Initial Strategic Research Plan for Future Earth in Asia

Editors Michael Manton, Tetsuzo Yasunari, Ailikun, Hein Mallee, Rodel Lasco, Ramachandran Ramesh
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(未来地球亚洲战略研究计划)

Editors  Michael Manton, Tetsuza Yasunari, Ailikun, Hein Mallee, Rolde Lasco, Ramachandran Ramesh
Abstract

The Future Earth program, initiated by ICSU, ISSC and other international partners, is now established, and researchers around the world are working with stakeholders on the development of the trans-disciplinary research needed to resolve some of the key challenges for global sustainability. To inspire the realization of Future Earth in Asia, the Monsoon Asia Integrated Regional Study (MAIRS), in collaboration with the Research Institute for Humanity and Nature (RIHN) and with inputs of numerous other contributors, facilitated the preparation of this strategic research plan. This strategic research plan aims to be consistent with the global plans for Future Earth by recognizing the unique qualities of Asia and its challenges for sustainability. It has 6 chapters including 1) Introduction, 2) Dynamic Asia, 3) Asian development, 4) Crosscutting capacities, 5) Transformation to Asian sustainability, 6) Conclusions and key messages. Chinese Academy of Sciences (CAS) and Chinese Association of Science and Technology (CAST) financially supported the related workshops/meetings and publication.

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FUTURE EARTH IN ASIA

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Preface

The Future Earth program, initiated by ICSU and ISSC, is now established, and researchers around the world are working with stakeholders on the development of the trans-disciplinary research needed to resolve some of the key challenges for global sustainability. A significant aspect of Future Earth is that it is building on the global environmental change programs that have successfully promoted international collaboration for some decades. The Monsoon Asia Integrated Region Study (MAIRS) program is a regional environmental change program that has promoted regional collaboration across monsoon Asia for nearly a decade. At the meeting of the MAIRS Scientific Steering Committee in Guangzhou, China in March 2013, it was agreed that a strategic science plan should be prepared to show how MAIRS could link to Future Earth in Asia. The plan, which would aim to be consistent with the global plans for Future Earth but also recognize the unique qualities of Asia and its challenges for sustainability, would be prepared in cooperation with partners such as the Research Institute for Humanity and Nature (RIHN) in Japan.

To commence the process to prepare the plan, a small international workshop of invited experts was held on 31 July to 2 August 2013 at the Hong Kong Polytechnic University, China. The participants in the Hong Kong workshop are listed in Appendix 1. The workshop was excellently led by Professor Tetsuzo Yasunari, Director General of RIHN. At that meeting an outline was prepared as the basis for the current draft plan, with input from representatives of the Asia Pacific Network for Global Change Research (APN) and the ICSU Regional Office for Asia and the Pacific.

This draft plan is now being distributed to the broader stakeholder community to seek guidance on the improvement of the document. Input is
being sought especially from the international community involved in the consolidation of Future Earth, so that this plan can support the directions being taken in worldwide plans for the program.

I am grateful to all the people who have provided input to the plan at this stage, especially to Hein Mallee at RIHN and Ailikun at the MAIRS Office, and I look forward to receiving valuable suggestions from all potential stakeholders in Future Earth Asia.

Michael Manton
Chair, MAIRS Scientific Steering Committee
Foreword

In preparing a set of Sustainable Development Goals, world leaders recognize that global societies need to transform so as to support and protect both human communities and the environment in the future. The International Science and Technology Alliance for Global Sustainability has established the Future Earth program to promote transdisciplinary research that addresses key challenges for global sustainability. The Future Earth Initial Design Report of the Transition Team (2013) provides an initial framework for establishing the program’s research agenda.

The Initial Strategic Research Plan for Future Earth in Asia, based on the Initial Design Report, aims to give an Asian perspective for the development of Future Earth activities across Asia and the Pacific. This perspective is necessary because of the unique features of both the environmental and social features of the region. The region has a very complex topography, extending from the highest mountains in the world to extensive coast-lines and small islands. The annual cycle of the Asian monsoon has influenced the development of natural ecosystems and human communities across the region over thousands of years. The natural disasters of the region vary from glacial lake outburst floods to typhoons and earthquakes.

Asia and the Pacific has given rise to stable and diverse cultures that have adapted to the local environments for past centuries up to millennia. But in recent decades it has experienced the most rapid economic growth along with increasing urbanisation and social mobility. Asia is in transition, and must confront the associated challenges of land degradation, air and water pollution, and social inequality.

It is essential that Asia and the Pacific’s transition to sustainability is built on its long history of recognition of harmony between nature and humanity.
| Foreword

The traditional cultures of the region provide a sound foundation for Asia to have its own vision of future sustainability and its own pathways for reaching sustainability. This Initial Research Plan for Future Earth in Asia can provide an opportunity for the communities of the region to work together to develop the required vision and pathways to sustainability.

Yuan-Tseh LEE
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Executive Summary

Future Earth has been launched as a global research platform to provide the knowledge and support to accelerate our transformations to a sustainable world. It will bring together existing global environmental change programs and strive to generate knowledge in partnership with society and the users of science. To inspire the realization of Future Earth in Asia, the Monsoon Asia Integrated Region Study in collaboration with the Research Institute for Humanity and Nature and with inputs of numerous other contributors facilitated the preparation of this strategic research plan.

Asia is a special region of the world, particularly when considering future pathways towards sustainability. The Asian monsoon and the Himalaya-Tibetan Plateau drive a unique climate with global impacts and which, through traditional cultures and practices, have supported a range of sustainable natural ecosystems and human societies for millennia. However, Asia is now in transition. Its population accounts for about 60% of the world total and its rapidly growing economies produce 36% of world GDP, more than any other region. Soon half of Asia’s population will live in cities, including 21 of the world’s 37 megacities. Asia’s geographical extent and demographic and economic weight mean that developments in the region will inevitably influence global environmental change trends. Global sustainability is not possible without major transformations in Asia.

The research programs for Future Earth in Asia will need to be developed carefully, through consultation and collaboration with stakeholders across the region and with the international research community. This research plan
identifies the following ten key issues that can provide appropriate focuses for Future Earth in Asia.

(1) Co-design and co-implementation within diverse cultures. A key innovation of Future Earth is the involvement of stakeholders beyond the research community in the design and implementation of the initiative. How to do this in practical and meaningful ways in the diverse Asian context needs to be explored and evaluated.

(2) Uniqueness of monsoon climate and topography. The monsoon and the Himalayas form the foundation of the Asian rice-based economies and cultures. Research needs to incorporate knowledge of past harmonies and the likely future projections of climate for the region.

(3) Vulnerability to natural disasters. The Asia-Pacific region is the most disaster-prone in the world, being susceptible to both earthquakes and typhoons. Research needs to take a long-term view and contribute to development pathways that reduce vulnerability.

(4) Rapid economic growth. Exceptional growth has increased prosperity for many, but also is at the root of environmental deterioration. Global environmental change cannot be addressed without changing the development models in Asia. Research should assess the implications of different growth scenarios.

(5) Accelerated urbanization. The demographic balance of Asia is swinging towards the cities. This has provided numerous benefits, but the ecological footprint of these urban areas is enormous. Research needs to address urbanization as a dynamic process as well as point the way to integrated urban design.

(6) Sustainable food, water and energy systems. These provide Asia’s growing populations and economies with their basic needs, but current practices are clearly unsustainable. Research needs to consider these aspects as connected and interdependent systems.

(7) Safeguarding ecosystems. From tundra to tropical forests and from
deserts and coastal zones, ecosystems are under severe pressure in Asia. Research not only needs to monitor their dynamics and tipping points, but also uncover the drivers of degradation and explore solutions.

(8) Pathways guided by Asian traditions and cultures. Asia is characterized by a complex mosaic of social and ecological diversity developed through a long history of human interaction with nature. Research should examine how this history can inspire new pathways to sustainability.

(9) Social equity and inclusion. Not all of Asia’s population has benefited from rapid economic growth and many countries inequality has increased. Research must catalyze transformational change to enable Asia to increase institutional alternatives and innovations.

The transformation of Asia to sustainability requires a major research effort to underline and guide future policy and planning. This research plan aims to support the development and implementation of that effort.
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Chapter 1

Introduction

Future Earth (FE) has been launched as an international initiative to promote research for global sustainability by the international science and technology alliance, a partnership of the International Council for Science (ICSU), the International Social Science Council (ISSC), the Belmont Forum of funding agencies, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP), the United Nations University (UNU), and the World Meteorological Organization (WMO) as an observer (Future Earth, 2013). Future Earth will provide a single overarching structure for researchers, funders, service providers, and users, and it integrates the existing Global Environmental Change (GEC) programs\(^1\). The GEC programs have provided foci for several extensive international and multi-disciplinary networks of researchers investigating key human-environmental dynamics. Future Earth will build on these to develop a new generation network\(^2\). Future Earth proposes national and regional level committees, in addition to the regional nodes. The most

\(^1\) Four major global environmental change programs, all(s) sponsored by ICSU, operate in the planning and coordination of international global environmental change research: DIVERSITAS; an International Programme on Biodiversity Science; International Geosphere-Biosphere Programme (IGBP); International Human Dimensions Programme on Global Environmental Change (IHDP); World Climate Research Programme (WCRP).

\(^2\) http://www.icsu.org/future-earth/
essential issue for the overall FE activity towards global sustainability will be how to integrate efforts and activity for solving environmental problems and achieving sustainability at local to regional scales.

This document presents a strategic science plan for FE in Asia, including the Pacific/Australasia and the Indian Ocean basin region. The aim of the plan is to commence a dialogue amongst the broad stakeholder community with interests in the transformation to sustainability across Asia.

1.1 Asia as a key region for Future Earth

More than 60% of the global population is concentrated in Asia, and the total GDP of Asian countries is equal to about one-third of the global GDP. The region as a whole is characterized by dramatic demographic change and rapid economic growth and urbanization, great disparities of wealth both within and between countries, and social and ecological vulnerability to the potential impacts of climate change. This region is also a huge hot-spot region for greenhouse gas emissions and air and water pollutions, which are affecting emissions and pollution at the global scale. The biodiversity loss of the terrestrial and marine ecosystems of this region is increasing most rapidly in the world.

At the same time, however, the region has offered many examples of long-term social and ecological sustainability under the humid monsoon climate and in the so-called “Asian Greenbelt (from tropics to boreal region)” with great biodiversity, where many traditional systems of agriculture and livelihood have supported large numbers of people through time. The contemporary sustainability challenges in Asia, therefore, will require wholly new approaches in science, technology and governance; “innovation” will also entail more active recognition of the wisdom already embedded in traditional thought and patterns of livelihood. Designing sustainable interactions between humanity and nature in Asia is a global challenge, and the ultimate goal of
Future Earth, global sustainability, cannot be achieved without it (Yasunari et al., 2013).

1.2 Complexity of environmental issues in Asia

The Asian monsoon climate system underpins the ecosystem services on which billions of people depend. Human activity is increasing industrial pollution, land-use change and greenhouse gas emissions in the region and is leading to changes in monsoon patterns that may significantly harm social and economic development in the region.

Asia is experiencing significant transformation of terrestrial and aquatic ecosystems. Most extensively, forest disruption continues to increase in scale and pace in developing countries (particularly those of the tropics). Multiple scale and transnational analysis is required to determine the specificity of such trends and whether they reflect gross reduction or displacement of forest resource use and degradation to other countries or regions.

Over-extraction of surface and subsurface water sources and pollution, diversion and obstruction of waterways have significant negative impacts on ecosystems and human populations at local, regional and continental scales. Asian delta systems are often densely populated, intensively used and highly vulnerable to shifts or shocks originating upstream or in neighboring seas and oceans. A grand challenge of sustainable water resources management is to secure the access to clean water necessary to meet basic human needs, such as health and sanitation, food production and renewable energy, taking account of the linkages between ecological change, land use, urbanization, industrial activities and water systems.

Asia exhibits three important trends related to urbanization: urban growth, especially through increasing migration to urban centers; the emergence of new urban centers; and the convergence of multiple cities into mega-urban regions. Contemporary urbanization is therefore central to
global economic and environmental change. Coastal Asian cities are highly vulnerable to impacts of climate change, particularly sea level rise, and decisions need to be taken now to promote their social and ecological resilience. The pursuit of low carbon cities and innovative industrialization is increasingly promoted as a strategy for achieving urban/domestic sustainability and addressing global climate change. The extent to which such strategies put significant pressure on natural resources in other parts of the globe should also be considered.

Asia must improve its capacity for risk management of both natural and human-caused disasters, since the region exhibits high human vulnerability to extreme hydro-climatological and tectonic events (e.g. typhoons, heavy rains, floods and droughts, landslides, earthquakes and tsunamis). Disasters expose different dimensions of social-ecological vulnerability and therefore disaster risk reduction is an important field of sustainability research and action. In the event of disaster, it is crucial to address immediate recovery needs while also developing learning systems that will improve social-ecological resilience to potential future disasters and build sustainability in the long term.

1.3 Complex and diverse human social systems in Asia

Asia contains a complex mosaic of social and ecological systems developed through a long history of human interaction with nature. Many customary but large-scale systems of resource management, such as paddy-rice, agro-pastoralist and agro-forestry systems, have contributed to agro-biodiversity and maintained intensive food production, employment opportunities and community livelihood over long periods of time. The combined effects of globalization and climate change, however, are threatening ecosystem productivity in this region, undermining resource-based livelihoods and communities and exacerbating social inequity.
Asia currently demonstrates great disparities of wealth and political power and accountability both within and between countries. Concerns for national development and security increase competition for control over key natural resources. However, large-scale foreign direct investment (FDI) and mega-development projects can disenfranchise local communities and increase disparities between nations. Because social, political and economic marginalization is often linked to environmental degradation, participatory decision making is an essential component of good governance. There is a need for further analysis of local, domestic and international institutions and of the structural conditions that perpetuate inequities as well as those that can enable positive social-ecological transformations (Biermann et al., 2009, 2012).

Poverty alleviation is an intrinsic component of sustainability, as social, political and economic marginalization are often linked to environmental degradation. At the same time, the negative ecological impact of current patterns of consumption is already evident in both local and distant environments. In this sense, traditional indicators of economic growth such as GDP provide insufficient measures of development and are unable to describe key components of human wellbeing and environmental sustainability. Similarly, a “green economy” strategy based principally on economic development and technological change may not address environmental risk and ecological scarcities. New concepts such as “inclusive wealth” that combine measures for ecological surety and social equity may be necessary to develop a more comprehensive description of human wellbeing.

A concerted research and policy process for sustainability in Asia will require new approaches developed through dialogue between science, technology and governance. Existing traditions and wisdom, as represented by the traditional Chinese saying: “温故知新”, which means “keep cherishing old wisdom and knowledge while continually learning anew to serve others”, can guide this process. Achieving this spirit of wisdom at a regional level amid
on-going social and cultural inter-generational changes may be the fundamental bottleneck.

1.4 Need for networking in Asia

In order to address the Asian challenge described above, sustainability science must overcome its emphasis on environmental science approaches and incorporate knowledge from the social sciences and humanities, enter into dialogue with other knowledge traditions, and conduct studies to enhance human wellbeing and biodiversity and ecosystem services, paying special attention to the priorities of developing countries. There is a particularly strong need to establish networks and to deepen existing consonant networks throughout Asia, considering the complex and urgent issues mentioned above.

We need to establish a network to promote Future Earth in Asia (FE-Asia). The fundamental task of FE-Asia would be to increase research coordination and capacity necessary to address the specific regional dimensions of global environmental change in Asia described above. At a regional level, the network would lead the way in identifying and creating innovative funding needs and sources, as well as provide the appropriate institutional support mechanisms that will facilitate regionally-based integrated sustainability research within the monsoon Asia and the Pacific/Australasia regions.

The complexity of sustainability issues in Asia will require visionary political and scientific leadership and a high level of exchange and coordination between different epistemic communities in the region. This includes increasing research capacity in developing countries, especially through investment in the training of a new generation of developing world scientists who are able to effectively contribute to problems requiring interdisciplinary and transdisciplinary approaches①. Leadership, capacity building and education

① http://start.org/
for transformative change are the foundation of sustainability and require specific attention at local, national, and regional scales. FE-Asia should be a base platform for these interdisciplinary and transdisciplinary research networks, integrating new centers relevant to Future Earth in Asia and ongoing regional endeavors (e.g., the Asian-Pacific Network for global change research (APN)).

