2015). 'Quantifying renewable groundwater stress with GRACE'. Water Resources Research 51(7), 5217-5238. doi: 10.1002/2015WR017349 http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1159&context=nasapub

Rodda, G.H. and Savidge, J.A. (2007). 'Biology and Impacts of Pacific Island Invasive Species. 2. Boiga irregularis, the Brown Tree Snake (Reptilia: Colubridae) 1'. Pacific Science 61(3), 307-324. doi: http://dx.doi.org/10.2984/1534-6188(2007)61[307:BAIOPI]2.0.CO;2 http://www.bioone.org/doi/full/10.2984/1534-6188(2007)61%5B307:BAIOPI%5D2.0.CO%3B2

Roy, P., Murthy, M., Roy, A., Kushwaha, S., Singh, S., Jha, C., Behera, M., Joshi, P., Jagannathan, C. and Karnatak, H. (2013). 'Forest fragmentation in India'. Current Science 105(6), 774-780 https://www.researchgate.net/profile/P_Roy/publication/258243283_Forest_fragmentation_in_India/links/02e7e527b2fa541823000000.pdf

Sadoff, C.W., Hall, J.W.l., Grey, D., Aerts, J.C.J.H., Ait-Kadi, M., Brown, C., Cox, A., Dadson, S., Garrick, D., Kelman, J. et al. (2015). Securing Water, Sustaining Growth: Report of the GWP/OECD Task Force on Water Security and Sustainable Growth. University of Oxford, UK http://www.gwp.org/Global/About%20GWP/Publications/The%20Global%20Dialogue/SECURING%20WATER%20SUSTAINING%20GROWTH.PDF

Salafsky, N., Salzer, D., Stattersfield, A.J., Hilton-Taylor, C., Neugarten, R., Butchart, S.H.M., Collen, B., Cox, N., Master, L.L., O'Connor, S. et al. (2008). 'A standard lexicon for biodiversity conservation: Unified classifications of threats and actions'. Conservation Biology 22(2005), 897-911. doi: 10.1111/j.1532-1739.2008.00937.x http://www.ucipfg.com/Repositorio/MGAP/MGAP-10/SEMANA3/StandardLexicon_ClasificationThereatsandActions.pdf

Schandl, H., Fischer-Kowalski, M., Grunbuhel, C. and Krausmann, F. (2009). 'Socio-metabolic transitions in developing Asia'. Technological Forecasting and Social Change 76(2), 267-281 https://www.researchgate.net/profile/Fridolin_Krausmann/publication/222431454_Socio-metabolic_transitions_in_developing_Asia/links/ofcfd50af65ba8533c000000.pdf

Schwartz, M.L. (2005). Encyclopedia of coastal Science Schwartz, M.L. Springer, Netherlands, 1211 http://www.springer.com/us/book/9781402019036

Seppälä, R., Buck, A. and Katila, P. (2009). Adaptation of forests and people to climate change: A global assessment report. IUFRO World Series International Union of Forest Research Organizations (IUFRO), Helsinki http://webdoc.sub.gwdg.de/ebook/serien/yo/IUFRO_WS/ws22.pdf

Shah, A. (2005). Land degradation and migration in a dry land region in India. SANDEE Working Paper No. 10-05. South Asian Network for Development and Environmental Economics (SANDEE) http://opendocs.ids.ac.uk/opendocs/bitstream/handle/123456789/4275/774_PUB_report_wp10.pdf?sequence=1

Shang, Z.H. and Long, R.J. (2005). 'Formation causes and recovery of the 'black soil type' degraded alpine grassland in Qinghai-Tibetan Plateau'. Frontiers of Agriculture in China 1(2), 197-202. doi: 10.1007/s11703-007-0034-7 http://www.cwru.edu/affil/tibet/documents/ShangandLong2007.pdf

Shanmugam, G., Sampath, S., Selvaraj, K.K., Larsson, D.G.J. and Ramaswamy, B.R. (2014). 'Non-steroidal anti-inflammatory drugs in Indian rivers'. Environmental Science and Pollution Research 21, 921-931. doi: 10.1007/s11356-013-1957-6 http://www.ncbi.nlm.nih.gov/pubmed/23832803

Sharma, B., Rasul, G. and Chettri, N. (2015). 'The economic value of wetland ecosystem services: Evidence from the Koshi Tappu Wildlife Reserve, Nepal'. Ecosystem Services 12(2015), 84-93 http://www.sciencedirect.com/science/article/pii/S221204161500025X

Shea, J.M., Immerzeel, W.W., Wagnon, P., Vincent, C. and Bajracharya, S. (2015). 'Modelling glacier change in the Everest region, Nepal Himalaya.'. The Cryosphere 9(3), 1105-1128. doi: 10.5194/tc-9-1105-2015 http://www.the-cryosphere.net/9/1105/2015/tc-9-1105-2015.html

Siciliano, G. (2012). 'Rural-urban migration and domestic land grabbing in China: Drivers, impacts and trade-offs'. Land Deal Politics Initiative, Global Land Grabbing II. Ithaca, NY, 17-19 October 2012. Cornell University https://www.researchgate.net/profile/Giuseppina_Siciliano/publication/259542235_Rural-Urban_Migration_and_Domestic_Land_Grabbing_in_China/links/541bf3fbocf2218008c4d7bd.pdf

Siebert, S., Burke, J., Faures, J.M., Frenken, K., Hoogeveen, J., Döll, P. and Portmann, F.T. (2010). 'Groundwater use for irrigation: A global inventory'. Hydrology and Earth System Sciences 14, 1863-1880 http://www.fao.org/docrep/013/al816e/al816e00.pdf

Sikder, M.T., Kihara, Y., Yasuda, M., Mihara, Y., Tanaka, S., Odgerel, D., Mijiddorj, B., Syawal, S.M., Hosokawa, T. and Saito, T. (2013). 'River water pollution in developed and developing countries: Judge and assessment of physicochemical characteristics and selected dissolved metal concentration'. CLEAN–Soil, Air, Water 41(1), 60-68 http://eprints.lib.hokudai.ac.jp/dspace/bitstream/2115/53992/2/Revised%20Manuscript%20FinalSikder.pdf

Singh, S. (2013). The socio-economic context of illegal logging and trade of rosewood along the Cambodia-Lao border Forest Trends Report Series: Forest Trade and Finance http://www.forest-trends.org/documents/files/doc_4193.pdf

Smith, D.M.S., G.M., M., I.W., W., B.K., H., G.S., S., W.B., H. and S. M., H. (2007). 'Learning from episodes of degradation and recovery in variable Australian rangelands. '. Proceedings of the National Academy of Sciences 104(52), 20690-20695 http://www.pnas.org/content/104/52/20690.full.pdf

SNL (2015). SNL Metals & Mining http://www.snl.com/Sectors/MetalsMining/Default.aspx

Sodhi, N.S., Koh, L.P., Clements, R., Wanger, T.C., Hill, J.K., Hamer, K.C., Clough, Y., Tscharntke, T., Posa, M.R.C. and Lee, T.M. (2010). 'Conserving Southeast Asian forest biodiversity in human-modified landscapes'. Biological Conservation 143(10), 2375-2384 http://laurancelab.org/publications/ruben/Sodhi_et_al_2010%20-%20Conserving%20Southeast%20Asian%20forest%20biodiversity%20in%20human-modified%20landscapes.pdf

Somvanshi, A. (2014). 'Solid wealth'. DownToEarth, 31 August http://www.downtoearth.org.in/content/solid-wealth (Accessed: 31 August 2014)

Spang, N., Feldmann, A., Huesmann, H., Bekbulat, F., Schmitt, V., Hiebel, C., Koziollek-Drechsler, I., Clement, A.M., Moosmann, B. and Jung, J. (2014). 'RAB3GAP1 and RAB3GAP2 modulate basal and rapamycin-induced autophagy'. Autophagy 10(12), 2297-2309. doi: 10.4161/15548627.2014.994359 http://dx.doi.org/10.4161/15548627.2014.994359

Spanu, A., Daga, L., Orlandoni, A.M. and Sanna, G. (2012). 'The role of irrigation techniques in arsenic bioaccumulation in rice (Oryza sativa L.)'. Environmental Science & Technology 46(15), 8333-8340. doi: 10.1021/es300636d http://pubs.acs.org/doi/pdf/10.1021/es300636d