Given the scale and complexity of social-ecological systems in Asia and their unparalleled impact on the whole Earth system, designing sustainable interactions between humanity and nature in Asia represents a major step towards the goal of Future Earth. FE-Asia should play a significant role in providing the research framework to make such a transformation possible.

1.5 Scope of plan

This science plan aims to outline the key issues of sustainability research for Asia while conforming to the structure described in the Draft Initial Design Report for Future Earth (2013), and so provide a basis for informed discussion amongst the broad stakeholder community, especially across the research community of Asia. The breadth of sustainability research is so broad that any separation of the research agenda into parts may seem to be simple and inappropriate. On the other hand, the three research themes identified in the Draft Initial Design Report, along with the supporting cross-cutting capabilities, provide an approach that aligns with the existing research and capacity building activities for global environmental change research, while leading to the new challenges and methodologies required for transdisciplinary research in Future Earth.

The first theme of Dynamic Planet is cast as Dynamic Asia in the present plan, and it encapsulates much of the current research carried out within broad disciplines that describe the issues underlying many societal problems. Continuing research in these areas provides an essential foundation for more
societally oriented research in the other two themes.

The second theme of Global Development is named Asian Development in the present plan, and it aims to provide the data and knowledge needed to ensure proper stewardship of natural resources, especially food, water, energy and biodiversity, while enhancing human security. Key stakeholders for this theme are the development agencies focused on solving the practical challenges facing societies across Asia. Much research is needed to support current capacity building activities in the region.

The third theme of Transformation to Sustainability is cast as Transformation to Asian Sustainability in the present plan. It aims to build on the outcomes of the first two themes to provide the trans-disciplinary research needed to ensure that the future development of Asia is sustainable. The research needs to anticipate future directions of human and natural systems, to identify the key challenges and opportunities, and to provide optional strategies for Asian sustainability into the future. A key difference between Theme 3 and Theme 2 projects is likely to be the scale of the former: the magnitude of challenges associated with global transformation implies that Theme 3 projects should have at least national impact and their outcomes should be sustainable into the future.

For each theme, we highlight relevant research priorities. As an initial science plan, this document aims to avoid being prescriptive, but rather to provide a basis for discussion to bring together the broad base of stakeholders needed to address the issues of sustainability in Asia. A vital group of research stakeholders for the development of Future Earth is the existing global environmental change (GEC) community, and this plan will evolve in collaboration with that group.
References


Chapter 2

Dynamic Asia

The first research theme of this plan is Dynamic Asia, and it captures much of the research of the current global environmental change programs. We consider the major components of the human system, the geophysical system, and ecosystems and biodiversity. The human system of Asia is characterised by a large population, with rapid urbanization and increasing economic well-being but with challenges of inequality and social development. The geophysical system of Asia features a climate dominated by the seasonal monsoon and a topography dominated by the Himalaya-Tibetan Plateau. The ecosystems and biodiversity of Asia are very rich and varied, but they are under threat from both direct and indirect human activities.

2.1 Human system

Asia\(^\ddagger\) is very large: with around one-third of the world’s land, it contains over half of the population and more than one third of GDP. This means that changes in Asia often have a pronounced impact on global statistics. At the same time, Asia is also very diverse: it contains a large number of countries, economies and cultures, across widely varying landscapes and ecosystems. It is therefore challenging to make widely applicable statements about Asia.

Key challenges for research;

\(^\ddagger\) Unless stated otherwise, “Asia” refers to Asia and the Pacific.
(1) Research needs to be able to address the commonalities as well as the diversity of Asia. One next step could be to refine the analysis in this report to the sub-regions.

(2) Many dimensions of change in Asia will be dominated by developments in China and India (plus a few more). This is important and needs to be researched. At the same time, research also needs to take account of and serve the needs of all countries.

2.1.1 Population

Asia has accounted for over half of the world population for most of recent human history. In 2011, 3.9 billion people lived in Asia, which was about 56% of the world population. This population is not evenly distributed over the countries of the region. China and India account for almost two-thirds of the region’s population and adding Pakistan and Indonesia raises the proportion to 77%. At the other extreme, many countries in the Pacific and West and Central Asia have very small populations.

Overall, Asian birth rates have been falling while life expectancy has improved and the total population has expanded quickly, but there are clearly differing sub-regional trends. Total Fertility Rates (TFR, the average number of children who would be born to a woman within her reproductive life) overall have declined substantially, from 4 children per woman in 1990 to 3 in 2010. The developed and higher income countries have a low TFR, while Afghanistan, Pakistan, the Philippines, Tajikistan and most Pacific nations have high rates. Southeast and South Asian TFRs are mostly between 2 and 3 children.

Life expectancy at birth for the whole population across 22 Asian countries reached 72.2 years on average in 2010, a gain of more than 15 years since 1970, with East Asian countries having higher life expectancies than South Asian countries (OECD, 2012).
Chapter 2 Dynamic Asia

Fig. 2-1 Life expectancies in Asian countries (Lamb, Vicki L., 2013)

Population growth between 1990 and 2011 showed a mixed picture, with slow growth in East Asia (<1.4% per year), many SE Asian countries growing rapidly, and South Asia growing at different speeds (1.0%–2.6%, with Bangladesh 1.5%, India 1.7%, and Pakistan 2.2%). These differential growth rates will have significant impacts over the longer term. For example, the share of People’s Republic of China, Japan, and the Republic of Korea in the region’s total population will fall to 8.1% \(^1\) by 2050, from 39.0% in 2011. The region’s population is projected to peak in 2050 at around 5 billion and then fall to 4 billion in 2100, to about the same level as the present (United Nations World Population Prospects, 2011).

Asia (excluding Oceania) is very densely populated; there are 130–140 people per square kilometer in Asia, in contrast to only just over 50 for the rest of the world. This density has direct implications for the environment. For example, Asia’s forests are home to far higher numbers of people at higher densities than in other continents.

The age structure of Asia’s overall population at present is dominated by young people, but again there are marked regional differences, with

\(^1\) Needs triangulation.
countries such as Afghanistan, Timor-Leste and Pakistan having large young populations, while East Asia societies are rapidly ageing. In the coming decades, this ageing trend will gain more momentum and by the middle of the century Asia’s elderly population is projected to pass 900 million people and Asia will become the world’s oldest region. In developing countries, this ageing process will take place more rapidly than in developed regions, posing additional challenges.

2.1.2 Urbanization

Historically, Asia has been home to the majority of the world’s cities. However, in a global perspective the region has been and still is relatively less urbanized. This has begun to change rapidly, however, as Asia’s urbanization rate during the past 20 years was consistently higher than the global average. As a result, in what the ADB has termed an “unprecedented increase”, Asia has added over 1 billion people to its cities since 1980 and 43.1% of Asians lived in urban areas in 2011. This was 46% of the world’s urban population. Asia is also home to 12 of the world’s 23 megacities and this is expected to grow to 21 out of 37 by 2015 — thus coming more in line with Asia’s global population share (56%). Asian cities also tend to have higher population densities. It must be kept in mind, though, that urbanization levels and rates of change vary much across Asia. China, in particular has added large numbers of urbanites, as its urbanization level increased from 27% in 1990 to 52% in 2012. In 2010, Asia had 506 million people dwelling in slums, or 61% of the world slum population.

It is important to note that, in spite of these powerful urbanizing trends, Asia still contains 69% of all rural people in the world. The total Asian rural

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1. In 2000, Asia had 49 of the world’s 100 largest cities, compared to 64 in 1800 (Satterthwaite, 2007).
2. Against 50.9% globally.
population of 2.3 billion (2011) is expected to decrease to 2.1 billion in 2030 and 1.8 billion by 2050. In other words, both urban and rural populations in Asia will continue to be numerous and important and need to be addressed in research (United Nations World Urbanization Prospects, 2011).

2.1.3 Urban land use

Data on urban land expansion are limited and it is hard to assess what the land-use implications of the demographic and economic expansion of urban areas in Asia are. A meta-analysis of a range of studies estimates that urban areas worldwide grew by between 1.56% and 3.89% per year between 1970 and 2000. China and Southwest Asia stood out with a high expansion rate. Importantly, urban land expansion rates were higher than urban population growth rates everywhere, suggesting that there is scope to improve the “land efficiency” of urbanization (Seto et al., 2011).

2.1.4 Urban environmental impacts

Cities in the Asia-Pacific region are highly productive and creative; the 43% of the population living in urban areas contribute 80% of the region’s gross domestic product (GDP). This urban growth has been accompanied with major environmental challenges. Environmental impacts are largely an outcome of urban processes of structural development, waste and pollution, and resource consumption. In the case of coastal cities due to the complex and delicate nature of coastal ecosystems, their environmental impact can also be disproportionate. The most significant impacts are subsidence due to excessive building load and groundwater extraction, pollution of soils and groundwater reserves, and resource extraction. Urbanization takes a toll on natural ecosystems, directly affecting them; for example, when coastal wetlands are reclaimed for settlements or indirectly by polluting them resulting in changes in species competition, loss of biodiversity and losses in a variety of services such as protection from flooding and storm surges. Pollution loads leading into
estuaries can alter regimes of sedimentation and erosion, damaging existing structures. Microclimate changes such as urban heat islands have been extensively recorded (Pelling and Blackburn, 2013).

2.1.5 Economic growth

These population and urbanization trends relate to and intertwine with Asia’s fast economic development. Developing Asia GDP on average grew by 7.0% from 1990 to 2010. Much of this aggregate growth was driven by developments in China (9.9%) and India (6.4%). As a result, Asia’s economic weight in the world has shifted; overtaking North America in 2000 and Europe in 2004, Asia’s GDP accounted for 35.7% of world GDP in 2011 (cf. Europe: 27.6% and North America: 23%). 70% of Asia’s GDP is concentrated in China, India and Japan.

This overall economic growth has propelled enormous advances in incomes and poverty reduction. The region’s mean per capita GDP grew from USD 1633 to USD 5133 between 1990 and 2008 and the proportion of people living on less than USD 1.25 per day declined from 53.9% to 21.5%, with 716 million people moving out of poverty.

Asia’s economies not only became much larger, but also became more integrated with each other and the rest of the world. Asia accounted for over one-third of the world’s exports and imports of merchandise goods in 2011. More than half of the exports from Asian countries stayed within the region.

2.1.6 International migration

International migration is an important feature of the social landscape in Asia. In 2010, there were over 50 million migrants in the region, which is one-quarter of migrants globally. Every year 3 million Asians leave their countries to work abroad. As a result, migrant workers’ remittances are an important source of income. In Nepal, about 1.4 million families (30%)

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received remittances in 2008. Remittances form a considerable part of national GDP in Tajikistan, Tonga, the Kyrgyzstan, Sri Lanka, Nepal, Bangladesh, the Philippines and Vietnam. In 2011, India received USD 64 billion in remittances. China USD 26 billion and Pakistan and Bangladesh each USD 12 billion.

2.1.7 Inequality and poverty

Rapid economic growth has not benefited all Asians in equal measure. Inequality has risen significantly compared to historical trends and 80% of the Asian population live in countries that have witnessed increased inequality in per capita expenditure or income in the past 20 years. During this period, China saw the most rapid increase in inequality in the region, as indicated by a Gini coefficient that rose from 32.4 to 43.4 (1.6% annual increase), but some of the other large economies also saw inequality deepen (India’s Gini coefficient went from 32.5 to 37 and that of Indonesia from 29 to 39). However, it should be noted that in spite of these trends inequality in Asia remains lower than in other developing regions of the world.

In spite of the impressive track record in poverty reduction noted above, Asia remains home to large numbers of poor people. In eight countries over 20% of the population are counted as poor, including Bangladesh (43.3%), India (32.7%) and Pakistan (21.0%). Two-thirds of the world’s extreme poor are Asians. Malnourishment is a serious problem in several countries; the proportion of under-5 children who are underweight was over 30% in Afghanistan, Bangladesh, India, Laos, Pakistan and Timor-Leste. As in other developing regions, improving child survival is difficult. In 2010 close to 3.2 million children under 5 years of age died, about 2.5 million of them before reaching 1 year.

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(1) A Gini coefficient of 40 or more is regarded as indicating “high inequality”.

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2.1.8 Human and social development

The Human Development Index, which goes beyond national income by including measures of life expectancy and education, has been improving for most of Asia. However, the index reveals considerable regional variation (see Table 2-1). In terms of population, most Asians live in countries with “medium human development”.

<table>
<thead>
<tr>
<th>Table 2-1 Human Development Index, Asia &amp; Pacific, 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HDI rank</strong></td>
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<tr>
<td></td>
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<tr>
<td>VERY HIGH HUMAN DEVELOPMENT</td>
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<td>MEDIUM HUMAN DEVELOPMENT</td>
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<tr>
<td>LOW HUMAN DEVELOPMENT</td>
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<td>153</td>
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<td>157</td>
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<td>172</td>
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</tbody>
</table>

*** = Data not available at cutoff date. HDI = Human Development Index.

Source: ADB Key Indicators 2012; p 132.
In terms of education, Asia is making steady progress. The average net primary school enrollment rate in East Asia (96.6%) is comparable with that of developed countries. The other parts of Asia show enrollment rates between 91.5% and 95.4%, which also compare positively with other regions in the world. A major challenge, however, is to keep enrolled students in school and ensure they reach the last grade of primary school.

As part of the Millennium Development Goals process, most Asian countries report progress in reducing gender inequality. For example, almost two-thirds of reporting countries have equal proportions of boys and girls attending primary school. Likewise, advances in gender parity in secondary and tertiary education, women’s participation in non-agricultural wage employment and in female representation in national parliaments have been made.

However, these positive developments should not mask the fact that on many aspects of gender equality Asia is lagging. For example “Asia has the highest male-female sex ratio at birth in the world, with sex-selective abortion and infanticide leaving a trail of 96 million “missing” women in some countries. Women comprise 51% of the population in most regions worldwide, yet they account only for 49% of the total population in Asia-Pacific.”

Research priorities

(1) What are the sustainability implications of the transformation of the demographic structure of Asian countries? Are there lessons to be learned from those countries where societal ageing is already advanced?

(2) What are the environmental and social consequences of the rapid pace of urbanization in Asia? What are the land use patterns associated with urbanization in Asia? What historical trajectories have led to the formation of

mega-cities and what are the sustainability implications? What is the overall environmental and social footprint of urbanization?

(3) What are the causes of increased inequality in many Asian countries? What are the implications for sustainability? What lessons can be learned from countries where development benefits have been more equitably shared?

(4) What are the gender implications of Asian development patterns? How can development contribute to gender equality and how can some of the excesses of gender inequality (such as skewed sex ratios at birth) be curbed?

2.2 Geophysical System

Asia is characterized by a complex mosaic of social and ecological diversity developed through a long history of human interaction with nature. The Asian monsoon climate system underpins the ecosystem services on which the livelihoods and wellbeing of billions of people depend. Monsoon Asia is also characterized as an active tectonic zone with the Himalaya-Tibetan Plateau surrounded by the subduction zone along the periphery of the continent. Many alluvial plains and valleys formed under this geomorphological condition, which combined with the monsoon climate provide the best condition for rice paddy cultivation. The Tibet-Qinghai Plateau and surrounding mountain ranges contain the largest glacially-stored fresh water (snow and ice) resources, which support densely-populated lowland plain and delta systems. This geological-climatological condition, on the other hand, has caused frequent and serious natural disasters (e.g., earthquakes, landslides, tsunamis, and floods) in this region.

2.2.1 Variability and trends of Asia-Pacific climate

A clear drying trend in central-northern India was found in many observed datasets in the last 60 years; positive trends of extreme precipitation events were found over the west coast and north western parts of the Indian
peninsula over 1901–2006. In contrast to extreme rainfall events, a decrease is seen in the frequency of moderate rainfall events over central India during the monsoon season for 1950–2000. For the East Asia Summer Monsoon (EASM), many studies have found a clear weakening of the monsoon over the last three decades, showing a drying trend in northern China and wetting trend in the Yangtze River Basin; such changes may lead to simultaneous floods and droughts over eastern Asia. Strong increasing trends of the very-wet-day index are observed in South East Asia, and Republic of Korea, where heavy rainfall events occur during the monsoon period. In contrast, there are decreasing trends in northern China and southeastern Australia. Some research showed a linkage between increasing extreme events and global warming, larger and faster than previously expected (Salinger et al., 2013).

A weakened relationship between interannual variability of ENSO and the Indian summer monsoon and an enhanced relation between ENSO and East Asian Summer Monsoon (EASM) from the 1980s are found in many studies (Li et al., 2010). There is evidence to support the hypothesis that the weakening of the easterly shear is due to an eastward shift of the Walker circulation, associated with strengthening of the El Niño (Goswami et al., 2010). A modeling study by Stevenson et al. (2011) found no significant changes of ENSO in its extent or frequency in the future, but the warmer and moister atmosphere could make ENSO events more extreme.