SPC (2013). Deep sea minerals: Summary highlights. Secretariat of the Pacific Community http://gsd.spc.int/dsm/public/files/meetings/TrainingWorkshop4/UNEP_summary.pdf

SPC (2014). Paper 6.2: Strategy for climate and disaster resilient development in the Pacific (SRDP). Forty-Fourth Meeting of the Committee of Representatives of Governments and Administrations, 4–7 November 2014, SPC/CRGA 44 (14) http://www.spc.int/crga/sites/default/files/documents_uploads/CRGA44%20-%206.2%20Strategy%20for%20Climate%20and%20Disaster%20Resilient%20Development%20in%20the%20Pacific%20(SRDP).pdf

SPREP (2012a). Pacific islands regional marine species programme 2013-2017. Secretariat of the Pacific Regional Environment Programme Apia https://www.sprep.org/attachments/Publications/Marine_Species_Programme_2013-2017.pdf

SPREP (2012b). Pacific Environment Climate Change Outlook. SPREP, Apia http://www.unep.org/pdf/PEECO.pdf

SPREP (2014). State of conservation in Oceania: Key findings from a comprehensive regional report on the state of conservation in 22 countries and territories of the Pacific Islands region. Programme, S.o.t.P.R.E. (ed.), Apia http://www.sprep.org/attachments/Publications/BEM/SOCO_Key_Findings.pdf

SPREP (2015). Pacific Islands Protected Area Portal. http://pipap.sprep.org/

STAP (2011). Hypoxia and nutrient reduction in the coastal zone: Advice for prevention, remediation and research A STAP Advisory Document. Global Environment Facility, Washington, D.C. https://www.thegef.org/gef/sites/thegef.org/files/publication/STAP_Hypoxia_low.pdf

Staudinger, M.D., Grimm, N.B., Staudt, A., Carter, S.L., Stuart Chapin III, F., Kareiva, P., Ruckelshaus, M. and Stein, B.A. (2012). Impacts of climate change on biodiversity, ecosystems, and ecosystem services: Technical input to the 2013 National Climate Assessment. Cooperative report to the 2013 National Climate Assessment. United States Global Change Research Program, Washington, D.C. https://downloads.globalchange.gov/nca/technical_inputs/Biodiversity-Ecosystems-and-Ecosystem-Services-Technical-Input.pdf

Sun, Q., Miao, C., Duan, Q. and Wang, Y. (2015). 'Temperature and precipitation changes over the Loess Plateau between 1961 and 2011, based on high-density gauge observations'. Global and Planetary Change 132(2015), 1–10. doi: 10.1016/j.gloplacha.2015.05.011 http://www.sciencedirect.com/science/article/pii/S0921818115001083

Sundarambal, P., Balasubramanian, R., Tkalich, P. and He, J. (2010). 'Impact of biomass burning on ocean water quality in Southeast Asia through atmospheric deposition: field observations'. Atmospheric Chemistry and Physics 10(2010), 11323-11336. doi: 10.5194/acp-10-11323-2010 http://www.atmos-chem-phys.net/10/11323/2010/acp-10-11323-2010.html

Sunderlin, W.D., Hatcher, J. and Liddle, M. (2008). From Exclusion to Ownership? Challenges and opportunities in advancing forest tenure reform. Rights and Resources Initiative, Washington, DC http://www.sinkswatch.org/sites/fern.org/files/media/documents/document_4235_4236.pdf

Takata, K., Saito, K. and Yasunari, T. (2009). 'Changes in the Asian monsoon climate during 1700–1850 induced by preindustrial cultivation'. Proceedings of the National Academy of Sciences 106(24), 9586-9589 http://www.pnas.org/content/106/24/9586.full.pdf

Terry, J.P. and Goff, J.R. (2012). The special vulnerability of Asia–Pacific islands to natural hazards Geological Society, London http://sp.lyellcollection.org/content/361/1/3.full.pdf

Thomas, V., Albert, J.R.G. and Perez, R.T. (2013). Climate-related disasters in Asia and the Pacific. Asian Development Bank Economics Working Paper Series No. 358. Asia Development Bank Manila http://www.adb.org/sites/default/files/publication/30323/ewp-358.pdf

Trisurat, Y., Alkemade, R. and Verburg, P.H. (2010). 'Projecting land-use change and its consequences for biodiversity in Northern Thailand'. Environmental Management 45(3), 626-639. doi: 10.1007/s00267-010-9438-x http://link.springer.com/article/10.1007/s00267-010-9438-x/fulltext.html

Trisurat, Y., Kanchanasaka, B. and Kreft, H. (2015). 'Assessing potential effects of land use and climate change on mammal distributions in northern Thailand'. Wildlife Research 41(6), 522-536 https://www.researchgate.net/profile/Holger_Kreft/publication/273349819_Assessing_potential_effects_of_land_use_and_climate_change_on_mammal_distributions_in_northern_Thailand/links/54ff086cocf2eaf210b4904b.pdf

Uddin, K., Chaudhary, S., Chettri, N., Kotru, R., Murthy, M., Chaudhary, R.P., Ning, W., Shrestha, S.M. and Gautam, S.K. (2015). 'The changing land cover and fragmenting forest on the Roof of the World: A case study in Nepal's Kailash Sacred Landscape'. Landscape and Urban Planning 141(2015), 1-10. doi: 10.1016/j.landurbplan.2015.04.003 http://www.sciencedirect.com/science/article/pii/S0169204615000791

Ueda, S. and Benouahi, M. (2009). 'Accountable Water and Sanitation Governance: Japan's Experience'. In Water in the Arab World: Management Perspectives and Innovations. Jagannathan, N.V., Mohamed, A.S. and Kremer, A. (eds.). World Bank and Middle East and North Africa Region (MNA), Washington, DC, chapter 8, 131-156 http://siteresources.worldbank.org/INTMENA/Resources/Water_Arab_World_full.pdf

Umezawa, Y., Hosono, T., Onodera, S., Siringan, F., Buapeng, S., Delinom, R., Yoshimizu, C., Tayasu, I., Nagata, T. and Taniguchi, M. (2009). 'Erratum to "Sources of nitrate and ammonium contamination in groundwater under developing Asian megacities"'. Science of the Total Environment 407(2009), 3219–3231. doi: 10.1016/j.scitotenv.2009.01.048 http://www.researchgate.net/publication/232380853_Erratum_to_Sources_of_nitrate_and_ammonium_contamination_in_groundwater_under_developing_Asian_megacities

UNCTAD (2014). Review of Maritime Transport. United Nations Conference on Trade and Development, Geneva http://unctad.org/en/PublicationsLibrary/rmt2014_en.pdf

UNDESA (2014). World urbanization prospects: The 2014 revision: Highlights. United Nations Department of Economic and Social Affairs, New York http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

UNDP (2013). Population living on degraded land (%). UNDP Human Development Reports. United Nations Development Programme http://hdr.undp.org/en/content/population-living-degraded-land (Accessed: 18 February 2016)

UNDP (2015). The Millennium Development Goals Report 2015. United Nations, New York http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%20 2015%20rev%20%28July%201%29.pdf

UNEP (2006). Challenges to international waters: Regional assessments in a global perspective. United Nations Environment Programme http://www.unep.org/dewa/giwa/publications/finalreport/giwa_final_report.pdf (Accessed: 24 February 2016)

UNEP (2008). Global glacier changes: Facts and figures. United Nations Environment Programme http://www.grid.unep.ch/glaciers/ (Accessed: 5 September 2015)

UNEP (2011). Resource efficiency: Economics and outlook for Asia and the Pacific. United Nations Environment Programme, Nairobi http://www.unep.org/dewa/Portals/67/pdf/Resource_Efficiency_EOAP_web.pdf

UNEP (2012). Managing post-disaster debris: The Japan experience. United Nations Environment Programme http://postconflict.unep.ch/publications/UNEP_Japan_post-tsunami_debris.pdf

UNEP (2012a). Regional Resource Notebook on Coastal Erosion. United Nations Environment Programme (UNEP), Bangkok, Thailand. http://www.unep.org

UNEP (2013). Global mercury assessment 2013: Sources, emissions, releases and environmental transport. United Nations Environment Programme, Nairobi http://www.unep.org/PDF/PressReleases/GlobalMercuryAssessment2013.pdf

UNEP (2014). 'Wealth in the oceans: Deep sea mining on the horizon?'. UNEP Global Environmental Alert Service, May 2014. United Nations Environment Programme (UNEP) http://www.unep.org/pdf/GEAS_May2014_DeepSeaMining.pdf

UNEP (2015). Sundarbans: Environmental change hotspots. United Nations Environment Programme. http://na.unep.net/atlas/webatlas.php?id=35

UNEP (2015a). Data from greenhouse gases (GHG) emissions. United Nations Environment Programme (UNEP). http://www.uneplive.org/reg/index/AS#data_tab.

UNEP (2016). Status of leaded gasoline phase-out in the Asia-Pacific region January 2016 http://www.unep.org/Transport/new/PCFV/pdf/Maps_Matrices/AP/map/AP_MapLead_January2016.pdf

UNEP (in press). State of biodiversity in Asia and the Pacific: A mid-term review of progress towards the Aichi Biodiversity Targets United Nations Environment Programme, Nairobi http://www.unep.org/delc/Portals/119/regional%20brief%20for%20Asia%20and%20Pacific.pdf

UNEP and ISWA (2015). Global Waste Management Outlook. United Nations Environment Programme, Osaka http://www.unep.org/ietc/Portals/136/Publications/Waste%20Management/GWMO%20report/GWMO%20full%20report.pdf

UNEP-DHI and UNEP (2016). Transboundary river basins: Status and trends. United Nations Environment Programme. http://twap-rivers.org/indicators/

UNEP-WCMC (2014). Protected Planet Report 2014: Tracking progress towards global targets for protected areas. United Nations Environment Programme, Cambridge http://www.unep-wcmc.org/system/dataset_file_fields/files/000/000/289/original/Protected_Planet_Report_2014_01122014_EN_web.pdf?1420549522

UNESCAP (2011). Statistical Yearbook for Asia and the Pacific 2011. http://www.unescap.org/stat/data/syb2011/escap-syb2011.pdf (Accessed: 1 August 2015)

UNESCAP (2013). Building resilience to natural disasters and major economic crises. United Nations Economic and Social Commission for Asia and the Pacific, Bangkok http://www.drrgateway.net/sites/default/files/ThemeStudy2013-full.pdf

UNFCCC (2005). Sixth compilation and synthesis of initial national communications from parties not included in Annex 1 to the Convention. 23rd Session, 28 November to 6 December 2005, FCCC/SBI/2005/18, 25 October 2005 http://unfccc.int/resource/docs/2005/sbi/eng/18.pdf

UN-Habitat (2015). Urbanization and climate change in Small Island Developing States. HS Number: HS/004/15E. UN-HABITAT, Nairobi http://unhabitat.org/books/urbanization-and-climate-change-in-small-island-developing-states/

UN-Habitat and UNESCAP (2015). The state of Asian and Pacific cities 2015: Urban transformations shifting from quantity to quality. UN-Habitat and UNESCAP http://www.unescap.org/sites/default/files/The%20State%20of%20Asian%20and%20Pacific%20Cities%202015.pdf (Accessed: 24 February 2016)

UNU (2015). Sustainability in Asia and the Pacific Online Learning. United Nations University http://onlinelearning.unu.edu./en/api/ (Accessed: 2 December 2015)

UNWTO (2012). 'Special Report: Cruise tourism: Current situation and trends in Asia and the Pacific'. Asia Pacific Newsletter 2012(25), 28-31 http://cf.cdn.unwto.org/sites/all/files/pdf/unwtoapnewsletter25contents.pdf

USGS (2012). Minerals information: Asia and the Pacific. United States Geological Survey http://minerals.usgs.gov/minerals/pubs/country/asia.html

Van Vliet, N., Mertz, O., Heinimann, A., Langanke, T., Pascual, U., Schmook, B., Adams, C., Schmidt-Vogt, D., Messerli, P. and Leisz, S. (2012). 'Trends, drivers and impacts of changes in swidden cultivation in tropical forest-agriculture frontiers: a global assessment'. Global Environmental Change 22(2), 418-429 http://ir.kib.ac.cn/bitstream/151853/17626/2/van%20Vliet-2012-Trends,%20drivers%20and.pdf

Visconti, P., Bakkenes, M., Baisero, D., Brooks, T., Butchart, S.H., Joppa, L., Alkemade, R., Di Marco, M., Santini, L. and Hoffmann, M. (2015). 'Projecting global biodiversity indicators under future development scenarios'. Conservation Letters 9(1), 5-13 http://onlinelibrary.wiley.com/doi/10.1111/conl.12159/pdf

Walter, H. (1985). Vegetation of the earth and ecological systems of the geo-biosphere. http://www.bookmetrix.com/detail/book/b8275517-ff8a-466e-80e3-6f582904199d#citations

Wang, T., Yan, C., Song, X. and Li, S. (2013). 'Landsat images reveal trends in the aeolian desertification in a source area for sand and dust storms in China's Alashan Plateau (1975–2007)'. Land Degradation & Development 24(5), 422-429 http://onlinelibrary.wiley.com/doi/10.1002/ldr.1138/pdf

Waste Atlas (2015). 'Waste Atlas' http://www.atlas.d-waste.com/ (Accessed: 25 September, 2015)

Wetzelhuetter, C. (2013). Groundwater in the coastal zones of Asia-Pacific. Springer, Perth, WA http://www.springer.com/us/book/9789400756472

WHO (2008). 'Key health challenges in the Asia Pacific Region'. In Health in Asia and the Pacific. World Health Organization, chapter 13, 517-529 http://www.wpro.who.int/health_research/documents/dhs_hr_health_in_asia_and_the_pacific_18_chapter_13_key_health_challenges_in_the_asia_pacific_region.pdf (Downloaded: 23 July 2015)

WHO (2012). Global Health Observatory data repository. World Health Organization http://apps.who.int/gho/data/node.main.156?lang=en

WHO (2014a). Public health, environmental and social determinants of health (PHE): Ambient (outdoor) air pollution in cities database 2014. World Health Organization http://www.who.int/phe/health_topics/outdoorair/databases/cities/en/

WHO (2014b). Burden of disease from ambient air pollution for 2012. World Health Organization, Geneva http://www.who.int/phe/health_topics/outdoorair/databases/AAP_BoD_results_March2014.pdf

WHO (2015). Reducing global health risks through mitigation of short-lived climate pollutants: Scoping report for policy-makers. World Health Organization http://apps.who.int/iris/bitstream/10665/189524/1/9789241565080_eng.pdf

WHRC and EDF (2015). Tropical forest carbon in indigenous territories: A global analysis. Woods Hole Research Center https://www.edf.org/sites/default/files/tropical-forest-carbon-in-indigenous-territories-a-global-analysis.pdf

Wilkie, M.L. (2009). 'Whither the forests of Asia and the Pacific?'. The Future of Forestry in Asia and the Pacific: Outlook for 2020, Bangkok, Thailand Leslie, R.N. (ed.). Chiang Mai, Thailand 16–18 October 2007. Food and Agricultural Organization of the United Nations, Bangkok http://www.fao.org/docrep/011/i0627e/i0627e00.htm

Wilson, C. and Tisdell, C. (2015). 'Coastal development, coral reefs and marine life in Asia: Tourism's double-edged sword'. In Handbook of Environmental Economics in Asia. Managi, S. (ed.). Routledge, London, 379-400 http://espace.library.uq.edu.au/view/UQ:353467

Winkel, L., Berg, M., Amini, M., Hug, S.J. and Johnson, C.A. (2008). 'Predicting groundwater arsenic contamination in Southeast Asia from surface parameters'. Nature Geoscience 1(8), 536-542. doi: 10.1038/ngeo254 http://www.nature.com/ngeo/journal/v1/n8/full/ngeo254.html

WMO (2016). WMO Sand and Dust Storm Warning Advisory and Assessment System: The SDS-WAS programme at WMO https://www.wmo.int/pages/prog/arep/wwrp/new/Sand_and_Dust_Storm.html

Wong, P.P. (2013). 'Policy and planning coastal tourism in Southeast Asia'. In Coastal Tourism Development. Dowling, R. and Pforr, C. (eds.). Cognizant Communication Corporation, New York, NY, chapter 7, 103-119 https://www.cognizantcommunication.com/tourism-dynamics-series/coastal-tourism-development

Wong, P.P., Losada, I.J., Gattuso, J.-P., Hinkel, J., Khattabi, A., McInnes, K.L., Saito, Y. and Sallenger, A. (2014). ' Coastal systems and low-lying areas'. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Field, C.B., Barros, V.R., D.J. Dokken, Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., K.L. Ebi, Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press, Cambridge, chapter 5, 361-409 http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap5_FINAL.pdf