A significant weakening of the northern part of the summer Hadley Circulation (HC) was found and a reverse see-saw relationship of the zonal-mean updraft over 10–20°N and around the equator (Feng et al., 2011). This transition is accompanied by the southward retreat of the HC core and it is well correlated with the weakening of tropical summer monsoons. The interannual variability of ENSO and the strength of its climate teleconnections are modulated on decadal timescales by a long-lived pattern of Pacific climate variability known as the Pacific Decadal Oscillation (PDO) or the Interdecadal Pacific Oscillation (IPO). When ENSO is a major source of interannual climate
variability, decadal variability in the SST field of the Pacific is associated with
decal variability in atmospheric variables, such as sea-level pressure, winds
and precipitation (Burgman et al., 2008).

In addition to the open oceans, because of their huge meridional heat
transport, the western boundary currents like the Kuroshio, and Oyashio are
crucially important for the East Asian climate, atmospheric disturbances
including Typhoons, and oceanic ecosystem. While human beings live on the
land, oceanic states are crucially important for societies because the ocean is
the fundamental source of water and food for people living along the coast.
Understanding oceanic variability and impacts of global warming upon it are
as important as understanding the monsoons.

Research priorities

(1) What are the indicators of climate change in the Asia-Pacific region in
the past 60 years, including indicators of oceanic change? What are the
impacts of global warming on extreme events in the region?

(2) What are the impacts of global warming on Asian monsoon changes?
What is the relationship between Asian monsoon change and global circulation
such as ENSO, Hadley Circulation and PDO/IPO?

(3) What will be sea surface temperature changes over future decades,
and how will they affect the Asian monsoon climate?

(4) What are the roles of air-sea interactions in low and mid latitudes in
determining current climate variability and predictability, and future climate
in the Asia-Pacific region?

(5) What are the impacts of global warming and interannual to interdecadal
variability on the ocean-atmosphere system, particularly relating to sea level
rise?

2.2.2 Cycles of water, carbon and nutrient

The Asia-Pacific region contains most types of the world’s ecosystem,
including large areas of forests, mega-river basins, grasslands, croplands,
wetlands, gobi and deserts, which store a large amount of organic matter and carbon in their vegetation, organisms and soils, part of it in permafrost. The fate of this organic matter and carbon is uncertain under future climate conditions and human activities. The biogeochemical cycles of carbon and nitrogen could exert large feedbacks on the regional climate system. Some research suggests the radiative effect of CO₂ under global warming is much greater than the physiological effect on the water balance.

In tropical Asia, much concern has been raised about how cropland expansion and associated management practices (nitrogen fertilizer use, irrigation, etc.) have affected the terrestrial carbon cycle. Significant decreases in vegetation carbon occurred across most regions of Southeast Asia due to continuous cropland expansion and associated shrinkage of natural forests. Ren et al. (2012) show that both crop net primary production (NPP) and soil organic carbon storage (SOC) increased from 1980 to 2005. Land management practices, particularly nitrogen fertilizer application, appear to be the most important factor in stimulating the increase in NPP and SOC.

Mega-river systems in Asia have also played a vital role in storing and releasing terrestrial carbon and nitrogen through water and sediment carriers. This is closely linked to the land surface processes via erosion due to climate change and deforestation. Furthermore, numerous reservoirs constructed in river basins have altered the residence time of water and sediment delivery to the estuary. This causes large-scale imbalance of the carbon and nitrogen budget on land and in the ocean, to the extent that it drives future climate change.

Many environmental problems are related to changes in the nitrogen cycle driven by human activity, especially in urban areas of Asia. Within urbanized regions, nitrogen cycles are mediated by complex interactions between human and natural factors, but the impact of human activity on the biogeochemical cycle is still not clear due to a lack of observations and knowledge. Thus, comprehensively quantifying changes in the nitrogen cycle in urbanized
regions, as well as understanding the effects of human factors on the variations of reactive nitrogen (Nr) fluxes, are a crucial topic in global change research. In coastal areas these fluxes have significant impact on the ocean nutrient budget.

**Research priorities**

1. What is the sink or source of carbon in the different ecosystems of the Asia-Pacific region at present and for the future (e.g., 21st–22nd century)?

2. What is the sensitivity of the carbon balance of different ecosystems to the changes of climate, land use, and land cover due to anthropogenic activities?

3. How is anthropogenic land use and cover change influencing the regional balance of carbon and nitrogen?

4. How will the biogeochemical cycles of carbon, nitrogen etc. change in this century in the Asia-Pacific region? What will be the consequences of this biogeochemical cycle change to the region?

5. What will be the function of Asian mega-rivers in terms of carbon and nitrogen delivery, budgets and cycling? What will be the impact of these changes on the reservoirs of carbon and nitrogen?

6. How will primary productivity in estuarine waters be affected by changes in terrestrial carbon and nutrients? Will these changes in turn affect carbon cycling and climate on local scales?

7. What are the impacts of human activities on coastal areas and the open ocean in the Asia-Pacific region in terms of carbon and nutrient cycling?

2.2.3 **Human impact on geophysical system**

Whether and how the Asian monsoon can be affected by such regional high-intensity human activities have become important scientific problems, causing great international academic dispute due to a lack of long-term and systematic research. Many studies show that, although regional high-intensity human activities cannot fundamentally change the dynamic system of the
natural monsoon, they can alter the intensity of the monsoon and the phase of the monsoon cycle. But the influence of climate change on the intensity of the monsoon circulation, onset timing, number of rainy days and extreme events is still not well understood.

Mohmood and Li (2013) recognized that black carbon heating might delay the onset of the Indian summer monsoon. It was pointed out the drying trend in central-northern India from 1940 to 2005 can be attributed mainly to human-influenced aerosol emissions; the drying is a robust outcome of a slowdown of the tropical meridional overturning circulation, which compensates for the aerosol-induced energy imbalance between the Northern and Southern Hemispheres (Bollasina et al., 2011). Other research showed that the increasing SO\textsubscript{2} and black carbon emissions could decrease September precipitation significantly in the East Asian monsoon area.

Many studies recognize that the urban land cover change in eastern China will influence the regional atmospheric circulation and rainfall of the East Asian monsoon. Omer et al. (2013) show that 2050 land-cover/land-use change in mainland Southeast Asia is likely to have little impact on regional climate, but an extreme-irrigated-crop parameterization caused precipitation to increase slightly in the Indochina Peninsula, decrease substantially in southeastern China, and increase significantly in the South China Sea.

**Research priorities**

1. How has the rapid land cover/use change in the Asia-Pacific region in the last 100 years impacted on local and regional climate? What is the feedback?

2. What are the impacts of GHG and aerosol emissions in the Asia-Pacific region on regional and global climate? What is their dependency on the stage of development, physical/climatic location?

3. What are the interactions between land cover/use change and air pollution in the Asia-Pacific region? How does land use/cover change modify the local and regional effects of the Asian monsoon?
(4) Is the Asian monsoon system resilient to the transformations of land, water and air in the Asia-Pacific region?

2.2.4 Tectonic events

Asia-Pacific is the most disaster-prone area in the world. Nine out of 10 people affected by natural disasters worldwide were in Asia according to data from 1950 to 2011. From 1970 to 2011, 74% of global disaster fatalities were from the Asia-Pacific region. Although the total mortality number by geophysical and hydro-meteorological disasters is decreasing in the whole Asia-Pacific region, the economic loss from natural disasters is continually increasing. Losses in the Asia-Pacific region have grown by more than 16 times since 1970, while the GDP has increased by 13 times.

From 1900 to 2012, 58% of seismic disasters happened in the Asia-Pacific region, six of the most costly seismic disasters were from this region (ESCAP/UNISDR Asia-Pacific Disaster Report, 2012). Tectonic events make some areas much more vulnerable to hydro-meteorological disasters such as flood and rain-triggered landslides. Mud-flood and landslides caused by strong rainfall in the summer of 2013 in Wenchuan/China destroyed many new towns built after the earthquake of 2008.

A further interesting phenomenon has also been recognized in the Asian region – the distribution of rice paddy fields is always along the tectonic zones. The special topography of the Tibetan Plateau and its large downstream low land area fed by rich water supply from the monsoon climate has resulted in productive Asian paddy fields in South, East and Southeast Asia.

Research priorities

(1) What is the impact of extreme events on human society and ecosystem in the tectonic zones of Asia-Pacific?

(2) What kinds of early warning system and risk management system for hydro-meteorological disasters can be set up in the tectonic zones of Asia-Pacific?
2.3 Ecosystems and Biodiversity

Asia is rich in biodiversity; it contains 7 out of 17 mega-biodiverse countries (Australia, China, India, Indonesia, Malaysia, Papua New Guinea, Philippines), and 14 biodiversity hotspots out of 35 worldwide. However, ecosystems in Asia are undergoing rapid and sometimes irreversible changes as a result of human activities. As a consequence, their biodiversity resources are under threat and their ability to provide livelihoods to hundreds of millions of people in the future are at risk.

2.3.1 Forest ecosystems

Just under one-third of total land in the Asia-Pacific region is classified as forest, which is 18% of the global forest area. It includes the world’s third-largest tropical rain forest, 74% of the forest in the region is in China, Australia, Indonesia, India and Myanmar, 22% of the forest in the region is within formally established protected areas (FAO, 2011). Forest ecosystems in Asia have undergone significant transformations in the past two decades. During the first decade, there was a slight overall decline in forest cover (Table 2-2). However, in the second half, there was an increase in forest cover area. There was a net loss of forest of some 0.6 million ha annually in the 1990s, and a net gain of more than 2.2 million hectares of forests annually in the period 2000–2010 (FAO, 2010).

Within this overall trend, there are large differences in the state of each individual country’s forest. The bulk of the forest-cover increase occurred in China, while severe forest loss is occurring in Indonesia, albeit at a lower rate in 2005-2010. In the former, the increase is due to expansion of large-scale afforestation, while in the latter the decrease is mainly from tropical

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1 Note that the FAO data exclude West and Central Asia.
deforestation with the corresponding loss of their rich biodiversity. Primary forest is declining across Asia and the Pacific and is now around 19% of the total while planted forest accounts for 16% (FAO, 2011). Thus, the overall increase in forest cover in Asia may be masking the continued decline in biodiversity resources. On the positive side, there was an increase in the forest area designated for conservation of biological diversity and in the area of forest in protected areas and forests designated for protective functions in Asia (FAO, 2010) and 22% of the forest in the region was within formally established protected areas (FAO, 2011).

Table 2-2  Forest cover change in Asia

<table>
<thead>
<tr>
<th>Year</th>
<th>Area ($\times 10^3$ ha)</th>
<th>Change from the previous year(%)</th>
</tr>
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<tbody>
<tr>
<td>1990</td>
<td>576110</td>
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</tr>
<tr>
<td>2000</td>
<td>570164</td>
<td>-0.10</td>
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<tr>
<td>2005</td>
<td>584048</td>
<td>0.48</td>
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<tr>
<td>2010</td>
<td>592512</td>
<td>0.29</td>
</tr>
</tbody>
</table>


The main direct drivers of deforestation are destructive logging and conversion to agriculture.

2.3.2 Mountain ecosystems

The Eurasian landmass has the largest mountain area of all continents. All of the world’s mountains above 7000 m are in Asia, and all peaks above 8000 m are situated in the Greater Himalaya range. Mountain systems are changing more rapidly than at any time in human history. The most critical factors driving change in mountains are intensification of land use and overexploitation of natural resources (Korner et al., 2005).

In general, both poverty and ethnic diversity are higher in mountain regions, and people are often more vulnerable than people elsewhere (Korner et al., 2005). The Tibetan Plateau is the most extensive inhabited land area above 2500 m elevation. Ninety percent of the global mountain population of
about 1.2 billion people lives in developing countries and countries in transition—with one third of these in China and half in the Asia-Pacific region.

Asian mountains have extremely high biodiversity but these are in danger of being severely degraded. For example, it is estimated that by 2100 only about 10% of the land area of the Indian Himalayas will be covered by dense forest (>40% canopy cover) due to deforestation (Pandit et al., 2010). This would lead to the loss of almost a quarter of the endemic species in the region, including 366 endemic vascular plant taxa and 35 endemic vertebrate taxa.

Asian mountains are also an important source of water for hundreds of millions of people. The Greater Himalayas hold the largest mass of ice outside polar regions and are the source of the 10 largest rivers in Asia (Xu et al., 2009). As the planet warms, the volume of Himalayan glaciers is declining. In the future, climate change will likely increase uncertainty in water supplies and will affect agricultural production across Asia.

2.3.3 Coastal and marine ecosystems

Asia is bounded on the east by the Pacific Ocean and on the south by the Indian Ocean. Asia’s coastal zone is very densely populated, highly productive and undergoing rapid change. Though two-thirds of the world’s population live in Asia, the available coastline is only about a quarter of the length of the world’s coastline. Speedy economic growth illustrated by large-scale industrial development supported by the development of infrastructure, such as large ports and harbours and urbanization, has also come at a considerable cost of pollution and degraded coastal habitats, competition for space and declining fish stocks (Agardy et al., 2005).

Coral reefs, mangrove forests and seagrass beds are the three most productive coastal systems in this region with millions depending on them for their livelihood, while also harbouring high biodiversity. These three ecosystems are inter-tidal or sub-tidal systems and hence highly impacted by
anthropogenic land-based activities as well as sea-based activities such as oil spills (from shipping and drilling activities). Apart from anthropogenic threats, physical threats to Asia’s coastal region result from a combination of factors related to climate change including sea level rise, increased intensity of storms and storm surges and increased coastal flooding. Two-thirds of the world’s people in the risk zone susceptible to flooding are located in Asia. Migration towards the coast as well as natural population growth, urbanization (due to building over natural waterways and increases in impermeable areas), land subsidence (due to coastal oil wells, abstraction of water from coastal aquifers etc.) will play an important role in the extent of coast vulnerable to sea level rise and consequently, numbers of people at risk (Hirabayashi et al., 2013).

Many coastal ecosystems such as wetlands and tidal flats are important feeding grounds for aquatic avifauna. Some of the coastal ecosystems also harbour endangered or threatened species (e.g. dugongs in seagrass ecosystems) or are important repositories of biodiversity and hence have been declared protected under different categories. Other ecosystems such as sandy shores are known as nesting sites for sea turtles and horseshoe crabs.

Stocks of coastal fisheries are in decline in many areas. In Asia, large-scale coastal fisheries deprive coastal communities of subsistence and are causing increasing conflicts. Illegal and destructive fisheries cause habitat damage as well as overexploitation. This is also partly because of the move from traditional subsistence and small-scale local operations to motorization and mechanization that allow fishers to harvest from deeper waters since nearshore waters have been largely depleted of fish.

Asia harbors 42% of the world’s mangrove forests, the largest among all the continents (Giri et al., 2011). Most of the best developed mangroves of the world can be found in Asia which include those in the Sundarbans, Mekong Delta, and Southeast Asia. The 6000 km² Sundarbans between Bangladesh and India is the largest mangrove area in the world. Indonesia has
by far the most mangrove cover of all nations with 23% of the world’s total. Many of Asia’s mangroves are under threat.

Thirty-three percent of the world’s coral reefs of about 100,000 km² are located in Southeast Asia. With 600 of the about 800 reef-building species, these reefs have the highest levels of marine biodiversity on earth with large numbers of coral reef fish, molluscs and crustaceans (Burke et al., 2002). The coral reefs of portions of Southeast Asia have suffered the greatest rates of degradation and are expected to continue to be the most threatened (Agardy et al., 2005).

Seagrasses are the only flowering plants that can live underwater. They are found in shallow coastal waters and are the main diet of dugongs and green turtles and provide a habitat for many, smaller marine animals, some of which, like prawns and fish, are commercially important. They absorb nutrients from coastal runoff and help to keep the waters clean and also form a natural barrier against waves and tides, thus protecting the coast. Like mangroves and coral reefs, they are very important in terms of carbon sequestration (blue carbon). There are 50 species belonging to 12 genera in the world. Currently 28 species of seagrass from 11 genera are found in Asia. Despite the high biodiversity of seagrasses in this region, research and monitoring have been limited, leaving a gap in seagrass knowledge for Asia. In-depth research on the ecology, threats and uses for seagrass in this region could assist managers in appropriate conservation practices for this region.

2.3.4 Inland water ecosystems

There are an estimated 286 million ha of inland wetland area in Asia. Agricultural development has been the chief cause of the loss of inland water systems worldwide. It is estimated that by 1985, 27% of suitable inland water systems had been drained for intensive agriculture in Asia (Finlayson et al.,

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2005).

For example, the volume of water in the Aral basin has been reduced by 75% since 1960, due mainly to large-scale upstream diversions of the Amu Darya and Syr Darya flows for irrigation of close to 7 million hectares of land. The loss of water, coupled with excessive chemical inputs from agricultural runoff, has caused a collapse in the fishing industry and a loss of species diversity and wildlife habitat.

Natural wetlands in Northeast Asia and High Asia have been greatly depleted and degraded, largely due to global climate change, drainage and conversion to agriculture and silviculture, hydrologic alterations, exotics invasions, and misguided management policies (An et al., 2013).

In Southeast Asia, most of the tropical peat swamp forests have been heavily degraded, and large extents have been lost over the last four decades. The main cause of this has been logging for timber and pulp (Finlayson et al., 2005).

Since the beginning of the Green Revolution in the 1960s, the global use of synthetic nitrogen fertilizer increased more than nine fold and phosphorus use more than tripled. However, more than three quarters of the added nutrients are believed to be lost to the environment resulting in waste of the energy used to produce them, and causing pollution through emissions of the greenhouse gas nitrous oxide ($N_2O$) and ammonia ($NH_3$) to the atmosphere, plus losses of nitrates ($NO_3$), phosphate and organic N and P compounds to water. These have resulted in the overloading of waters with nutrients resulting in eutrophication of not only freshwater systems but also coastal waters, especially estuaries.

Eutrophication leads to a variety of adverse impacts including algal blooms including harmful algal blooms (HAB), mortality of benthic organisms, shellfish poisoning, unsuitability of water for human consumption and collapse of fisheries. Studies have indicated an increase in frequency of HAB, as well as in area affected, over the last few decades. Nutrient effects on water
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Oxygen levels are exacerbated when local water bodies become stratified, and mixing and thus oxygenation of layers is prevented resulting in hypoxia and mass fish kills. The greatest projected increases in global nitrogen fertilizer are expected to be in Asia over the next 25 years and hence are likely to be a major driving force for ecosystem change.

2.3.5 Dryland ecosystems

Drylands, as defined by UNCCD, are defined by their water scarcity in regions where the ratio of annual precipitation to potential evaporation is less than 0.65. They can be further classified into dry sub-humid lands, semi-arid lands, arid lands, and hyper-arid lands (deserts) in tropical, temperate and cold climate zones. Approximately 40% of Asia lands are drylands stretching from Turkey in the west to Mongolia in the east, primarily in the Middle East, Central Asia, and Mongolian Plateau.

Ecosystems and communities in dryland Asia are disproportionately vulnerable to climate change and global disturbances relative to their adaptive capacity to mitigate the effects of climate change on livelihoods and critical ecosystem services. Enough evidence suggests that climate anomalies are much worse in the dryland region (Hansen et al., 2010), where extreme climate events increased by as much as 5% in some areas over the past 30 years, in comparison with the average from 1961–2010, in the form of extreme low/high temperatures and precipitation intensity, duration of these events such as drought and severe winter storms (Groisman et al., 2009; Lu et al., 2010). The growing water shortage resulting from reduced glaciers in Asia and altered precipitation patterns threatens the regional agricultural productions of both cropping and rangelands systems, while the food demand continued to increase. According to the United Nations Fund for Population, population in Central Asia will reach more than 70 million people by 2020-2030. As such, the agricultural water use and demand for food is expected to increase dramatically. At the same time, triggered by migration and institutional
changes in the region, overgrazing, intensified irrigation of croplands, and abandonment of agricultural lands and infrastructures in rangelands, there has been severe land degradation in the form of salinization, soil erosion, and reduced vegetative covers. The complexity of the coupled climate change, ecosystem degradation, and socioeconomic reforms in dryland Asia presents a major challenge in developing effective, balanced strategies to cope with these continued changes (Liu et al., 2007; Qi et al., 2012) unless measures are taken to transition from existing approaches to co-design and co-produce solutions.

Existing knowledge is insufficient to address the complex issues of sustainable development in the dryland regions of Asia under increasing climate variability. Past foci of global climate change implications in Asia were on other ecosystems than drylands. Thus, to transform from “Science for Science” to “Science for Society” of the Future Earth must address some specific challenges facing dryland regions in Asia.

(1) Insufficient data in the region to holistically assess climate impacts on ecosystem services, water resources, and socioeconomics. For example, water is probably the most important issue in the region but there are very limited hydrological stations to understand the water resources. Further, few data exist on the social dimensions of the climate change, such as human health, gender disparity, age structure, education, cultural beliefs, and other social demographic aspects of the region, and thus it is difficult or impossible to assess the societal strategies to cope with negative climate impacts.

(2) Great challenges exist in regional coordination and collaboration to holistically address water resources across international boundaries. Implications should be assessed and coordinated efforts need to be put in place to holistically assess the socioeconomic consequences of increased human alterations of water systems such as dam construction, intensified irrigation, and canal constructions without coordination. There is little knowledge on international water rights within the region and the knowledge of total human consumption demands is lacking.
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(3) Majority riverine systems in Asia rely on the glacier melting in the Himalaya Mountains. However, the role of regional glaciers needs to be better understood because the fate of the glaciers is unclear under current and future climate change (e.g., Immerzeel et al., 2011). Glaciers are exceptionally important in providing water recharges in the rivers and groundwater of the region.

(4) Information on land cover and land use change dynamics, particularly on urbanization, is lacking. It was recognized that the total urban area within the region may not be significantly large compared with the total other land area. However, the urban expansion and development played a key role in the change of the livelihoods of farmers and herders in the past. The majority of the younger generations of rural areas migrated to urban cities, leaving behind vacant or abandoned land. How the shift in demography, particularly in the age distribution, affected the grassland ecosystems needs to be further studied.

(5) Innovative technologies are required to enhance water use efficiencies in agricultural practices that prevent land degradation, including soil salinization and land degradation, while increasing the water use efficiency.

(6) Societal impacts of climate change have not been fully assessed and are not understood. Little is known about how climate change has impacted the livelihoods of the rural communities of the region; food, health, and water security.

(7) Capacity building is lacking. Research infrastructure is limited to allow interdisciplinary effort that holistically addresses the regional issues under changing climate. Research and education programs need to be enhanced, coordinated, and effectively executed to build the capacity to engage multi-agencies and stakeholders to develop sustainable solutions.

2.3.6 Small island ecosystems

Island ecosystems in Asia are sparse and sporadically distributed across
coastal areas and the deep oceans. Some of them have been inhabited by humans for centuries while others have not been exploited yet. These ecosystems have many unique socio-ecological characteristics and thus they provide unique ecosystem services, including richness in biodiversity, abundance in fisheries, as well as other natural resources such as valuable minerals and petroleum and natural gases. However, these ecosystems become increasingly vulnerable to human disturbances and global change, as human activities are escalating to exploit the ecosystems for human benefits and at the same time extreme climate events and sea level rise impose further damage to these systems. Thus, the sustainability of these vulnerable ecosystems is being threatened for them to continue providing services that humans rely on. Due to their unique socio-ecological nature these island ecosystems impose distinctive challenges for sustainable development solutions.

Island ecosystems are increasingly subjected to sea level rise threats. Expected sea level rise of up to 3 m in the long term would result in substantial portions of many island coastal cities to be submerged. Subsequent escalation in saltwater intrusion and subsidence of land have caused significant threats to the wetlands and aquaculture of many island countries. In addition to sea level rise, expected escalation in magnitude, strength, and frequency of extreme climate events further pose a great threat to island ecosystems. Storm surges and strong typhoons have caused significant damage to property and infrastructure of island ecosystems as well as human deaths. Flood-induced landslides and drought-induced forest fires and freshwater shortages are expected to worsen under the currently predicted climate change, making the islands more vulnerable to climate change. Less understood geological and tectonic events such as tsunamis and undersea volcanic activities impose further risk of these island ecosystems that are difficult to predict and manage. These catastrophic disasters require a long-term risk mitigation plan, but few island communities have such capabilities, especially small islands.

The threats imposed by natural climate variability and change can be
further complicated by human activities on these islands. Urban development on resource-limited islands, mining, and agricultural cultivations of poor quality soils have caused coastal water pollution through increased discharges of nutrients and toxic materials into near-shore waters, changing the fish habitat and thus fishery production. Infrastructure development such as land reclamation and construction of bridges connecting islands alter the physical environment that have affected diversity both in the water and on the islands, such as fish and bird species. Nearshore water pollution can be further worsened by, for example, oil spills of petroleum ships and nearshore oil drilling.

A framework to assess vulnerability and risks imposed by human activity and climate needs to be developed that specifically considers the uniqueness of island ecosystems. Challenges exist, however, to develop a vulnerability assessment framework for individual islands, because island ecosystems are all connected through shared waters. Further, information on future climate variability and change is difficult to scale down to island level, especially for small islands. There is a need to balance environmental conservation and economic development of those fragile islands. On the one hand, infrastructure development on islands has caused environmental degradation, but on the other hand it is a practical means to reduce societal vulnerability imposed by changing climate and sea level rise.

Protection of island ecosystems requires a coordinated effort across islands as they are connected through shared waters. Pollutant transports by ocean currents may affect environmental habitats of remote islands. Overfishing in shared waters is another example that requires regional coordination. These challenges lead to the conclusion that a system is required for vulnerability assessment and subsequent sustainability development across island ecosystems.

Fundamental information on biodiversity, environmental conditions and natural resources is limited in many islands, especially uninhabited islands.
Thus, long-term observations are required to assess the magnitude of changes and associated causes, to identify major driving forces. This requires long-term planning and investment to develop vital databases and information for holistic assessment of island ecosystems.

2.3.7 Agriculture ecosystems

Agriculture, both cropping and grazing systems, is the primary source for food and fibre for Asia. It is anticipated that food production will need to increase by about 50% by 2030 to accommodate the growing population and provide economic well-being across Asia. Most of the world’s 450 million small-holder farms are in Asia, and they are challenged by both environmental and socio-economic threats. Climate change and variability are contributing to extreme weather events, such as typhoons and droughts. Moreover, the prices of fertilizer, seed and animal feed have more than doubled in less than a decade. Thus, economic development, rapid urbanization, change in food diet, and changes in climate have led to major challenges in agricultural systems. The current trends in arable land reduction and degradation, along with continued climate change and economic development, are reducing the ecosystem services provided by agricultural systems, and so threaten the sustainability of food security across Asia.

Agricultural land has been reduced significantly in recent decades under the pressures for urban development. Intensification and expansion of megacities in Asia has occurred in the most fertile lands and consequently good arable lands are being converted into urban lands. Balancing urbanization and economic development and agricultural land for food production remains a major challenge. Agricultural intensification, manifested in high-input cropping management and overgrazing practices, has resulted in a temporary increase in food production, but has led to major land degradation and environmental concerns. Soil erosion, increased nutrient leaching to aquatic ecosystems that caused eutrophication of lakes and streams, and altered
hydrology from extreme climate events such as flood and drought, have significant environmental implications. Ways to increase desirable ecosystem services from agricultural systems, while protecting the environment, have been lacking. These issues are further complicated by variable land tenure systems, and so research is needed to analyze and optimize the governance of agriculture across Asia.

2.3.8 Urban ecosystems

Between 1990 and 2010 urbanisation in Asia and the Pacific grew from 30% to 40%, with the urban population increasing from about 900 million to 1.5 billion. With the rapid urbanisation of Asia, the interactions between humans and the environment are very significant and important for the whole region. The health of both humans and the environment is determined by these complex interactions. Urban areas contain the main consumers of food, water and energy for the region. The provision of these services generally leads to an overall reduction in poverty but can also degrade the environment and other indicators of human well-being.

Over the period 1990 to 2010, the number of people living in poverty in Asia fell from 1.5 billion to about 760 million. Life expectancy has increased by up to 20 years in the countries of Asia over the same period. However, the changes vary widely across the region, and the overall number of people in poverty remains large and life expectancy is lower than in more developed countries of the world (Dahiya, 2012).

The primary impact of urbanisation is the transformation of land cover; for example, the urban area of the Pearl River Delta City Region of China grew by a factor of two and a half over the two decades to 2005. Asian cities also tend to have a high population density, and so building height tends to be high compared with that in other parts of the world. There are also many small, very high density buildings in the older parts of Asian cities. Asian cities consequently have the highest population densities in the world, at about
10,000 to 20,000 people per square kilometer.

Asia has the seven largest mega-cities of the world: Tokyo, Jakarta, Seoul, Delhi, Shanghai, Manila and Karachi, each with more than 20 million people. However, only 11% of the urban population live in mega-cities, and 60% live in cities with population less than 1 million. Thus there is great diversity in the nature of the cities of Asia, with many small cities acting as links between rural communities and the larger cities (World Bank Data, 2014; Demographia, 2013).

A consistent impact of the land-use change associated with urbanisation is the urban heat island effect, which has led to temperature increases of 1 to 2°C in cities like Seoul, Taipei and Tokyo. Changes in precipitation intensity, pattern and seasonality have also been found in Asian cities, such as Beijing, Guangzhou and Tokyo.

A growing concern across Asia is the impact of urbanisation on air quality, which tends to deteriorate in middle income countries owing to land-use change and the burning of fuels. Sources of air pollution include motor vehicles, electricity generation, industry, land clearing, and household cooking and heating. Air pollution, especially particulates, can be transported large distances by the wind, so that activities in the peri-urban areas can readily affect the central parts of large cities and the “brown haze” of South Asia has regional impacts on climate.

Air pollution has substantial impacts on human and ecosystem health. Particulates and ozone lead to many premature deaths from various respiratory and cardiac diseases. Other impacts of air pollutants may include erosion of infrastructure and reduction of crop yield (Marcotullio, 2013).

Urbanisation has a major impact on the flow of water through the landscapes of Asia. Urbanisation means that rain water, which formerly was channelled through natural water ways, becomes storm water that must be managed to avoid local flooding. Waste water from industry and household use must also be managed in cities. At the same time, drinking water is usually
transported from peri-urban areas, and so the overall management of water is a major challenge for urban areas. In 2006, about 80% of households in East Asia and the Pacific had water piped to their premises in urban areas, compared with about 50% in rural areas. Between 1990 and 2006, the fraction of the urban population of the region with access to drinking water remained at 96% which meant that the number of people without access to drinking water increased from 10 to 30 million (UNICEF, 2009).

The mode of governance of urban areas across Asia varies considerably. Decentralisation and local autonomy are apparent in some countries associated with growing capacities of local government. Effective governance is critical to the support of urban economies, which usually contribute much of the national GDP; for example, Bangkok generates about 40% of Thailand’s GDP. A trend over much of Asia has been for an increase in the number of working women, although their wages tend to be less than those of men (ESCAP, 2005).

**Research priorities**

1. What are the key drivers of ecosystem change in the sub-regions of Asia?
2. How do various drivers of change interact with each other?
3. What are the impacts of climate change to natural ecosystems? What are the approaches in formulating adaptation responses?

**References**


ESCAP. 2005. Urban environmental governance for sustainable development in Asia and the Pacific; a regional overview. ESCAP, Bangkok, pp100.

ESCAP/UNISDR Asia-Pacific Disaster Report 2012.


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*Nature Climate Change* 3: 816-82. doi:10.1038/nclimate1911.


Satterthwaite, David. 2007. The transition to a predominantly urban world and its underpinnings (IIEE).

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Chapter 3

Asian Development

3.1 Introduction

The second research theme of this plan is Asian Development, and it is concentrated on the provision of knowledge to assure the stewardship of the natural resources of the region, while enhancing human security. The stewardship of each of the ecosystems in Theme 1 is considered, with a view to enhancing and securing the future health of each ecosystem. The human security of Asia is seen to have particular challenges for water, food, energy, health and well-being.

3.2 Stewardship of Ecosystems

This section examines the stewardship of the ecosystems described in Section 2.3. The ways in which humans currently make use of the ecosystems is examined; how the systems are governed and the main threats are described. New or promising approaches to addressing some of the governance and degradation issues are then briefly reviewed.

The research in Future Earth will need to be closely linked with the activities of the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES), which was formally established in 2012 to provide independent assessment of the state of global biodiversity and associated ecosystems. The
IPBES developed from the Millennium Ecosystem Assessment (MA), and it aims to address the needs of the Multilateral Environmental Agreements related to biodiversity and ecosystem services.