Wongthong, P. and Harvey, N. (2014). 'Integrated coastal management and sustainable tourism: A case study of the reef-based SCUBA dive industry from Thailand'. Ocean & Coastal Management 95, 138-146 http://www.sciencedirect.com/science/article/pii/S0964569114000982

WOR (2013). The Future of fish: The Fisheries of the future. World Ocean Review: Living with the Oceans 2. Maribus, Hamburg http://worldoceanreview.com/wp-content/downloads/wor2/WOR2_english.pdf

World Air Quality (2015). World Health Organization: 2014 Air Pollution Ranking. World Health Organization. http://aqicn.org/faq/2015-05-16/world-health-organization-2014-air-pollution-ranking/

World Bank (2011). Introducing energy-efficient clean technologies in the brick sector of Bangladesh. World Bank, Washington, DC https://openknowledge.worldbank.org/bitstream/handle/10986/2797/601550ESW0P1110e00201100ColoroFINAL.pdf

World Bank (2012). Improved sanitation facilities. http://data.worldbank.org/indicator/SH.STA.ACSN/countries?display=default

World Bank (2012a). Acting Today for Tomorrow. Washington D.C. http://www.gfdrr.org/sites/gfdrr.org/files/Acting_Today_for_Tomorrow_June2012.pdf.

World Bank (2013). Water productivity http://data.worldbank.org/indicator/ER.GDP.FWTL.M3.KD (Accessed: 19 August 2015)

World Bank (2015). World development indicators: Agriculture inputs http://wdi.worldbank.org/table/3.2

WRI (2012). Coral reefs of the world classified by threat from local activities. World Resource Institute, Washington, D.C. (http://www.wri.org/resource/coral-reefs-world-classified-threat-local-activities

WRI (2013). Aqueduct country and river basin rankings. World Resources Institute. .http://www.wri.org/applications/maps/aqueduct-country-river-basin-rankings/

WRI (2015). CAIT Climate Data Explorer: Overview. World Resources Institute http://cait.wri.org/

WWAP (2012). The United Nations World Water Development Report 4: Managing water under uncertainty and risk. World Water Assessment Programme. UNESCO, Paris http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/WWDR4%20Volume%201-Managing%20Water%20under%20Uncertainty%20and%20Risk.pdf

WWAP (2015a). The United Nations World Water Development Report 2015: Water for a sustainable world. United Nations World Water Assessment Programme. UNESCO, Paris http://unesdoc.unesco.org/images/0023/002318/231823E.pdf

WWAP (2015b). Facing the challenges: Case studies and indicators: UNESCO's contribution to The United Nations World Water Development Report 2015 United Nations World Water Assessment Programme. UNESCO, Paris http://unesdoc.unesco.org/images/0023/002321/232179E.pdf

WWF (2011). Wild Mekong: New species in 2010 from the forests, wetlands and waters of the Greater Mekong, Asia's land of rivers. World Wide Fund For Nature http://d2ouvy59podg6k.cloudfront.net/downloads/greater_mekong_species_report_web_ready_version_nov_14_2011_1.pdf

WWF (2015). Hidden Himalayas: Asia's wonderland: New species discoveries in the Eastern Himalayas, volume II 2009-2014. World Wide Fund For Nature https://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/WWF_Report_2015_-_New_species_discoveries_in_the_Eastern_Himalayas.pdf

Wyett, K. (2014). 'Escaping a rising tide: Sea level rise and migration in Kiribati'. Asia and the Pacific Policy Studies 1, 171-185 http://onlinelibrary.wiley.com/doi/10.1002/app5.7/epdf

Xiong, Z., Freney, J., Mosier, A., Zhu, Z., Lee, Y. and Yagi, K. (2008). 'Impacts of population growth, changing food preferences and agricultural practices on the nitrogen cycle in East Asia'. Nutrient Cycling in Agroecosystems 80(2), 189-198. doi: 10.1007/s10705-007-9132-4 http://link.springer.com/article/10.1007/s10705-007-9132-4/fulltext.html

Yamamoto, S.S., Phalkeya, R. and Malik, A.A. (2014). 'A systematic review of air pollution as a risk factor for cardiovascular disease in South Asia: Limited evidence from India and Pakistan'. International Journal of Hygiene and Environmental Health 217(2–3), 133–144. doi: 10.1016/j.ijheh.2013.08.003 http://www.sciencedirect.com/science/article/pii/S1438463913001156

Yan, H., Chen, L., Su, L., Tao, J. and Yu, C. (2014). 'SO2 columns over China: Temporal and spatial variations using OMI and GOME-2 observations'. doi: 10.1088/1755-1315/17/1/012027 http://iopscience.iop.org/article/10.1088/1755-1315/17/1/012027/pdf

Zabel, F., Putzenlechner, B. and Mauser, W. (2014). 'Global agricultural land resources–a high resolution suitability evaluation and its perspectives until 2100 under climate change conditions'. PloS one 9(9), e107522. doi: http://dx.doi.org/10.1371/journal.pone.0107522 http://journals.plos.org/plosone/article/asset?id=10.1371%2Fjournal.pone.0107522.PDF

Zhang, Q.Q., Ying, G.G., Pan, C.G., Liu, Y.S. and Zhao, J.L. (2015). 'Comprehensive evaluation of antibiotics emission and fate in the river basins of China: Source analysis, multimedia modeling, and linkage to bacterial resistance'. Environmental Science & Technology 49(11), 6772-6782 doi: 10.1021/acs.est5b00729 http://pubs.acs.org/doi/abs/10.1021/acs.est.5b00729

Chapter 3

ADB (2012). The Greater Mekong Subregion at 20: Progress and prospects. Asian Development Bank (ADB), Manila, Philippines http://adb.org/sites/default/files/pub/2012/gms-20-yrs-progress-prospects.pdf

ADB (2015). Greater Mekong Subregion Core Environment Program. Asian Development Bank (ADB), Manila http://www.gms-eoc.org/the-program (Accessed: 24 November 2015)

ADB and APWF (2013). Asian Water Development Outlook 2013: Measuring water security in Asia and the Pacific. Asian Development Bank and Asia Pacific Water Forum Manila http://www.adb.org/sites/default/files/publication/30190/asian-water-development-outlook-2013.pdf

Andersen, S.O., Sarma, K.M. and Taddonio, K.N. (2012). Technology transfer for the ozone layer: Lessons for climate change. Routledge http://www.theozonehole.com/technology.htm

ANMC (2011). Best practice of ANMC21 member cities http://www.seisakukikaku.metro.tokyo.jp/gaimubu/anmc21/anmc21org/english/bestpractice/Manila3.html (Accessed: 22 September 2015)

Aoki-Suzuki, C. (2016). 'Exploring potential policy motivation and approaches to improve resource efficiency in emerging Asia'. Journal of Material Cycles and Waste Management 18(1), 57-71 http://link.springer.com/article/10.1007/s10163-015-0432-5

Bahn-Walkowiak, B., Bleischwitz, R., Bringezu, S., Bunse, M., Herrndorf, M., Irrek, W. and Machiba, T. (2008). Resource Efficiency: Japan and Europe at the forefront: Synopsis of the project and conference results and outlook on Japanese-German cooperation. Federal Environment Agency, Wuppertal Institute for Climate, Environment, Energy, UNEP/Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production (CSCP), Berlin http://www.scp-centre.org/fileadmin/content/files/4_projects/33_Resource_productivity_in_Japan/RessEfficiency_Japan.pdf (Accessed: November 2015)

Bhutan, Ministry of Health (2012). National Health Policy. http://www.gnhc.gov.bt/wp-content/uploads/2012/04/nationalHpolicy.pdf (Accessed: 1st August, 2015)

BOBLME (2015). Bay of Bengal Large Marine Ecosystem (BOBLME) Project. http://www.boblmeindia.org/index.htm (Accessed: 11th November, 2015)

Brander, L.M., Wagtendonk, A.J., Hussain, S.S., McVittie, A., Verburg, P.H., de Groot, R.S. and van der Ploeg, S. (2012). 'Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application'. Ecosystem Services 1(1), 62-69 http://ac.els-cdn.com/S2212041612000046/1-s2.0-S2212041612000046-main.pdf?_tid=7f16bafa-1800-11e6-9d92-00000aacb360&acdnat=1463030289_cab96f8551d4ba38309da7ad29f71bf0