3.2.1 Forest ecosystems

Forest ecosystems in Asia are being managed for three major purposes: for commercial wood production, for biodiversity conservation, for protective functions and for local community use. In 2005, 774 million m$^3$ of wood were harvested in Asia and the Pacific of which 70% are fuelwood and the rest are industrial wood (FAO, 2010). The total value of these wood products is estimated at USD 28 billion. About 23% of the world’s forest biodiversity conservation areas (84 million ha) as of 2010 are in Asia and the Pacific, and the total area has been increasing by about 2% per year in the last decade. Forests maintained for their protective functions (e.g. soil and water conservation) cover 123 million ha, which about 40% of the world’s total. A large portion of forests in the continent is used by local communities for food, fodder, as grazing lands, non-timber forest products (e.g. resin, mushroom, rattan), and for cultural and spiritual purposes. However, there are no available statistics on these uses.

In terms of ownership, 75% of all forest areas in Asia and the Pacific are owned by the state (FAO, 2010). Of these public lands, the state manages about 60% of the total forest area, while the rest are managed mainly by the private sector and by local communities. In many developing countries, there is a clear trend on decentralization as management is devolved to local communities.

A comprehensive study of drivers of deforestation and forest degradation shows that in Asia the leading drivers of deforestation are commercial agriculture followed closely by subsistence agriculture (Hosonuma et al., 2012). On the other hand, timber extraction and logging drives most of the degradation, followed by fuelwood collection and charcoal production,
uncontrolled fire and livestock grazing.

One recent initiative to capitalize on the role of forests in mitigating climate change is the so-called reducing emissions from deforestation and forest degradation plus (REDD+). The Copenhagen Accord under the UNFCCC recognized the crucial role of reducing emissions from deforestation and forest degradation. The parties of the Accord agreed for the immediate establishment of a REDD+ mechanism. There is also consensus among REDD+ negotiators to include the following components under REDD+: reducing emissions from deforestation, reducing emissions from forest degradation, conservation of forest carbon stocks, sustainable management of forest, and enhancement of forest carbon stocks (La Vina, 2010). Since then, there have been further advances in the negotiations as well as in implementing REDD+ activities in various countries. The Cancun Agreements officially launched the REDD+ mechanism under the UNFCCC (La Vina et al., 2011).

3.2.2 Mountain ecosystems

The mountain ecosystems of Asia are represented by the Himalaya-Tibetan Plateau (HTP) region. The region is known as the Third Pole, as it stores the third largest amount of water in glaciers, snow and ice. The region is also known as the Water Tower of Asia, and a major service provided by the ecosystem is water for about 1.4 billion people living in the Indus, Ganges, Brahmaputra, Yangtze and Yellow River basins.

The HTP extends over about 7 million square kilometres, including a huge rangeland of about 3 million square kilometres that in the past has supported both pastoral cultures and a varied natural ecosystem. The flora and fauna of the HTP vary with the temperature and precipitation, which are largely affected by altitude so that ecological zones tend to be vertically stacked.

The population of the HTP is about 100 million and it is increasing. Thus there is pressure on natural ecosystems such as water, food and
electricity which are provided for the mountain communities. Tourism also has a significant impact in some countries, such as Nepal. These pressures vary greatly with population density and culture. The alpine environment of the Himalayas is rich in biodiversity, but about 10% of the known species of the region are listed as threatened.

Economic development is affecting most communities of the HTP through a range of forces. The increase in urban areas is leading to the usual pressures on ecosystems and natural resources in the peri-urban areas. Even remote mountain communities are vulnerable to economic and governance changes as well as climate change. In many areas, market forces are affecting small communities that trade with neighbouring hubs, leading to price fluctuations that are difficult to manage in an essentially subsistence style of living. Formerly-nomadic communities are affected by changes in land tenure with the enclosure of pastures and by changes in governance that discourage traditional methods. Climate variability leads to unpredicted fluctuations in pasture and crops, that produce additional stresses for small communities. Change, with associated changes in temperature, precipitation and streamflow, is causing tree lines to rise, as well as cause increases in hazards such as glacial lake outburst flooding (GLOF) (Heath et al., 2013).

The governance of the ecosystems of the HTP vary with the type of human settlement, which varies from urban areas. There are cities such as Lhasa with a population of about 500,000 and Kathmandu with a population of about 700,000. Large cities tend to have some administrative autonomy, but central governments tend to provide policy making and infrastructure (Koshy et al., 2013).

Institutions like the International Centre for Integrated Mountain Development (ICIMOD) provide a mechanism for trans-national cooperation in the HTP region. The strategic framework of ICIMOD facilitates regional multi-disciplinary programs covering the themes of livelihoods, ecosystem services, water and air, and geo-spatial solutions. The Asia Pacific Network for Global
Change Research (APN) also funds multi-stakeholder projects aimed at improving the understanding and livelihoods of mountain communities; for example, a capacity-building project has been carried out with the indigenous people of the eastern Tibetan Himalayas to promote community based adaptation to change.

### 3.2.3 Coastal and marine ecosystems

Fisheries constitute one of the most important coastal livelihoods in Asia. Both subsistence and commercial fisheries are practiced, ranging from individual fishers to industrial-scale fishing. Fish are harvested largely for food. In 2009, 85.4 million tonnes (20.7 kg per capita) comprising two thirds of the world’s fish consumption were in Asia, of which 42.8 million tonnes were consumed outside China (15.4 kg per capita). Asia accounts for more than 87% of the world total with China alone having almost 14 million people (26% of the world total) engaged as fishers and fish farmers. Asia has the largest fishing fleet, comprising 3.18 million vessels and accounting for 73% of the world total. A large segment of this fleet is in the small-scale sector. Six countries in Asia, namely Bangladesh, China, India, Philippines, Thailand and Vietnam, account for over half of the marine-capture fish production in the Asia-Pacific region, a quarter of which is used for livestock/ fish food in Asia.

In most countries in Asia, fisheries are open access but there may be local restrictions. For example, regulation of mesh size of fishing nets, fishing restrictions and closed seasons (ban on fishing) may be implemented.

Global aquaculture is also heavily dominated by the Asia-Pacific region, which accounts for 89% of production in terms of quantity (China: 62% of world production) (FAO, 2010). Aquaculture production has driven habitat loss, over-exploitation of fisheries for fish meal and fish oil, and pollution. The unnecessary use of chemicals and antibiotics in aquaculture has also put fish at risk of disease outbreaks. A study of tsunami-affected coastal areas of
Indonesia, Malaysia, Thailand, Burma (Myanmar), Bangladesh, India and Sri Lanka showed that the major causes of mangrove deforestation were agricultural expansion (81%), aquaculture (12%) and urban development (2%) (Giri et al., 2008). The value of ecosystem services provided by mangroves has been found highly variable depending on the biophysical and socioeconomic factors.

Reef degradation is due to a number of causes such as the use of destructive fishing techniques, trade in live reef food and ornamental fish, reef mining for calcium carbonate production, siltation due to deforestation, sewage and waste loads, marine pollution and disease. Human activities are believed to threaten an estimated 88% of Southeast Asia’s coral reefs, jeopardizing their biological and economic value to society. The same is true of reefs in South Asia which provide large benefits through fisheries and tourism, especially in the case of the Maldives and Sri Lanka. Here, in addition to human activities, climate change is considered to be the most serious threat.

Integrated Coastal Management (ICM) is an important approach towards resolving conflicts over space and resource as well as jurisdiction in coastal areas. PEMSEA has worked extensively on ICM in eleven countries of East Asia partnering with various governments, organizations and institutions to address local-level problems through an integrated approach, moving away from conventional sectoral approaches of environment and natural resource management, towards an integrated ecosystem approach in coastal governance. Integrated Coastal Zone Management is the approach that has been used in other countries including Bangladesh and India. In a number of countries, land zoning for various activities has been used, but designation of protected areas of various kinds (ranging from community reserves to no-take

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1 PEMSEA: Partnership in Environmental Management for the Seas of East Asia
www.pemsea.org
marine protected areas (MPAs) has largely been the approach. In countries such as the Philippines, community based coastal resource management is being piloted by NGOs working with people’s organizations and other civil society institutions towards enabling communities to sustain their resources and livelihood. A similar attempt is being made in Thailand through the mangroves for the future initiative. Several areas have been designated as MPAs but not all are successful in the field because of various reasons.

A search in the Protected Planet\(^\text{1}\) database returned the following IUCN Category-wise results for protected areas in the marine eco-region of Asia; the total numbers include those located in countries of West Asia (e.g. Iran, Saudi Arabia).

<table>
<thead>
<tr>
<th>IUCN Category</th>
<th>Explanation</th>
<th>Number</th>
<th>Break-up Excluding West Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>Strict Nature Reserve</td>
<td>64</td>
<td>(Brunei-5, China-1, India-1, Indonesia-49, Malaysia-2, Sri Lanka-1, Taiwan-4, China)</td>
</tr>
<tr>
<td>IB</td>
<td>Wilderness Area</td>
<td>16</td>
<td>(India-1, Indonesia-4, Japan-8, Philippines-3)</td>
</tr>
<tr>
<td>II</td>
<td>National Park</td>
<td>171</td>
<td>(Cambodia-1, India-9, Indonesia-30, Japan-17, Republic of Korea-3, Malaysia-54, Myanmar-1,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pakistan-1, Philippines-11, Sri Lanka-3, Taiwan-4, China, Thailand-26, Vietnam-3)</td>
</tr>
<tr>
<td>III</td>
<td>Natural Monument or Feature</td>
<td>5</td>
<td>(Indonesia-1, Republic of Korea-1, Philippines-1)</td>
</tr>
<tr>
<td>IV</td>
<td>Habitat/Species Management Area</td>
<td>269</td>
<td>(Bangladesh-5, Hong Kong-2, India-105, Indonesia-28, Republic of Korea-54, Malaysia-3, Myanmar-3,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pakistan-3, Philippines-12, Singapore-2, Sri Lanka-10, Taiwan-3, China, VietNam-8)</td>
</tr>
<tr>
<td>V</td>
<td>Protected Landscape/Seascape</td>
<td>323</td>
<td>(China-41, Hong Kong-5, Indonesia-35, Japan-90, Republic of Korea-111, Malaysia-2, Philippines-20,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Timor-Lest-1, VietNam-1)</td>
</tr>
<tr>
<td>VI</td>
<td>Protected area with sustainable use of natural resources</td>
<td>213</td>
<td>(China-2, India-1, Indonesia-33, Malaysia-1, Philippines-176)</td>
</tr>
</tbody>
</table>

\(^1\) Protected Areas www.protectedplanet.net accessed 28 November 2013.
The South Asia region was ranked the lowest in the world in terms of declared marine and coastal protected areas in the 2003 United Nations List of Protected Areas. In addition, the inclusion of essential coral reef habitat in MCPA provisions is minimal, making the Indian Ocean, with its wealth of coral reefs, sea grasses, and mangrove forests, perhaps the most poorly protected ocean\(^\text{1}\).

### 3.2.4 Inland water ecosystems

In Asia about 30% of inland water systems have been drained for intensive agriculture, with a consequent loss of biodiversity and ecosystem services. Agricultural activities can lead to pollution of local rivers, with the impacts carried to downstream communities. Agriculture and urban communities draw on local rivers and associated groundwater systems, with over-extraction leading to subsidence in cities such as Bangkok, Beijing and Manila.

The inland water systems of Asia, which include over 200 million hectares of wetlands, support a wide range of biodiversity that maintains the quality of the water, provides food for communities, and is increasingly attracting tourists. However, many inland water species are under threat of extinction, including 74% of freshwater turtles and tortoises and 80% of freshwater cetaceans (Finlayson and D’Cruz, 2005).

An increasing use of the large rivers of Asia is the production of electricity through hydro-electric generators based at major dams. China and India are planning to construct many dams along the rivers from the Himalaya-Tibetan Plateau region. Both the local and downstream impacts of these constructions have not been fully analysed. However, past river modification in Thailand and China has had adverse effects on riverine mammals and fish stocks.

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Carp have been introduced to inland fisheries in China, sometimes to the detriment of indigenous species of fish. In 2004 China accounted for 25% of total inland-capture fisheries, with India and Bangladesh accounting for another 15%. China also has significant investment in inland water aquaculture, which can lead to habitat degradation if good management practices are not followed. Over-harvesting of vertebrates, such as turtles and water birds, for food, medicine or recreation has caused substantial population declines in South and Southeast Asia (Heath et al., 2013).

The state of inland water ecosystems implies that governance has not been particularly effective across most of Asia. However, regulation of inland waters has been improving in some parts of Asia in recent years. For example, a UK-supported project in Bangladesh (Oxbow Lakes Small-Scale Fishermen Project) has allowed poor fishers to have equitable access to inland waters. Providing long-term lease arrangements to poor fishers has meant that they not only have catches sufficient to maintain their livelihood, but also that they have incentive to invest in protecting the inland waters.

A novel initiative of the Asian Development Bank is the promotion of inland waterways for the transport of people and goods in order to reduce road traffic and to increase cross-border trade. The initiative is being taken up in Indonesia, Vietnam, India and China.

Perhaps the greatest challenge for governance of the inland waters of Asia is management and planning for the large trans-national rivers of the region. The Indus Waters Treaty is an example of an effective mechanism for cooperation between nations (India and Pakistan) to ensure the sharing of water from rivers that cross nation borders. The Abu Dhabi Dialogue has provided a forum for multi-national discussion on the sharing of water from rivers of the Himalaya-Tibetan Plateau. However, formal multi-national mechanisms are needed to ensure that planning and management of cross-border rivers of Asia is carried out in a cooperative framework.
3.2.5 Dryland ecosystems

Owing to an overall lack of data on dryland ecosystems, the information on the management and use of these areas has some uncertainty. It appears that about 17% of the drylands of Asia are degraded, with perhaps 50% of the Tibetan Plateau degraded by overgrazing. Degradation of drylands, especially desertification, leads to impacts in other areas due to transport of dust and sediments and due to migration of people from drylands when they lose their livelihood. Infant mortality in the drylands of Asia is about 35%, which is higher than in other ecosystems of the region. The lack of health services and infrastructure is seen to be a significant reason for this anomaly (Safriel and Adeel, 2005).

Agriculture from the drylands of Asia often provides substantial contributions to national gross domestic product (GDP). For example, the drylands of India generate over 45% of total agricultural production, and over 30% of the GDP of Pakistan comes from dryland agriculture. Grazing of livestock is also a major use of drylands in Asia; for example, grazing provides about 25% of the GDP across Asia.

Many traditional practices support sustainable ecosystem services in the drylands of Asia. Such practices include water harvesting and storage, afforestation to control soil erosion and diversification of crops. These practices need to be supported by community institutions that enable technical innovation and interactions with markets.

A continuing threat to the sustainability of dryland ecosystems in Asia is climate variability and change. Dryland communities have generally learned to live with the huge inter-annual variability of rainfall. However, climate change as well as changes in the socio-economic environment(such as land enclosures and global markets) poses an additional stress on vulnerable communities.

It is interesting to note that much of the development activity on dryland
ecosystems of programs like the Drylands Development Centre of UNDP is focused on Africa. However, recent initiatives in Asia include a project on an Integrated Strategy of Sustainable Land Management in Dryland Ecosystems of the Asian Development Bank with China which aims to build on an existing decade-long collaboration to prepare a strategy and action plan to improve productivity in dryland regions. The collaboration has included pilot projects to promote sustainable land management practices, the development of infrastructure to support those practices, and policy development to underpin long-term support (Mortimore, 2009).

### 3.2.6 Small island ecosystems

A common feature of small islands is their isolation, which leads to diversity in natural and human systems across the region but a lack of speciation on individual islands. Subsistence livelihood is common in many rural areas of small islands based on either agriculture or fishing. Coastal fisheries are a major source of food for small island communities, and overfishing has had significant impacts on both subsistence and commercial fishing in Asia and the Pacific. Where there are commercial activities, they are often vulnerable to market pressures arising from their isolation. The smallness of island economies, including narrow resource bases, contributes to this vulnerability. Even the cities of small islands are small by world standards, and about 25% of the population of Pacific islands live in urban areas. Urban planning tends to be minimal (Wong et al., 2005).

The small islands of the Pacific generally have some form of parliamentary democracy. Kinship relationships tend to be important in all aspects of social organisation, including land tenure.