Cambodia, Ministry of Environment (2006). National Adaptation Programme Of Action To Climate Change (NAPA): Endorsed by the Council of Ministers in its Meeting on 20 October 2006 Ministry of Environment, Kingdom of Cambodia http://www.undp-alm.org/resources/assessments-and-background-documents/cambodia-national-adaptation-programme-action-napa (Accessed: 22nd July, 2015)

Dey, D. (2010). Conserving wetlands through microfinance programs, India: [A TEEB Case Study]. Convention on Biological Diversity https://www.cbd.int/financial/privatesector/india-privatemicro.pdf (Accessed: 7th August, 2015)

Elder, M. and Zusman, E. Cooperation on climate and air pollution in East Asia. 16th IUAPPA World Clean Air Congress. Cape Town, South Africa, September 29 – October 4 2013 Institute for Global Environmental Strategies

Funge-Smith, S., Briggs, M. and Miao, W. (2012). Regional overview of fisheries and aquaculture in Asia and the Pacific 2012. RAP Publication 2012/26. Asia-Pacific Fishery Commission and Food and Agriculture Organization of the United Nations Bangkok http://www.fao.org/docrep/017/i3185e/i3185e00.pdf

Hobbs, P., Gupta, R. and Meisner, C. (2006). Conservation agriculture and its applications in South Asia. http://www.betuco.be/CA/Conservation%20Agriculture%20-%20Its%20Applications%20in%20South%20Asia.pdf

Hsu, A. and Zomer, A. (2015). 'Four hurdles to getting data and science into the SDGs: Rigorous integration will ensure the goals inspire rather than deter commitment'. Scidev.net, http://www.scidev.net/global/data/opinion/four-hurdles-data-science-sdgs.html

ICAP (2015). Emissions trading worldwide: International Carbon Action Partnership (ICAP): Status report 2015 International Carbon Action Partnership hthttps://icapcarbonaction.com/images/StatusReport2015/ICAP_Report_2015_02_10_online_version.pdf

IEA (2015). Energy and climate change: World energy outlook special report. International Energy Agency https://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf

IGES (2012). Greening integration in Asia: How regional integration can benefit people and the environment. IGES White Paper V. Institute for Global Environmental Strategies (IGES) http://www.indiaenvironmentportal.org.in/files/file/Greening%20Integration%20in%20Asia.pdf

India, Ministry of Environment and Forests and Climate Change (2008). Implementation Of Montreal Protocol In India. http://www.ozonecell.com/uploads/files/1293002878196-Presentation-Dir_(O)25.11.2010.ppt (Accessed: 30 July 2015)

India, Ministry of Finance (2015). Budget 2016-2017. India Ministry of Finance http://indiabudget.nic.in/ub2016-17/bs/bs.pdf (Accessed: 22nd July, 2015)

India, Ministry of New and Renewable Energy (2015). Renewable energy in India: Growth and targets. Ministry of New and Renewable Energy (MNRE), India http://cseindia.org/docs/photogallery/ifs/Renewable%20Energy%20in%20India%20Growth%20and%20Targets.pdf (Accessed: 10th July, 2015)

India, Ministry of Agriculture and Farmers Welfare (2015). The World of organic agriculture in India. National Project on Organic Farming http://ncof.dacnet.nic.in/OrganicFarming-AnOverview/TheWorldofOrganicAgricultureinIndia%202010.pdf (Accessed: 10 September 2015)

IUCN (2015). The IUCN Red List of Threatened Species. International Union for Conservation of Nature http://www.iucnredlist.org/details/22823/0

JMP (2015). Joint Monitoring Programme for water supply and sanitation. WHO and UNICEF. http://www.wssinfo.org/ (Accessed: 30 September 2015)

Mekong River Commission (2015). Climate Change and Adaptation Initiative. http://www.mrcmekong.org/about-mrc/programmes/climate-change-and-adaptation-initiative/

Middleton, C. and Dore, J. (2015). 'Transboundary Water and Electricity Governance in mainland Southeast Asia: Linkages, Disjunctures and Implications'. International Journal of Water Governance (Special Issue) 3(1), 93-120 https://www.researchgate.net/publication/279523936_Transboundary_water_and_electricity_governance_in_mainland_South_East_Asia_linkages_disjunctures_and_implications

Nachmany, M., Fankhauser, S., Davidová, J., Kingsmill, N., Landesman, T., Roppongi, H., Schleifer, P., Setzer, J., Sharman, A., Singleton, C.S. et al. (2015). 'Climate Change Legislation in Maldives: An excerpt from the 2015 global climate legislation studay a review of climate change legislation in 99 countries'. In The 2015 Global Climate Legislation Study - A Review of Climate Change Legislation in 99 Countries, 7 http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2015/05/MALDIVES.pdf (Downloaded: 22nd September, 2015)

O'Connor, D. and Ford, J. (2014). 'Increasing the Effectiveness of the "Great Green Wall" as an Adaptation to the Effects of Climate Change and Desertification in the Sahel'. Sustainability 6(10), 7142-7154. doi: 10.3390/su6107142 http://www.mdpi.com/2071-1050/6/10/7142/htm

Philippine, Department of Health (2010). Philippine National Environmental Health Action Plan 2010-2013. Department of Health, Republic of the Philippines http://www.wpro.who.int/philippines/areas/environmental_health/philippine_nehap_2010-2013_07.07.10.pdf (Accessed: 24 August, 2015)

Singapore, National Environmental Agency (2015). Control of ozone depleting substances http://www.nea.gov.sg/anti-pollution-radiation-protection/chemical-safety/multilateral-environmental-agreements/ozone-depleting-substances (Accessed: 1st August 2015

SPREP (2012). Pacific Islands meteorological strategy 2012-2021: Sustaining weather and climate services in Pacific Islands countries and territories. Secretariat of the Pacific Regional Environmental Programme Apia https://portals.iucn.org/library/sites/library/files/documents/Atm-Cl-107.pdf

TivayanondMongkhonvanit, Prapaporn Hanvoravongchai and Piya Hanvoravongchai 2016, "The Impacts of Universalization: A Case Study on Thailand's Social Protection and Universal Health Coverage", in Towards Universal Health Care in Emerging Economies: Opportunities and Challenges,edited by Ilcheong Yi. Basingstoke: Palgrave Macmillan and United Nations Research Institute for Social Development

UN (2015). The Millennium Development Goals Report 2015. United Nations New York http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20%28July%201%29.pdf

UNDESA (no date). Millennium Development Goals indicators. United Nations Department of Economic and Social Affairs. http://mdgs.un.org/unsd/mdg/Data.aspx (Accessed: 15 December 2015)

UNDG (2010). Thematic paper on MDG 7: Environmental sustainability. United Nations Development Group http://www.climatechange.gov.bd/sites/default/files/ThematicPaperMDG%207.pdf

UNDP (2012a). MDGs success stories from Asia and the Pacific: Accelerating achievement of the MDGs The UN High-Level Plenary Meeting on the Millennium Development Goals. United Nations Development Programme http://endpoverty2015.org/wp-content/uploads/2012/06/MDG-Success-Stories-AP_web.pdf (Accessed: 12 July 2015)

UNDP (2012b). Faces of the MDGs volume 1: Anthology of city stories as replication guides. United Nations Development Programme http://www.ombudsman.gov.ph/UNDP4/wp-content/uploads/2013/07/Faces-Vol-1.pdf

UNDP (2013). Towards food and nutrition security in Bangladesh: Policy and investment frameworks for coordinating and monitoring actions. Case Study Brief Series No. 5 http://www.asia-pacific.undp.org/content/dam/rbap/docs/Research%20&%20Publications/poverty/RBAP-PR-2013-MDG1-RTWG-Case5.pdf (Accessed: 5th August, 2015)

UNEP (2011). Payment for forest ecosystem services (PFES): Pilot implementation in Lam Dong Province, Vietnam. United Nations Environment Programme http://www.un.org/waterforlifedecade/green_economy_2011/pdf/biodiversity_protection_cases_vietnam.pdf (Accessed: 30th July, 2015)

UNEP (2012). Status report on the application of integrated approaches to water resources management. United Nations Environment Programme http://www.un.org/waterforlifedecade/pdf/un_water_status_report_2012.pdf

UNEP (2013). Recent trends in material flows and resource productivity in Asia and the Pacific. United Nations Environment Programme, Nairobi http://www.unep.org/pdf/RecentTrendsAP(FinalFeb2013).pdf

UNEP (2015). Environment and health Linkages in Asia Pacific: Discussion document for Session 4. First Forum of Ministers and Environment Authorities of Asia Pacific. Bangkok, 19-20 May 2015 http://www.unep.org/roap/Portals/96/Ministerial%20Forum%20Agenda/Environment%20and%20Health%20Linkages%20in%20Asia%20Pacific_FINAL.pdf

UNESCAP, ADB and UNDP (2015). Making it happen: Technology, finance and statistics for sustainable development in Asia and the Pacific Asia-Pacific Regional MDGs Report 2014/15 http://www.unescap.org/sites/default/files/150612%20UNESCAP%20making%20IT%20happen%20report.pdf

UNFCCC (2014). INDCs as communicated by parties. United Nations Framework Convention on Climate Change http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx

UNISDR (2013). The Hyogo Framework for Action in Asia and the Pacific Regional Synthesis Report 2011-2013. UNISDR, Geneva

UNISDR (2014). UNISDR Annual Report 2014. The United Nations Office for Disaster Risk Reduction (UNISDR), Geneva http://www.unisdr.org/files/42667_unisdrannualreport2014.pdf

UNISDR (2015). Sendai Framework for Disaster Risk Reduction 2015-2030. http://www.cma.gov.cn/en2014/20150311/20151010/2015101002/201510/P020151012525690375817.pdf

UN-REDD (2011). UN-REDD Lessons Learned: Asia-Pacific. The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries Geneva http://theredddesk.org/sites/default/files/resources/pdf/2012/1110-unredd-cop17-espagnol-web2_1.pdf

USAID (2012). Disaster risk reduction: East Asia and The Pacific. https://dec.usaid.gov/dec/content/GetDoc.axd?ctID=ODVhZjk4NWQtM2YyMi00YjRmLTkxNjktZTcxMjM2NDBmY2Uy&rID=MzMxMzQ3&pID=NTYw&attchmnt=VHJ1ZQ==&rdp=ZmFsc2U (Accessed: 18 July 2015)

USAID (2015). Improving forest management in Lam Dong. [Infographic]. http://www.leafasia.org/library/infographic-improving-forest-management-lam-dong

Vainerere, T. (2010). Fiji achieve universal primary education http://www.spc.int/ppapd/index.php?option=com_content&task=view&id=724 (Accessed: 8th July 2015)

Wang, X., Zhang, C., Hasi, E. and Dong, Z. (2010). 'Has the Three Norths Forest Shelterbelt Program solved the desertification and dust storm problems in arid and semiarid China?'. Journal of Arid Environments 74(1), 13-22. doi: 10.1016/j.jaridenv.2009.08.001 http://www.cabdirect.org/abstracts/20103009703.html;jsessionid=02502C3F42F6514FC4D4240045ADC90F

WHO (2013). Malaysia health system review. Health Systems in Transition Vol. 3 No. 1. World Health Organization (WHO), Geneva http://www.wpro.who.int/asia_pacific_observatory/hits/series/Malaysia_Health_Systems_Review2013.pdf (Accessed: 21st September, 2015)

WHO (2014). The Lao People's Democratic Republic health system review. Health Systems in Transition Vol. 4 No.1. World Health Organization, Geneva http://www.wpro.who.int/asia_pacific_observatory/hits/series/Lao_Health_System_Review.pdf (Accessed: 24th September, 2015)

World Bank (2009). Mid-term evaluation of China's 11th 5 year plan. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2009/03/10/000334955_20090310064851/Rendered/PDF/476960ESW0Whit1Plan1mainoreportoeng.pdf

WWAP (2012). The United Nations World Water Development Report 4: Managing water under uncertainty and risk. World Water Assessment Programme, Paris http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/pdf/WWDR4%20Volume%201-Managing%20Water%20under%20Uncertainty%20and%20Risk.pdf

WWF (2015). Heart of Borneo http://wwf.panda.org/what_we_do/where_we_work/borneo_forests

Zhang, T. (2015). A Conflict-sensitive approach to climate change mitigation and adaptation in the urbanizing Asia Pacific. The Hague Insitute for Global Justice Working Paper 7. The Hague Insitute for Global Justice, Hague http://www.thehagueinstituteforglobaljustice.org/wp-content/uploads/2015/10/Working-Paper-7-Climate-Change-in-Urbanizing_Asia-Pacific.pdf

Chapter 4

AASA (2012). Towards a sustainable Asia: Environment and Climate Change. Jia, G., Fu, C., Zhou, Y. and Li, X. (eds.). The Association of Academies of Sciences in Asia (AASA), Berlin http://link.springer.com/book/10.1007/978-3-642-16672-3/page/1

ACP (2014). Bringing development and climate together in Asia. Asian Co-Benefits Partnership White Paper 2014. Ministry of Environment of Japan, Tokyo http://pub.iges.or.jp/modules/envirolib/view.php?docid=5082 (Accessed: 17 September 2015)

ADB (2011). ASIA 2050: Realizing the Asian century: Executive summary. http://adb.org/sites/default/files/asia2050-executive-summary.pdf (Accessed: 10 August 2015)

ADB (2014). Asian Development Outlook 2014: Fiscal policy for inclusive growth. ADO. Asian Development Bank http://adb.org/sites/default/files/pub/2014/ado-2014.pdf

AFP News (2012). 'Asia 'megacities' face disaster timebomb'. AFP News, 15 August https://sg.news.yahoo.com/asia-megacities-face-disaster-time-bomb-003759377.html

Alcántara-Ayala, I., Altan, O., Baker, D., Briceño, S., Cutter, S., Gupta, H., Holloway, A., Ismail-Zadeh, A., Díaz, V.J., Johnston, D. et al. (2015). Disaster risks research and assessment to promote risk reduction and management, ICSU-ISSC Ad-Hoc Group on Disaster Risk Assessment. Ismail-Zadeh, A. and Cutter, S. (eds.). International Council for Science and International Social Science Council http://www.icsu.org/science-for-policy/disaster-risk/documents/DRRsynthesisPaper_2015.pdf

APAN (2015). Adaptation Technology Database. http://www.apan-gan.net/adaptation-technologies/database

APEC (2014). APEC Summit Declaration. Asia-Pacific Economic Cooperation http://www.apec-china.org.cn/en/

APEC (2015). APEC Energy Overview 2014. Asia-Pacific Economic Cooperation, Tokyo http://aperc.ieej.or.jp/file/2015/6/19/APEC_Energy_Overview_2014.pdf

Blue & green tomorrow (2014). 'Pacific island Kiribati buys land in Fiji to escape climate change'. Blue&Green Tomorrow, 1 July http://blueandgreentomorrow.com/2014/07/01/pacific-island-kiribati-buys-land-in-fiji-to-escape-climate-change (Accessed: 1st July 2014)

Boos, D., Broecker, H., Dorr, T. and Sharma, S. (2014). How are INDCs and NAMAs linked?: A discussion paper on the links between INDCs, NAMAs and LEDS by the GIZ TUEWAS NAMA Working Group in collaboration with the UNEP DTU Partnership: First draft for consultation. Deutsche Gesellschaft fur International Zusammenarbeit (GTZ) GmbH and UNEP DTU Partnership http://www.igep.in/live/hrdpmp/hrdpmaster/igep/content/e54413/e54441/e61720/NAMAINDCPublication.pdf

Cheam, J. (2015). 'The rise of the circular economy in Asia'. Eco-Business, 10 March http://www.eco-business.com/news/rise-circular-economy-asia

Creutzig, F., Baiocchi, G., Bierkandt, R., Pichler, P.-P. and Seto, K.C. (2015). 'Global typology of urban energy use and potentials for an urbanization mitigation wedge'. Proceedings of the National Academy of Sciences 112(20), 6283-6288. doi: 10.1073/pnas.1315545112 http://www.pnas.org/content/112/20/6283.full.pdf

Dangerman, A.J. and Schellnhuber, H.J. (2013). 'Energy systems transformation'. Proceedings of the National Academy of Sciences 110(7), E549-E558. doi: 10.1073/pnas.1219791110 http://sciences.blogs.liberation.fr/files/r%C3%A9sistance-de-l%C3%A9nergie-carbone-1.pdf