Biodiversity on many small islands is under threat from the growth of human populations which can be over 2% per year. While traditional fishing was sustainable, modern methods are depleting the fish stocks of many small islands. Fresh water supply and waste disposal are often critical issues in the
islands of the Pacific. Saline intrusion on groundwater lenses is a major threat, as increased population and agricultural activities lead to excessive withdrawal of fresh water. This threat is exacerbated by natural disasters, such as storm surges (Koshy et al., 2013).

Climate change is a significant threat to small island communities and natural ecosystems. Biodiversity tends to be finely adapted to the local environment with little speciation, making it very vulnerable to relatively rapid changes due to global warming. Sea level rise has been a continuing concern of the small islands of the Pacific. While the gradual rise of sea level will threaten the overall habitability of many islands, more immediate threats come from inundation of fresh-water lenses associated with extreme events such as storm surges (Heath et al., 2013).

The small island developing states of the Pacific and Indian Oceans have contributed greatly to the international negotiations of the United Nations Framework on Climate Change Convention (UNFCCC). The Pacific Islands Framework for Action on Climate Change 2006–2015 provides a comprehensive and informed approach to strategies to mitigate and adapt to climate change at national, regional and international levels. Within this framework, there have been many projects aimed at facilitating adaptation to climate change on small islands. A major initiative is the Pacific Adaptation to Climate Change (PACC) program, which began in 2009 and involves 14 island countries and territories. The program promotes coordinated activities that identify practical adaptation measures, incorporate climate risk management into national planning, and effectively communicate information on climate adaptation (SPREP 2011, 2013).

3.2.7 Agriculture ecosystems

The development of civilisation is founded on the development of agriculture, and so agricultural practices and societal practices are often tightly connected. In Asia there is a close link between agricultural systems
and human culture; for example, there are rituals associated with the seasonal cycle of rice production in Indonesia.

Over the last decades of the 20th century, cropland has expanded over much of Asia but in some areas, such as Japan and eastern China, urbanisation and even reforestation have reduced croplands. In Asia and the Pacific, rain-fed agriculture accounts for about 70% of the total arable land and accounts for a significant fraction of national GDP. Small-holder agriculture with mixed crop-livestock farming accounts for 95% of livestock across Asia. This strategy of diversity allows farmers to exploit the multiple purposes of livestock in rural societies and to sustain their livelihoods. In some areas (for example, Indonesia and Bangladesh) cooperative systems can evolve to develop more intensive production and more effective interaction with external markets. Large-scale livestock systems and large-scale cropping systems are also being developed in Asia to accommodate the increasing population and socio-economic standards (Cassman and Wood, 2005).

Irrigation systems have significant water losses through leakage and evaporation. The water efficiency of irrigation systems varies from 25% to 45% across Asia, with about 40% in India and China but 50%–60% in Japan and Taiwan, China. Across all agriculture in Asia, water-use is not very efficient, and some studies have shown that re-introducing traditional practices of water conservation can improve overall water efficiency. The proposed increases in dam construction for hydro-electricity production on the major rivers from the Himalaya-Tibetan Plateau could threaten downstream agricultural systems, and regional cooperation will be needed to optimise water-use along these rivers. As water becomes more scarce, it will be necessary for agricultural productivity to increase not just through increased production per hectare but also through increased production per kilolitre of water (Heath et al., 2013).

All agricultural ecosystems, from a subsistence farm to a large plantation, are managed and the quality of the management is determined by the incentives to drive the manager. The demand for food increases with
population and with socio-economic standards: population growth accounted for only 60%–70% of the total increase in calories from 1961 to 2002. Over the forty years to 2000, 80% of the increase in agricultural output in South Asia was due to yield increases (the Green Revolution).

Poverty limits the ability of small-holder farmers to improve agricultural practices, and can lead to a continuing degradation of productivity. Policies on land tenure and food security can have a significant impact on the long-term viability of agricultural lands. Government investment in China in infrastructure, research and education has led to agricultural growth, as well as poverty reduction. On the other hand, labour productivity across Asia has not been high by world standards.

The Asian Development Bank has many projects aimed at responding to the need to feed the 600 million hungry people of Asia. Programs are evolving from direct support for improved agricultural practices to a multi-sectoral approach to the underpinning of food security. For example, a recent study on management of grasslands in Mongolia examines the vulnerability of nomadic pastoralists to climate change and proposes adaptation strategies extending from livestock husbandry to government policies (ADB, 2013).

3.2.8 Urban ecosystems

Over half the world’s urban population lives in Asian cities. The continuing trend of urbanisation in Asia is driven largely by people migrating to improve the livelihood and well-being of themselves and their families. Cities are the centres of industry, commerce and trade, and they generate much of a nation’s GDP. The driving forces for economic growth in Asia tend to be exports, urban infrastructure and services, and commerce between cities nationally and internationally. Domestic markets are also growing in some countries, and exports are evolving from basic manufacturing to knowledge-based products and services. Over the twenty years from 1990, service sector employment in Asia increased from about 25% to 35%, while agricultural
employment fell from about 55% to 40% (Marcotullio, 2013).

In many countries of Asia, their mega-cities are the centres of economic, financial and political power. Mega-cities are also often becoming urban corridors that link whole regions, such as the area of the Pearl River Delta of China and the proposed Delhi-Mumbai Industrial Corridor of India. Such regions require a governance regime that allows for coordination across jurisdictions for planning and management. Across Asia, smaller cities often have some local autonomy, but central governments tend to maintain authority over many aspects of finance and administration.

The economies of Asian cities often have large informal sectors, which tend to support the transition from a developing to a developed economy. The informal sector grows as a result of inadequate administrative systems and the absence of regulatory frameworks. The sector, which by definition is difficult to monitor, can give rise to poor working conditions especially for women and to the loss of revenue for city administration and infrastructure (Marcotullio, 2013; ESCAP, 2005).

The challenges for sustainability in Asia can essentially be equated with the challenges for sustainable cities in Asia. Urban areas are the prime consumers of water, food and energy, and the prime sources of greenhouse gas emissions and air pollution, as well as the prime generators of national economic wealth. A key challenge for Asia is the development of urban designs that at the one time support the economic activities required to enhance the wealth and well-being of the population, while minimising the impact on the environment. This challenge is a substantial component of the overall strategy for “green growth”, which requires an integrated approach to the design, implementation and management of urban infrastructure and services, as well as to the policy settings for the promotion of relevant commercial activities and capacity building.

The delivery of sustainable services will require new approaches; for example, effective water services will depend upon better use of natural
rainfall and better disposal of waste material (water-sensitive cities). Water availability is especially important for poorer communities, who are vulnerable to health hazards from a lack of drinking water and the treatment of waste. Indeed the availability of drinking water declined in some countries of Asia between 1990 to 2008 (OECD, 2013; Dahiya, 2012).

The interactions between urban and peri-urban areas need to be optimised to reduce transport costs for food, other goods and commodities. Governance will be a key issue, to ensure that benefits are equitably and efficiently distributed; in particular, education and poverty alleviation need to be linked to sustainability. Associated with governance is the development of effective policies to secure land tenure and fund the provision of infrastructure and services. Public-private partnerships have already been used in China, India and Indonesia to support housing construction.

Climate change gives rise to a further challenge for the cities of Asia. Urban design, aimed at eliminating the urban heat island effect and air pollution, will be a critical aspect of effective strategies. Increasing frequency of heat waves, with prolonged high over-night temperatures, are likely to increase morbidity, especially for the very young and old. The coastal mega-cities of Asia are particularly vulnerable to storm surge associated with sea level rise, as well as flooding from inland storms.

3.3 Human Security

3.3.1 Water security

Water is at the nexus of the coupled nature and human systems, connecting human consumption, agricultural irrigation, and hydropower generation through important geophysical and bio-geochemical processes in the atmosphere, oceans and land. Water is one of the most important elements for human development and therefore human sustainability. Under
changing climate and rapid human development, water security has been threatened in numerous ways that require immediate attention in order to ensure a sustainable future earth.

**Challenges and priorities**

Challenges in water security come from both quantity and quality perspectives (as well as regulation and regional coordination), as water is one of the most shared natural resources. The quantity is primarily shaped by water availability and accessibility. Increased extreme climate events such as droughts and floods drastically change water availability, particularly at the time of high demand during growing seasons, which has significant implications for food and human sustainability. Continued glacier retreat in the Himalayas (the “Asian water tower”) has significant implications for water supplies to major rivers in Asia that change the dynamics of water resources and water availability for human use. Human alterations to hydrological processes (including diversion of water through canals and construction of hydropower dams) aim to control floods, conserve water, generate power, and irrigate crops. However, these human alterations also alter the hydrological processes, changing water distribution that affects the accessibility of different communities and nations. The water cycle is also changed at regional to global scales, especially through evaporation processes. Urbanization is another major issue that affects water security. As populations are concentrated in cities, water supplies become a major issue as consumption patterns shift dramatically while urban development continues in Asia.

In addition to the quantity, water quality is another important aspect of water security. As urbanization continues, agricultural intensification through irrigation, tighter controls of water flows through dams, water pollution and contamination make the already scarce water less accessible and useable. Further, it also has significant implications for human health due to poor water quality. Sanitation technology, availability, and adoption for water treatment is another major issue that requires attention especially in less
developed countries and communities.

The challenges of water quantity and quality are further exacerbated by water rights and governance. There is lack of effective policies on water rights and ownership, and this is even more complicated when water is shared by different communities, administrative units and nations. The knowledge generated by the scientific community has not been effectively linked with the specific needs of stakeholders for water, including water conservation, protection, utilization and sharing.

3.3.2 Food security

Food security is at the heart of sustainability. There is a clear need to ensure sufficient, safe food supplies to meet the changing demands of an ever increasing population.

Food security is shaped by three connected systems; 1) the food production system from agriculture, aquaculture, marine-culture, and livestock sectors, 2) food demand, processing and distribution systems of changing urban and rural populations, and 3) food safety from contamination during the production and processing stages. The pressures on the production system include both geophysical and human induced changed. The seasonal monsoon has a major influence on agriculture across Asia. Recent changes in extreme climate events, shifts in climate seasonality, changes in water resources and hydrological processes, and latitudinal shifts in environmental niche characteristics suitable for fisheries, livestock and crops have direct impacts on agriculture, aquaculture, marine-culture, livestock for food production. For example, monsoon floods in 2010 caused a significant reduction in paddy rice in Thailand, leading to a sharp rise in price that was felt around the globe.

These geophysical processes also interact with human systems to further escalate pressures to increase food demand. Economic development, population growth, industrialization, increases in trade, changes in land
tenure systems, and lifestyle changes (such as shifts in diet) not only increase the pressure for food but also change the way food is processed and distributed.

In addition to these pressures, food security is further threatened by food safety resulting from contamination at the production stage, such as pesticide applications as well as contaminated soil and water from mining, industrial discharges of toxic materials. Contamination of food occurs also at the processing stage where artificial additives are used to enhance flavor, color, and preservation. Expired foods are often distributed to customers without acknowledgement. While food labeling is theoretically regulated in many countries in Asia, enforcement may not be strict.

**Food security gaps and priority areas**

Innovation is needed to support food security in a changing climate, with a focus on production systems, including cropping systems, aquaculture, marine-culture, and livestock. These systems should be analyzed to diagnose constraints, opportunities and scalability of innovations to support resilient and sustainable food production systems. Integrated assessments are needed to estimate uncertainty in the climate/agricultural/human decision-making system, and to identify possible areas to reduce uncertainty for a) livestock systems, b) cropping systems, c) aquaculture and marine-culture at local and regional scales. Assessment of the current state of crops or livestock or fisheries, climate, land use, and human decision making/management models are needed, and exploration of the sensitivities of the combined systems to plausible future climate scenarios would help guide the development of food sustainability strategies. Identification of thresholds/tipping points or of transformational adaptive states are required to minimize food production risk or food security risk. Alternative food production systems such as oceans should be further explored. Urbanization and migration and the way they impact food demand and distribution should be quantified. As globalization continues, global analyses are needed to assess the food security issue at the
regional level, as food demand often results from remote communities and even countries.

3.3.3 Energy security

Asia plays an important role in the world energy system. Asian economies have dramatically developed in the last two decades which has caused a corresponding increase in energy demand. There are expectations of further economic and population growth in the region, which will fuel demand in the energy sector (ASEAN Energy Outlook, 2011). This implies a need for significant investment and a challenge for energy in the period ahead (Asian Development Outlook, 2013). A problem for the region is that despite becoming a strong driver of global energy-demand consuming 68% of the world’s coal, 18% of natural gas and 32% of oil in 2012, Asia contains a disproportionately small share of energy resources, containing only 21% of the world’s coal, 6% of its gas and just 2% of its oil on the basis of proved reserves (BP, 2013). Furthermore, demand is predicted to rise much further, on the back of continuing economic growth (IEA World Energy Outlook, 2013), with proven reserves of fuels unlikely to keep pace. Asia’s huge rise in energy demand and expected fossil-fuel use make grim reading for emissions control efforts, as this would double carbon dioxide \((\text{CO}_2)\) emissions to over 20 billion tonnes by 2035 (Asian Development Outlook, 2013). By 2035 the share of Asia’s energy in world consumption is expected to be between 51% and 56%.

Across Asia there is high variability between the level of economic development (a strong indicator of energy demand) and available domestic energy resources (both renewable and conventional). The region is host to some of the smallest and largest countries by area and by population. It contains the two most populated countries in the world (India and China). It is also home to a disproportionate population of developing countries, with only around 30% of the world’s GDP in Asia, while it also contains two of the
largest economies (Japan and China). In line with the variability in economic development and resource availability, the quantity and mix of energy utilised across Asia is highly varied (Fig. 3-1).

Energy security is generally defined as the level of “self-sufficiency” or the amount of energy that is produced domestically (rather than imported) and the ability to continue to supply the demand for energy across an extended period of time. In the current context, we will consider energy security largely from the perspective of available domestic resource, but will also consider the feasibility of regional Asian energy supply and vulnerabilities induced by certain energy trends. One example of energy security is the index of energy self-sufficiency (data sourced from the International Energy Agency, IEA non-OECD 2010, IEA OECD 2010)—this is the ratio of domestically produced energy to total energy consumed. Fig. 3-2 shows the energy self-sufficiency across all forms of energy, where an index greater than one indicates that in addition to being self-sufficient the country exports more energy than it uses. The data show that across Asia as a region, the level of self-sufficiency is high (close to one) although the OECD countries of Asia and Oceania are much less self-sufficient particularly in the case of Japan, which is close to 0% self-sufficient (or nearly 100% dependent on imports to put it another way). Such energy self-sufficiency can be broken down by energy source, as shown in Fig. 3-3, highlighting that there is a great disparity between the self-sufficiency of Asia with regards to oil as compared to other energy sources. The importance of oil in transportation, as well as the increase in motorised transportation associated with economic development, is one reason for the focus on oil with regard to energy security. Asia’s dependence on Middle-East oil will continue to grow rapidly over the next two decades, making countries in the region increasingly vulnerable to supply shocks, while continuing to increase the emissions of greenhouse gases. Asia’s oil imports are expected to almost triple to over 31 million barrels a day in 2035, from 11 million barrels a day in 2010, (growth of around 4.2% a year). Asia’s use of coal will likely
increase by 81% by 2035, while natural gas use will more than triple (Asian Development Outlook, 2013).

![Energy mix and total energy consumption in selected countries of Asia](image)

**Fig. 3-1** Energy mix and total energy consumption in selected countries of Asia (BP, 2013)

![Energy self-sufficiency in regions of Asia](image)

**Fig. 3-2** Energy self-sufficiency in regions of Asia (IEA non-OECD, 2010; IEA OECD, 2010)
The challenges and benefits of energy can be widely considered within the International Energy Agency’s (IEA’s) framework of the “3E’s”-energy security, economic development and environmental protection. Both economic development and environmental protection are key elements that are affected by and affect energy security. The linkage of energy and economic development is apparent for example, in Fig. 3-4, which shows the energy per capita and GDP per capita of countries of the Association of South-East Asian Nations (ASEAN) and Japan. Countries with a higher GDP per capita, generally indicative of economic development, tend to have a higher energy usage per capita. It is also apparent that energy can be a driver of economic and social development; countries such as Brunei Darussalam for example, are highly dependent on energy exports (oil and gas) for income. One of the most important considerations of economic development with regards to Asian energy security is the fact that so many countries are still developing. The countries at the bottom left hand corner of Fig. 3-4 are examples of countries whose GDP per capita is very low, and which could be expected to develop towards the upper right of the chart, in line with the higher GDP nations of Brunei, Japan and Singapore. In the case where these economies follow the general pattern of using cheapest available energy technologies to fulfil the
growing demand, they are likely to end up utilising far more energy than at present.

![Graph showing TPES and GDP per capita for ASEAN countries](image)

**Fig. 3-4** Total primary energy supply (TPES) and Gross Domestic Product (GDP) per capita for ASEAN countries

Modernisation of Energy Sources

In line with economic growth, the people living in developing nations of Asia have expectations of improved standards of living. One of the key elements of this with regards to energy security is the provision of cleaner modern fuels and the potential for alleviating health, poverty and environmental problems through these. Traditional fuels, such as dung and firewood are known to be causes of respiratory illness, especially in women in developing countries, whose role it is often to cook, typically indoors with poor ventilation. This can be somewhat alleviated through the utilisation of cleaner-burning fuels such as kerosene and natural gas (preferred but less available) and ultimately through electrification. The use of modern fuels is considered an important indicator of development (IEA World Energy Outlook, 2013), and associated benefits such as improvement in education due to lighting, and reducing the firewood collection burden on children, is also highlighted. In many countries suffering from overpopulation, drought or domestic conflict, the required time and distance for collecting firewood has
increased, which has affected both the local environment and populace, generally reducing resilience. The Energy Development Index (EDI) developed by the IEA, is modelled off the Human Development Index (HDI) established by the UN. The EDI of countries considered to be highly developed is 1, while for developing countries the EDI is typically lower. The EDI and two of the key indicators are shown in Fig. 3-5 for Asian developing nations.

![Graph showing Energy Development Index (EDI) and related indicators.](image)

**Fig. 3-5** Indices of energy development and the Energy Development Index (EDI)

*(IEA World Energy Outlook, 2013)*

**Electricity**

The utilisation of electricity in the home is important. However, electricity is also a strong enabler of commercial and industrial growth. Figure 3-6 shows the electricity consumption per capita in various sub-regions of Asia. This again shows the disparity between the more developed economies and the developing countries. Electricity is generally a largely-domestic industry, although areas such as the EU and parts of ASEAN are interconnected. Increased electricity consumption as a substitute for alternative forms of energy supply improves energy security if it is produced from hydro, other renewables or nuclear power. However, the cost of installing infrastructure may be prohibitive for many developing nations. Moreover, a four-to-eight-fold increase (to reach the level of OECD Asia) in electricity consumption will
have a significant primary energy burden associated with it, and a significant environmental impact if sourced from coal and oil. If primary energy is sourced beyond the borders, then this will also have a significant energy security risk associated with it.

![Electricity consumption per population in regions of Asia](image)

Fig. 3-6 Electricity consumption per population in regions of Asia

(IEA non-OECD, 2010; IEA OECD, 2010)

**Non-resource energy security challenges**

There are some key challenges affecting energy security beyond the traditional issues of available reserves and energy imports.

“Even if Asia is able to secure enough physical energy supply, there remains the question of whether it can do so while safeguarding environmental sustainability and ensuring affordable energy for all.” (Asian Development Outlook, 2013)

Emerging energy security issues are gaining in importance, including

- Environmental protection (both climate change and local environmental concerns)
- Energy safety (particularly with respect to nuclear energy in the post-Fukushima period)
- Rapidly shifting energy markets, and the reduction in the cost of
natural gas and renewable energy technologies (induced in large part by the shale gas expansion in the US and renewable energy tariffs in the EU respectively)

- Regional transboundary and territorial conflicts.

With regards to environmental protection, most of Asia’s developing countries are suffering from high levels of local air and water pollution, to which energy activities contribute significantly, particularly with the dependence on combustion of coal for electricity and oil in the transportation sector. Technologies to reduce the pollutants from centralised electricity generation are regulated in developed countries, but the rapid demand growth and relatively less-mature energy regulatory system, in addition to cost pressures, may lead to an uptake of relatively inefficient and polluting technologies. This becomes an energy security risk if later government or international agreements require these operations to be shut down. The Clean Development Mechanism has been one method to encourage technology leapfrogging so that developing nations can utilise better, more efficient and cleaner technologies, but this will not solve all of the problems.

Energy safety has been highlighted again in the wake of the Fukushima nuclear accident, and has shifted policy to a varying degree across Asia and the world (Hayashi and Hughes, 2013; Wittneben, 2012). In Asia, a number of countries have reconsidered their plans to use nuclear power, while in others (China for instance) no change was made. Energy security through nuclear power was one of the key elements of Japan’s energy strategy over the past 40 years, but that strategy has been called into question (McLellan BC, et al., in press, Vovida V, 2012) and it is uncertain when and if public confidence will be restored. The Asian region is subject to a wide range of natural disasters, many of which are expected to be exacerbated by climate change, and energy security requires the consideration of infrastructure robustness and resilience to prevent loss of supply.

Other forms of energy have also struck challenges with consumer
acceptances; for example the controversy over shale gas “fracking” in the USA and Canada, coal seam gas (CSG) in Australia and biofuels in Indonesia, with conflict over the use and impact on farmland in the first two cases, and the impact on forest and food security in the latter case.

Rapidly shifting markets, particularly spikes in the price of oil over the past decade and then the rapid decline in gas and coal prices due to the shale gas boom in the USA have made investment decisions more risky. They have also made the cleaner option of natural gas more attractive, whilst declining coal prices may increase domestic consumption. Prices for renewable energy technologies have also been driven down, through ongoing demand in Europe and rapid production in China, which could be positive for energy security if investment takes place in developing countries. The potential for methane hydrates extraction, currently being trialled in Japan, could open up an entirely new era of low cost natural gas for Asia if it is effectively and economically achieved.

Two of the major issues for the Asian region are transboundary effects and the impact of territorial conflict. The close proximity of Asian nations makes potential energy trade within the region a likely and useful security measure, especially for countries that may have little in the way of domestic energy supply. There is a strong trade of electricity within the ASEAN nations, and there have been gas pipeline and high voltage electricity transmission plans even between China, Korea and Japan. However, many of these projects have failed to come about due to ongoing territorial disputes (particularly islands in the South China Sea). Moreover, the potential for political trade interference and cutting-off of energy supplies make current supply of fuel and potential cross-border infrastructure a high risk to energy supply. The disparate nature of the region, and the varying definitions of what Asia consists of, are also hindrances to EU-style cooperation. There are also projects which may have associated environmental impacts, such as dams on the Mekong river which may affect livelihoods of downstream neighbours,
that could otherwise improve energy security. These projects highlight the interconnectedness of the region, and the need for cooperative negotiation.

There are several reports on the analysis of energy efficiency or energy intensity in Asia (Asian Development Outlook, 2013; APERC, 2013; IEA ERIA, 2013), and various academic reviews of policy and technology within the area whose main points are highlighted here.

(1) Energy efficiency
(a) Most countries in Asia recognise that improvement of energy efficiency is one of the key factors for sustainable development and energy security (ASEAN Energy Outlook, 2011; Lee et al., 2013)
(b) Energy subsidies in some Asian countries remove the incentive to save energy, whilst nominally supporting economic growth (Asian Development Outlook, 2013)

(2) Renewable Energy
(a) Feed-in-tariffs are seen to be one of the best policy mechanisms for renewable energy expansion (Sovacool, 2010)
(b) Biofuels have had a strong investment and are argued to be a potential way towards lower emissions (Lim and Lee, 2011), but have also caused conflict on food and rainforest preservation grounds, as well as uncertainty in their overall efficiency.

(3) Environment and emissions
(a) Causal relationships between energy consumption and economic growth have been determined (Lean and Smyth, 2011), with indications that economic growth under the current paradigm leads to environmental damage and increased emissions (Saboori and Sulaiman, 2010).
(b) Fossil fuels are being relied upon to a greater degree to fill the gap in energy supply associated with economic growth (Bakhtyar et al., 2013).
(4) Regional cooperation and conflict

(a) Asia has strong potential for energy interlinkages and cooperative growth of energy industries (Asian Development Outlook, 2013; Lim and Lee, 2011; Carroll and Sovacool, 2010)

(b) Lack of regional agreement on technical specifications will block expanded cooperation and cross-boundary trade in energy

(c) Various opinions and stakeholder perspectives must be incorporated, particularly in areas such as the Mekong where hydropower installations can have significant cross-boundary effects (Chang, 2013).

(d) Conflict, ideological and territorial disputes may hinder progress, and present significant barriers to energy supply security for many countries.

Asia must both contain rising demand and explore cleaner energy options, which will require creativity and resolve, with policy makers having to grapple with politically-difficult issues like the abolishment of fuel subsidies and regional energy market integration.

Promoting support for renewable energy technologies is also an important step towards energy security. Next generation wind, solar and biofuel technologies, are expected to be more cost competitive than current options and may offer potential solutions. One of the keys to energy security in the region must be cooperative development and technology transfer from the developed to developing nations, in order to reduce the overall burden on energy supply as these economies develop.

Oil consumption in the region could be reduced by eliminating inappropriate government intervention in oil markets, removing price distortions and allowing market prices to reflect the true cost of oil. Tax benefits and incentives should be designed to encourage the use of energy-saving goods and services, such as hybrid automobiles, and to support increased use of renewable energy. In addition to these “carrots”, policy
minders will need to introduce “sticks” such as higher taxes on excessive energy consumption and higher mandatory standards for automobile fuel efficiency. However, these approaches are often unpopular.

3.3.4 Health and wellbeing

Access to high-quality services for health promotion, prevention, treatment, rehabilitation, palliation and financial risk protection cannot be achieved without evidence from research (WHO, 2013). The WHO further recommends the promotion of health systems research as the third pillar of medical research, complementing biomedical and clinical research. Developments following the Rio+20 United Nations Conference on Sustainable Development suggest that health systems research in the context of global sustainability need to also focus on the connections between policies that affect health via different sectors of the economy, and not concentrate just on the relations between the environment and health.

At the global level, unsafe water and poor sanitation have fallen in importance in the ranking of risk factors contributing to ill health (WHO, 2013). In Asia the main environmental risk factors identified include indoor air pollution, largely from the use of solid fuels in households, and outdoor air pollution, which facilitate and exacerbate lower-respiratory infections. Other risk factors include injuries arising from hazards in the workplace, from radiation and from industrial accidents. In addition there are re-emerging vector-borne and infectious diseases such as malaria and tuberculosis that are often associated with policies and practices on land use, deforestation, water resource management, migration, settlement siting and house design. It is also known that health policies whose primary objectives are to address environmental threats can also yield major health co-benefits, and research on health systems has been shown to play an important role in advocating for such policies.
There is a need for a more holistic understanding of health systems for global sustainability in Asia where about half the world’s population resides. The region is substantially urban, and urbanization is increasing rapidly with more than 40 million people being added to the urban population each year. About 50% of these people are below 25 years of age (ROAP, 2011). Policy makers in the region need to take into account the growing material aspirations of the people while planning developmental activities with improved environmental and health safeguards.

**Challenges and priorities**

A new conceptual framework for considering the multi-factorial nature of both the determinants and the manifestations of health and wellbeing, especially in urban populations, has been proposed by ICSU (2011). Research under this framework should address, within an inclusive and multi-level ‘ecological’ frame, major health risks or outcomes associated with the changing environment. Strategically, the results of such research should be amenable to systems analysis and, importantly, the analyses and interpretation should facilitate policy responses.

The long-term policy impacts of health research should be identified and the potential for strengthened research and decision-making capacity should be evaluated at the beginning of any research program on health. Multiple aspects of health, especially urban health, are simultaneously researched along with other relevant natural and social science and other implementation issues in order to generate understanding and knowledge products useful to policy-makers.

There is an increasing need to understand better the relations between health and agricultural practice, education, finance systems, and the effects of social policy on health. Coupled with this is the need to have better access and sharing of appropriate data and indicators on health in Asia. The need to understand how the integrity, diversity and functioning of ecological and evolutionary systems can be protected and managed so as to equitably enhance
human health and well-being while maintaining life and ecosystem services on earth is a priority issue.

**Emerging Infectious Diseases in Asia**

The emergence and rapid regional or global spread of “new” infectious diseases such as Nipah, SARS, different types of avian influenza and MERS CoV in the past 15 years have raised the specter of pandemics with mass mortality and enormous economic cost. Some of these diseases appear to have disappeared (SARS) or been brought under control, while avian influenza H5N1 has become endemic in birds in several countries, with a trickle of human cases continuing to occur. Recent research shows that many parts of Asia (including much of China, South Asia and Southeast Asia) are important focal regions for such disease events, ranging from the emergence of pathogens from wildlife or domesticated animals, to vector-borne diseases and drug-resistant pathogens (Jones et al., 2008). This the result of a set of interrelated region-specific drivers, including the presence of diverse pathogens, high density, proximity and mobility of people and animal disease reservoirs, and land use and other transformations of ecosystems (Coker et al., 2011). Thus, the processes of disease emergence and spread are rooted in structural characteristics of the region. Under these circumstances, it is most likely impossible to prevent the emergence of new pathogens or eradicate those entrenched in animal populations. High mobility of people and trade in animals and animal products in a globalized world mean that the potential disease threat may reach far beyond the Asian region.

**Research priorities**

(1) How can the planning of land use, food production, transportation, and mobility be improved to reduce threats from new pathogens?

(2) How can societies become better prepared for and able to manage the consequences of the emergence of new diseases?
References


Carroll T., Sovacool B. 2010. Pipelines, crisis and capital; understanding the contested regionalism of Southeast Asia. The Pacific Review. 23: 625-647.


Cities. 29: S44-S61.


Chapter 3  Asian Development


SPREP. 2013. Adapting to climate change in the Pacific; the PACC programme. SPREP, UNDP, pp42.


Chapter 4

Cross-cutting Capabilities

4.1 Introduction

The Initial Design Report for Future Earth (2013) gives a detailed account of the several cross-cutting capabilities that will need to be developed and promoted to support Future Earth globally. Recognising the comprehensiveness and the relevance of that discussion to Asia, we focus on just four cross-cutting capabilities that are especially important for this region.

As the defining feature of Future Earth, we consider the challenges involved with the implementation of research within the framework of co-design, co-production and co-delivery. This framework poses particular challenges for Asia which has many different cultures and structures for governance. Future Earth will depend upon many sources of data to support its research. The sharing of observations of geophysical, ecological and social systems will be needed to ensure the validity of trans-disciplinary research results. However, the mutual benefits of data sharing have not yet been accepted across all relevant communities in Asia. The transformations needed to move societies towards sustainability will require major developments in education within both the research community and the broader community. The differences in culture and socio-economic development across Asia mean that special efforts will need to be taken to develop appropriate educational frameworks. The socio-economic differences will require focused capacity
building to ensure that all communities benefit from Future Earth. The networks for Future Earth will inevitably be complex, as they need to ensure effective communication among many stakeholders from a range of communities. These networks, building on existing links and organisations, will also provide the basis of comprehensive capacity building.

4.2 Co-design, co-production and co-delivery

Co-design, co-production and co-delivery of trans-disciplinary research activities are key aspects of Future Earth. Co-design entails articulation of the research challenges and overarching research questions through deliberative dialogue among researchers and relevant stakeholder groups in the formative stages of research. Co-production links the scientific knowledge-generating processes with implementation actions by the stakeholders. Dialogue and discussion with stakeholders happen not only in the design stage, but also in revisiting and adjusting the research activity by evaluation of its impact on stakeholders. A major feature of co-production is the assurance of “no surprises” for stakeholders as research results emerge. To transfer the scientific knowledge to broader communities and the public, co-delivery is necessary to promote the outcomes of co-design and co-production.

Setting up solution-oriented research can be beneficial to both stakeholders and scientific groups, the successful co-design will be based on mutual-benefit and mutual-trust relationships with various stakeholders. The transparency of the co-design process, including open access to information, can help to establish long-term engagement with stakeholders. Joint dissemination of co-designed products with stakeholders will bridge the gaps between scientific groups and the public. There is no fixed model for co-design, co-production and co-delivery. A key aspect of Future Earth will be learning by doing and sharing of successful experiences, as projects evolve with their different objectives and strategies.
Chapter 4  Cross-cutting Capabilities

Co-design, co-production and co-delivery are highlighted as the major mechanisms through which Future Earth will add value. Experience in Asia on practical implementation of research co-design is relatively sparsely documented. At this early stage of planning for Future Earth in Asia, the following preparatory steps are recommended:

1. Identify case studies of past experiences with co-design, co-production and co-delivery in Asia and undertake a meta-analysis of such experiences.

2. Based on the meta-analysis and through extensive consultations, develop guidelines for co-design, co-production and co-delivery of research.