De Oliveira, J.A.P., Doll, C.N.H. and Suwa, A. (2013). Urban development with climate co-benefits: Aligning climate, environmental and other development goals in cities. United Nations University Institute for Advanced (UNU-IAS), Yokohama http://archive.ias.unu.edu/resource_centre/urban_development_with_climate_cobenefits-e.pdf (Accessed: 17 September 2015)

Gallopin, G.C. (2012). Global water futures 2050: Five stylized scenarios. United Nations World Water Assessment Programme (WWAP) and United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris http://unesdoc.unesco.org/images/0021/002153/215380e.pdf (Accessed: 20 August 2015)

Georgescu, M., Morefield, P.E., Bierwagen, B.G. and Weaver, C.P. (2014). 'Urban adaptation can roll back warming of emerging megapolitan regions'. Proceedings of the National Academy of Sciences 111(8), 2909-2914. doi: 10.1073/pnas.1322280111 http://www.pnas.org/content/111/8/2909.full.pdf

Guan, D., Klasen, S., Hubacek, K., Feng, K., Liu, Z., He, K., Geng, Y. and Zhang, Q. (2014). 'Determinants of stagnating carbon intensity in China'. Nature Climate Change 4(11), 1017-1023 http://www.indiaenvironmentportal.org.in/files/file/carbon%20intensity%20in%20China.pdf

Hertwich, E.G., Gibon, T., Bouman, E.A., Arvesen, A., Suh, S., Heath, G.A., Bergesen, J.D., Ramirez, A., Vega, M.I. and Shi, L. (2015). 'Integrated life-cycle assessment of electricity-supply scenarios confirms global environmental benefit of low-carbon technologies'. Proceedings of the National Academy of Sciences 112(20), 6277-6282. doi: 10.1073/pnas.1312753111 http://www.pnas.org/content/112/20/6277.full.pdf

ICLEI (2015). carbonn® Climate Registry: 5 Year Overview Report (2010 - 2015). ICLEI – Local Governments for Sustainability, Bonn http://e-lib.iclei.org/wp-content/uploads/2015/12/cCR2015_5Year_Report.pdf

IDSA (2010). 12th Asian Security Conference on "Asian Strategic Futures 2030 : Trends, Scenarios and Alternatives". Institute for Defence Studies and Analyses http://www.idsa.in/event/12thAsianSecurityConference

IEA (2015). Energy and Climate Change: World Energy Outlook Special Report. International Energy Agency, Paris https://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf

IISD (2014). Financing the Sustainable Development Goals through fossil-fuel subsidy reform: Opportunities in Southeast Asia, India and China International Institute for Sustainable Development Working Paper. International Institute for Sustainable Development Winnipeg http://www.iisd.org/gsi/sites/default/files/financing-sdgs-fossil-fuel-subsidy-reform-southeast-asian-india-china(6).pdf (Accessed: 17 September 2015)

IPCC (2013). Climate Change 2013: The physical science basis: Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M.M.B., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V. and Midgley, P.M. (eds.). Cambridge University Press, Cambridge and New York, NY http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf

IPCC (2014a). Climate change 2014: Synthesis report: Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Pachauri, R.K. and Meyer, L.A. (eds.). Intergovernmental Panel on Climate Change, Geneva https://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf

IPCC (2014b). Climate Change 2014: Impacts, adaptation, and vulnerability Part A: Global and sectoral aspects: Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C. et al. (eds.). Cambridge University Press Cambridge https://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-PartA_FINAL.pdf

Japan, NIES (2012). AIM/CGE [basic] manual. National Institute for Environmental Studies (NIES), Japan http://www.nies.go.jp/social/dp/pdf/2012-01.pdf (Accessed: 15 May 2012)

Japan, NIES (2013). AIM/Enduse Manual. Japan National Institute for Environmental Studies (NIES) http://www.nies.go.jp/media_kit/16.AIM/Enduse/manual.html (Accessed: 5 February 2013)

Japan, NIES (2014a). 2050 Low-carbon society scenarios (LCSs): Asia scenario. Japan, National Institute for Environmental Studies (NIES) http://2050.nies.go.jp/LCS/eng/asia.html (Accessed: 29 October 2014)

Japan, NIES (2014b). Low-carbon society scenarios towards 2050. Japan, National Institute for Environmental Studies (NIES) http://2050.nies.go.jp/index.html (Accessed: 26 November 2014)

Jia, G., Xu, R., Hu, Y. and He, Y. (2015). 'Multi-scale remote sensing estimates of urban fractions and road widths for regional models'. Climatic Change 129(3-4), 543-554. doi: 10.1007/s10584-014-1114-3 http://link.springer.com/article/10.1007/s10584-014-1114-3

Jolly, W.M., Cochrane, M.A., Freeborn, P.H., Holden, Z.A., Brown, T.J., Williamson, G.J. and Bowman, D.M. (2015). 'Climate-induced variations in global wildfire danger from 1979 to 2013'. Nature communications 6(7537), 1-11. doi: 10.1038/ncomms8537 http://www.nature.com/ncomms/2015/150714/ncomms8537/pdf/ncomms8537.pdf

Keener, V.W., Marra, J.J., Finucane, M.L., Spooner, D. and Smith, M.H. (2013). Climate change and Pacific Islands: Indicators and impacts: Case studies from the 2012 Pacific Islands Regional Climate Assessment (PIRCA). Island press http://scholarspace.manoa.hawaii.edu/bitstream/handle/10125/26955/PIRCA-FINAL_Case-Studies.pdf?sequence=1

Kelly, R., Chipman, M.L., Higuera, P.E., Stefanova, I., Brubaker, L.B. and Hu, F.S. (2013). 'Recent burning of boreal forests exceeds fire regime limits of the past 10,000 years'. Proceedings of the National Academy of Sciences 110(32), 13055-13060. doi: 10.1073/pnas.1305069110 http://www.pnas.org/content/110/32/13055.full.pdf

Kenichi, K. (2014). The Relative significance of economic partnership agreements in Asia-Pacific. RIETI Discussion Paper Series 14-E-009. The Research Institute of Economy, Trade and Industry (RIETI) http://www.rieti.go.jp/jp/publications/dp/14e009.pdf

Kennedy, C., Ibrahim, N. and Hoornweg, D. (2014). 'Low-carbon infrastructure strategies for cities'. Nature Climate Change 4(5), 343-346. doi: 10.1038/nclimate2160 http://www.nature.com/nclimate/journal/v4/n5/full/nclimate2160.html

Kerschner, E.M. and Huq, N. (2011). 'Asian affluence: The Emerging 21st century middle class'. Thematic Investing, June 2011. Morgan Stanley Smith Barney http://www.morganstanleyfa.com/public/projectfiles/35257b34-b160-45e4-980d-8bca327db92b.pdf

Kindermann, G., Obersteiner, M., Sohngen, B., Sathaye, J., Andrasko, K., Rametsteiner, E., Schlamadinger, B., Wunder, S. and Beach, R. (2008). 'Global cost estimates of reducing carbon emissions through avoided deforestation'. Proceedings of the National Academy of Sciences 105(30), 10302-10307. doi: 10.1073/pnas.0710616105 http://www.pnas.org/content/105/30/10302.full.pdf

Kohli, H.S., Karma, A. and Sood, A. (2011). Asia 2050: Realizing the Asian Century. Asian Development Bank Manila http://www.iopsweb.org/researchandworking-papers/48263622.pdf

Kojima, M. and Michida, E. (eds.) (2013). International trade in recyclable and hazardous waste in Asia. Edward Elgar Publishing, Cheltenham http://www.elgaronline.com/view/9781782547853.xml

Kossin, J.P., Emanuel, K.A. and Vecchi, G.A. (2014). 'The poleward migration of the location of tropical cyclone maximum intensity'. Nature 509(7500), 349–352. doi: http://dx.doi.org/10.1038/nature13278 http://hdl.handle.net/1721.1/91576

Lambin, E.F. and Meyfroidt, P. (2011). 'Global land use change, economic globalization, and the looming land scarcity'. Proceedings of the National Academy of Sciences 108(9), 3465-3472. doi: 10.1073/pnas.1100480108 http://www.pnas.org/content/108/9/3465.full.pdf

Lehmann, J., Coumou, D. and Frieler, K. (2015). 'Increased record-breaking precipitation events under global warming'. Climatic Change 132(4), 501-515 http://link.springer.com/article/10.1007/s10584-015-1434-y/fulltext.html

Lindfield, M. and Steinberg, F. (2012). Green Cities. Urban Development Series. Asian Development Bank Manila http://www.adb.org/sites/default/files/publication/30059/green-cities.pdf (Accessed: 18 August 2015)

Mahbubani, K. (2012). 'The global village has arrived'. Finance and Development, 49, 3. International Monetary Fund http://www.imf.org/external/pubs/ft/fandd/2012/09/mahbuban.htm (Accessed: September 2012)

Marlier, M.E., DeFries, R.S., Voulgarakis, A., Kinney, P.L., Randerson, J.T., Shindell, D.T., Chen, Y. and Faluvegi, G. (2013). 'El Nino and health risks from landscape fire emissions in Southeast Asia'. Nature Climate Change 3(2), 131-136. doi: 10.1038/nclimate1658 http://www.nature.com/nclimate/journal/v3/n2/full/nclimate1658.htm

McDonald, R.I., Green, P., Balk, D., Fekete, B.M., Revenga, C., Todd, M. and Montgomery, M. (2011). 'Urban growth, climate change, and freshwater availability'. Proceedings of the National Academy of Sciences 108(15), 6312-6317. doi: 10.1073/pnas.1011615108 http://www.pnas.org/content/108/15/6312.full.pdf

NASA (2013). Always something brewing year 'Round on NASA's Hurricane Web Page: Map of the cumulative tracks of all tropical cyclones during the 1985-2005 time period http://www.nasa.gov/mission_pages/hurricanes/features/hurricane_brew.html#.VuY_ePl97IW

OECD (2012). OECD Environmental Outlook to 2050: The Consequences of inaction. Organisation for Economic Co-operation and Development http://www.oecd-ilibrary.org/docserver/download/9712011e.pdf?expires=1463045359&id=id&accname=ocid195767&checksum=D738D5E2144AC12056F1E7EC3809BC93

Pacific RISA (2012). PIRCA http://www.pacificrisa.org/projects/pirca

PCCSP (2015). The Pacific Climate Change Science Program. Pacific Climate Change Science http://www.pacificclimatechangescience.orgReardon, T., Timmer, C.P. and Minten, B. (2012). 'Supermarket revolution in Asia and emerging development strategies to include small farmers'. Proceedings of the National Academy of Sciences 109(31), 12332-12337. doi: 10.1073/pnas.1003160108 http://www.pnas.org/content/109/31/12332.full.pdf

Seto, K.C., Güneralp, B. and Hutyra, L.R. (2012). 'Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools'. Proceedings of the National Academy of Sciences 109(40), 16083-16088. doi: 10.1073/pnas.1211658109 http://www.pnas.org/content/109/40/16083.full.pdf

SPC Geoscience (2015). Strategy for climate and disaster resilient development in the Pacific (SRDP): Draft: 18 June 2015 (Version 17). Secretariat of the Pacific Community http://www.pacificdisaster.net/dox/SRDP.pdf (Accessed: 10 August 2015)

Strutt, A. and Nelgen, S. (2013). 'Food security scenarios for the Asia-Pacific: Inter-sectoral and Inter-economy Perspectives'. Presentation at the 2013 Meeting Food Security Goals with Good Policy Regional Dialogue. Medan, Indonesia, 26-27 June 2013. University of Waikato and University of Adelaide http://www.adelaide.edu.au/global-food/documents/medan-presentation-strutt.pdf

Surie, M.D. (2015). 'South Asia's water crisis: A Problem of scarcity amid abundance'. In Asia: Weekly Insights and Analysis, 25 March 2015. The Asia Foundation http://asiafoundation.org/in-asia/2015/03/25/south-asias-water-crisis-a-problem-of-scarcity-amid-abundance

Swaine, M.D., Mochizuki, M., Brown, M.L., Giarra, P.S., Paal, D.H., Odell, R.E., Lu, R., Palmer, O. and Ren, X. (2013). China's military & the US-Japan alliance in 2030: A Strategic net assessment. Carnegie Endowment for International Peace Washington, DC http://carnegieendowment.org/files/net_assessment_full.pdf

SWITCH-Asia (2015). Implementing industrial symbiosis and environmental management systems in Tianjin Binhai New Area http://www.switch-asia.eu/projects/industrial-symbiosis/

The Global Commission on the Economy and Climate (2015). Seizing the global opportunity: Partnerships for better growth and a better climate: The 2015 new climate economy report. The New Climate Economy http://www.unep.org/ccac/Publications/Publications/tabid/130293/Default.aspx (Accessed: 17 September 2015)

UNDESA (2015). SIDS Accelerated Modalities of Action [S.A.M.O.A.] Pathway. United Nations Department of Economic and Social Affairs http://www.sids2014.org/index.php?menu=1537

UNDP (2010). How-to Guide: Low-emission development strategies and nationally appropriate mitigation actions: Eastern Europe and CIS. United Nations Development Programme (UNDP), New York https://sustainabledevelopment.un.org/content/documents/956041_How%20to%20guide-%20low%20emission%20development%20strategies.pdf

UNEP (2015a). 'Environment outlook and pathways for Asia Pacific: Discussion document for Session 3'. First Forum of Ministers and Environment Authorities of Asia Pacific Bangkok. United Nations Environment Programme http://www.unep.org/roap/Portals/96/forumdocuments/Environment%20Outlook%20Background%20Document.pdf (Accessed: 17 September 2015)

UNEP (2015b). Design options for a sustainable financial sector: Lessons from inclusive banking experiments. Inquiry Working Paper. United Nations Environment Programme http://www.greengrowthknowledge.org/sites/default/files/downloads/resource/Design_Options_for_a_Sustainable_Financial_Sector_UNEP.pdf (Accessed: 17 September 2015)

UNEP and CSIRO (2011). Resource efficiency: Economics and outlook for Asia and the Pacific. United Nations Environment Programme and Division of Ecosystem Sciences, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia http://www.unep.org/dewa/Portals/67/pdf/Resource_Efficiency_EOAP_web.pdf

UNFCCC, UNEP and UNDP (2013). Guidance for NAMA design: Building on country experiences. http://namapipeline.org/publications/guidance_for_nama_design_2013_.pdf

WHO (2014). Ambient (outdoor) air pollution in cities database 2014. World Health Organization. http://www.who.int/phe/health_topics/outdoorair/databases/cities-2014/en/ (Accessed: 31 October 2015)

World Bank (2015). Global monitoring report 2014/2015: Ending poverty and sharing prosperity. The World Bank Press, Washington, DC http://www.asianewsnet.net/Asian-nations-top-achievers-on-energy-progress-77971.html

World Energy Council (2015). World energy trilemma: Priority actions on climate change and how to balance the trilemma. London https://www.worldenergy.org/publications/2015/world-energy-trilemma-2015-priority-actions-on-climate-change-and-how-to-balance-the-trilemma/

WWAP (2015a). The United Nations World Water Development Report 2015: Water for a sustainable world. United Nations World Water Assessment Programme. UNESCO, Paris http://unesdoc.unesco.org/images/0023/002318/231823E.pdf

WWAP (2015b). Facing the challenges: Case studies and indicators: UNESCO's contribution to The United Nations World Water Development Report 2015 United Nations World Water Assessment Programme UNESCO, Paris http://unesdoc.unesco.org/images/0023/002321/232179E.pdf

Xu, B., Cao, J., Hansen, J., Yao, T., Joswia, D.R., Wang, N., Wu, G., Wang, M., Zhao, H. and Yang, W. (2009). 'Black soot and the survival of Tibetan glaciers'. Proceedings of the National Academy of Sciences 106(52), 22114-22118. doi: 10.1073/pnas.0910444106 http://www.pnas.org/content/106/52/22114.full.pdf

Zenn, J. (2015). 'Future scenarios on the new silk road: Security, strategy and the SCO'. China Brief, 16(6), 19 March. The Jamestown Foundation http://www.jamestown.org/programs/chinabrief/single/?tx_ttnews%5Btt_news%5D=43675&tx_ttnews%5BbackPid%5D=789&no_cache=1#.VzQXzYR-96JA

www.unep.org
United Nations Environment Programme
P.O. Box 30552
Nairobi, 00100, Kenya
Tel: (+254) 20 7621234
E-mail: publications@unep.org
Web: www.unep.org

UNEP

Job No: DEW/1964/NA
ISBN: 978-92-807-3544-4