3. Develop broad regional ownership for the Future Earth in Asia Science Plan (this document). This is an important first step in the process of “joint framing” of the research agenda. It involves identifying relevant stakeholder groups (based on the eight groups identified in the Future Earth Draft Initial Design Report) and creating channels and mechanisms for their participation in the process. This could include the creation of national engagement committees in the region.

4.3 Observation and data

The Asian monsoon is seen as a comprehensive system including the interactions and feedbacks among land, ocean, atmosphere, ecosystem and human activities. Monitoring of biogeophysical, biogeochemical and social processes is needed to understand this complex system. The comprehensive observations to support Future Earth in Asia will be largely obtained through existing international systems such as the Global Earth Observation System of Systems (GEOSS), the Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS) etc. At the same time, the national observing systems in Asian countries should be used in Future Earth Asian activities by collaboration and coordination under this framework.

Although the benefits of data sharing have been discussed and promoted
internationally and nationally for several decades, the realisation of open
data access is still one of the most difficult targets for Future Earth in Asia.
In addition to the ICSU World Data System (WDS), Global Biodiversity
Information Facility (GBIF), ICSU Committee on Data for Science and
Technology (ICSU-CODATA) and Organisation for Economic Co-operation
and Development (OECD), the data sharing systems developed by the
GEC programmes WCRP, IGBP, IHDP, DIVERSITAS and their joint
projects such as Global Carbon Project (GCP), Global Land Project (GLP) and
Global Water System Project (GWSP) should also contribute to Future Earth in
Asia.

The requirements for data from multi-disciplinary fields by Future Earth
research will provide challenges for data information collection, data management
and data distribution, including both physical and socio-economic information
of the region. The collation of meta-data on existing open datasets will be an
important contribution to the consolidation of the data system for Future
Earth Asia. The linking of datasets and data centres established by
international and national programs and organisations will also contribute to
the Future Earth Asia data system.

4.4 Education and capacity building

Education and capacity building for sustainable development are core
capabilities that Future Earth needs to nurture through partnerships. Asia is
one of the most active areas for the promotion of capacity building for global
change research in the last two decades. International organizations such as
UNESCO, UNU, APN and START etc. have made great efforts in education
and capacity building across Asia. A review of existing initiatives on education
and capacity building for sustainable development will be needed to develop
the overall strategy for Future Earth in Asia.
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From the Future Earth perspective, training in inter-disciplinary and trans-disciplinary research approaches (including the co-design, co-production and co-delivery of relevant knowledge) will be of particular significance. As documented in the Future Earth draft initial design report (2013), education and capacity building will be developed by reforming the current capacity building systems at individual, organisational and systemic levels. The key challenge for capacity building of Future Earth in Asia is to engage more young and early career scientists in sustainability research, especially in working with stakeholders and policy makers, and to provide more opportunities in education and capacity building for them under the Future Earth Asia platform.

Education of sustainability science includes compiling examples of best practices of trans-disciplinary research on sustainability issues, beginning with small and local scale projects that could be scaled-up through programs at the regional and national levels. It will also be important:

1) to document case studies of successful integration and interdisciplinary work in the region and create guidelines on how to do co-design and co-production of research;

2) to increase human capacity development training programs, through short-term workshops, exchange of graduate students, increasing the number of graduate research positions and Professorial Chairs within countries in the region;

3) to develop mentoring of young scientists in least developed countries by more experienced researchers.

4.5 Networking

Collaboration and effective networking will draw together broad platforms of knowledge, allow sharing of limited financial resources and avoid duplication of efforts. Coordination of sustainability research across
disciplines and regions will be essential for Future Earth in Asia; while networking is an important aspect of support for regional/national coordination and collaboration. There are two types of networks in current global change research systems in Asia. One is vertical networks from global to regional and national levels mainly by establishing regional node offices and centres and national committees in each area, such as WCRP, IGBP, IHDP, DIVERSITAS, START, GCP, GLP, GWSP and ICSU-ROAP etc. Another is horizontal networks across the disciplines in the Asian region, such as APN and MAIRS etc. The building of the Future Earth Asia network will depend on further collaborations not only with vertical networks, but also horizontal networks in the region.

Future Earth in Asia needs to strengthen the existing networks by involving the scientific community, academia, governments and civil society; engaging donor communities from the outset (co-design stage); promoting public-private partnerships; and promoting open networks with common definitions and language (e.g. sustainability, inter/trans/multi-disciplinary may mean different things to different stakeholders). The establishment of science-policy and stakeholder interfaces will be taken into account in Future Earth Asia networks. Science-policy and stakeholder interfaces will mainly focus on:

(1) Developing an understanding of the points of entry into the policy arena;

(2) Developing approaches and programs to promote dialogue between groups of people who do not normally talk to each other;

(3) Translating and sharing models on how to communicate effectively with businesses and policy makers (taking into account the wide range of political systems and cultural settings prevalent in the region), and sustaining successful science-policy dialogues;

(4) Creating or identifying science-policy platforms to effectively inform and engage decision and policy makers;
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(5) Engaging with indigenous communities and local knowledge systems in the research process.

References

Chapter 5 Transformation to Asian Sustainability

5.1 Introduction

In this chapter we consider the research issues that provide the key challenges for Asia and the Pacific as the region undergoes its transformation to sustainability over the coming decades. The rate of change of the social and economic features of Asian societies means that the region is currently not in a state of sustainability in the sense of economic or social equilibrium. The current changes are generally leading to improvements in the overall well-being of people, but transformations are needed to ensure that the long-term human and natural ecosystems are sustainable.

The need for transformation was highlighted by the United Nations Rio + 20 summit in Brazil in 2012 where governments decided to prepare a set of sustainable development goals (SDGs). The SDGs will follow from the Millennium Development Goals (MDGs). Griggs et al. (2013) argue that priority should be given to both poverty reduction and the protection of the global environment. These dual priorities are necessary because a stable and thriving environment is needed to support global societies. Thus sustainable development should include security of both people and the planet. Griggs et al. outline a structured evolution from the MDGs to the SDGs that will ensure;
Chapter 5  Transformation to Asian Sustainability

(1) thriving lives and livelihoods
(2) food security
(2) water security
(4) clean energy
(5) healthy and productive ecosystems
(6) governance for sustainable societies.

These goals provide a sound basis for the key research challenges for Future Earth in Asia. If the research is to be effective it will need to be trans-disciplinary, involving a range of stakeholders to ensure that the work is well focused and that results are readily implemented.

The Initial Design Report of Future Earth (2013) identifies a number of key issues for sustainability across the globe. These issues are well discussed and are relevant to Asia, and so we focus on those issues that are key barriers to sustainability in Asia, bearing in mind the global context of the Initial Design Report. Ten issues are identified and briefly discussed. They are linked to the unique cultural diversity of the region as well as the current social and economic trends. For each issue, we consider the current status of the factors associated with the issue, the likely goals needed for sustainability, and the possible strategies for achieving the goals.

5.2 Co-design and co-implementation within diverse cultures

Current status

The basic approach for Future Earth is trans-disciplinary research to ensure that projects are properly focused on issues of practical importance and that the results of research are efficiently and effectively implemented. The development of trans-disciplinary teams is a natural evolution from multi-disciplinary teams that have been operating in some countries within some universities, government agencies and industries. Government agencies and industry are perhaps more familiar with teams focused on applied research.
developed in cooperation with user groups.

**Future directions**

For Future Earth, the complexity of the challenges and the scope of sectors affected by the challenges mean that the range of stakeholders will become much larger. Effective interactions between all the stakeholders will need to span not only differences in disciplines and sectors, but also differences in culture.

The first challenge in establishing a trans-disciplinary team is the identification of the key stakeholders. Each stakeholder needs to perceive benefits of involvement in the project, and this is achieved through the development of appropriate outcomes and impacts. The team needs initially to agree, not only on expected outcomes and impacts, but also on overall governance arrangements taking into account the likely diversity in culture and expectation.

**Research priorities**

The creation and operation of multi-stakeholder teams within the cultural diversity of Asia may be a particular challenge, especially where the issues are trans-boundary (for example, issues involving water usage in long rivers or the transport of air pollution over large distances). Trans-disciplinary teams will need to minimize hierarchical structures and to promote appropriate input from all relevant stakeholders. A particular aspect of Future Earth research in Asia should be comparative studies of the implementation of trans-disciplinary teams for specific projects. Lessons learned from early projects should be rapidly disseminated across teams at local, national and regional levels.

5.3 Uniqueness of monsoon climate and topography

**Current status**

Traditional life-styles across Asia have evolved within the context of the local climate and topography, which vary from the mountainous regions of the
Himalayas to the drylands of China and India and to the tropical climates of south east Asia and Pacific islands. As Asia undergoes its rapid economic development, the long-standing harmony between life-style and environment is being lost.

**Future directions**

Sustainability will return only when that harmony or balance is restored. However, not only are life-styles changing across Asia, but also the major climate systems of the region are being affected by the enhanced global greenhouse effect. Thus, the development of strategies for sustainability will need to take into account the changing environment of the region.

**Research priorities**

There remains uncertainty about the impact of climate change on the Asian monsoon and other drivers of Asian climate such as tropical cyclones and the El Nino-Southern Oscillation (ENSO). It will be essential for the trans-disciplinary teams working on the key sustainability issues to include expertise on the understanding of the role of climate and local environments on human and natural ecosystems of the region. Such understanding will need to incorporate knowledge of past harmonies as well as knowledge of the likely future projections of climate for the region.

5.4 **Vulnerability to natural disasters**

People in Asia-Pacific are four times more likely to be affected by natural disaster than in Africa and 25 times more than in Europe or North America. Almost 2 million people were killed in disasters between 1970 and 2011, representing 75% of all disaster fatalities globally. Asia is particularly susceptible to earthquakes and cyclones, with flooding a near-constant threat. Many data suggested that while the tropical cyclones (typhoons in Asia and the Pacific) are not increasing in number, more of them are stronger, making the region more susceptible to greater potential losses. It is
hydrometeorological (e.g. floods, storms) and climatological disasters (e.g. droughts), rather than the geophysical disasters (e.g. earthquakes and volcanic eruptions), that have been trending upwards in recent decades. Since 2000, more than 1.2 billion people have been exposed to hydrometeorological hazards alone, compared to the 355 million people exposed to climatological, biological and geophysical disaster events during the same period (ADB Economics Working Paper Series, 2013).

The increasing disaster risks in the Asia-Pacific region are driven by the growing exposure of its people and its rising economic assets. Rapid urbanization expands exposure to hazards, and it also increases people’s vulnerability, especially among the poor. The encouraging news is that despite the increases in both physical and economic exposure, the loss of life is decreasing from hydro-meteorological hazards in subregions like East and North-East Asia. This can be attributed to improved development conditions and shows the impact of investments made in early warning and preparedness. Unfortunately elsewhere, when equivalent development benefits either don’t exist or are not sufficiently inclusive, the vulnerabilities of people continue to rise. Among ongoing policies and strategies to reduce natural disaster exposure in Asia-Pacific region, ecosystem services management, land-use planning, financial investment in disaster risk management, global supply chain management and post-disaster recovery are key factors to reduce the vulnerability (ESCAP/UNISDR Asia-Pacific Disaster Report, 2012; Global Assessment Report, 2011).

5.5 Rapid economic growth

Current status

Underlying most of the processes described in this document is Asia’s rapid economic growth. Driven by developments in China and India, the economies of developing Asia GDP on average grew by 7.0% per year in the past two decades
and Asia’s GDP now accounts for over one-third of that of the world. This growth has brought increased prosperity and improved livelihoods for many, even though the benefits of growth are far from equitably spread over and among societies. It has also propelled urbanization, driven up energy consumption and CO₂ emissions, increased pollution and resource exploitation, and given rise to new health problems. Sustainability cannot be addressed without considering trends, patterns and models of economic growth.

**Future directions**

There is little doubt that economic growth will continue in Asia. With populations set to increase for several decades and two-thirds of the world’s extreme poor in Asia, such growth will also be needed to alleviate poverty and improve livelihoods. At the same time, strategies need to be devised to make growth more inclusive.

As the world’s center of economic gravity swings towards Asia, the continent’s future growth and its ramifications are increasingly of global importance. Continued strong economic growth in Asia will pose grave environmental challenges and complicate the transition to sustainability. Energy, food and water demand will continue to mushroom and pressure on ecosystems will increase even further both within the region and beyond.

While future growth in Asia is both inevitable and desirable, the realization is growing that pursuing growth for the sake of growth or conflating a wide range of development achievement into one single GDP growth indicator will no longer be feasible. Bhutan’s “gross national happiness” approach is well-known. China, where Deng Xiaoping once famously commented that “development is a hard principle”, has recently adopted the term “scientific development” in an effort to bring notions of sustainability and social fairness into its guiding philosophy. Around the Rio + 20 meetings, the notion of “green economy” has gained global currency. UNEP defines a green economy comprehensively as one that results in improved human well-being and social equity, while significantly reducing
environmental risks and ecological scarcities. While not without controversy, this concept has the welcome potential of refocusing attention away from a narrowly defined economic growth focus. In particular, the concept should drive societies towards the goal of sustainable consumption.

Research priorities

Future Earth research in Asia should take a broad view of economic development and its sustainability implications. The environmental and societal consequences of different economic growth concepts and strategies should be identified and assessed. Scenarios can be developed that explore the sustainability implications of these strategies, in terms of economic growth and livelihoods, social inclusion and equity, and environment, ecosystems and planetary boundaries. Such scenario-building should engage a range of societal stakeholders and explore long-term visions that are locally-appropriate and globally desirable. The movement towards a “green economy” in the full sense of the word should be critically assessed and supported.

5.6 Continuing urbanization

Current status

Rapid urbanisation is a continuing feature of Asian countries, with 1.5 billion people living in cities in 2010. Cities are major consumers of food, water and energy, resulting in cities and their associated peri-urban areas being the main sources of water pollution, air pollution and greenhouse gases. In many Asian countries, food insecurity is a greater challenge in urban than in rural areas, owing to difficulties with distribution as well as rising prices, which particularly affect the poor. The growing affluence of Asia is leading to changes in diet away from grains towards meat and fruits, which require more inputs than traditional foods. Both water availability and quality are limited in many Asian cities, and the disposal of sewage and industrial waste is inadequate. Economic development across Asia has been closely linked with
increasing demand for energy on a per capita basis. Coal-fired power plants in urban and peri-urban areas, as well as motor vehicles, affect human health through air pollution and also lead to significant emissions of greenhouse gases. Hydroelectric power generation has led to downstream trans-national effects on river ecosystems, fish and water availability.

**Future directions**

While there are many challenges associated with cities across Asia, there are also many indications that cities have benefits associated with efficiencies of scale and density. Access to public transport, shorter commuting distances, and higher density networks for many services mean that urban communities use fewer resources than rural communities at the same socio-economic level. On the other hand, there are large variations in the accessibility to services generally linked to socio-economic status, and so an important aspect of the development of sustainable cities in Asia is a more equitable distribution of infrastructure and services.

Urban design needs to be an integrating activity, taking into account the local topography and climate in order to ensure that storm water is effectively captured and used (rather than diverted as waste), that waste products are recycled efficiently, that urban heat islands are avoided, that green energy systems are utilised, that buildings are energy and water efficient, that transport systems are both efficient and effective, and that social equity is optimised. Appropriate urban design will also ensure that food supply networks are efficient and that human well-being and natural ecosystems are maintained. The transformation of cities will be a key element in the transition to low-carbon societies across Asia.

**Research priorities**

A foundation for integrated urban design must be based on a growing number of comparative studies of current urban areas across Asia and the Pacific. While mega-cities will continue to grow in number and size, it is expected that most people will live in cities with populations less than 1
million. Therefore, the comparative studies need to cover the full range of urban size and density, because at present there are wide variations in the efficiency and sustainability of individual cities.

Because cities are increasing in number and size across the region, the development of strategies to ensure all cities move towards sustainability is perhaps the most pressing challenge for Asia and the Pacific. The associated research strategy will therefore be vitally dependent upon co-design and co-implementation to ensure that the research is properly focused and that the impacts of research can be put into practice as soon as possible. Starting with selected cities, it would be appropriate to assemble trans-disciplinary research teams to work with city planners to identify and solve specific challenges for the future sustainability of each city. The priorities would vary from city to city, and so a role of Future Earth would be to promote cooperation between teams in order to share knowledge and accelerate progress for individual teams.

5.7 Sustainable food, water and energy systems

Current status

There is a global increase in demand for food, water and energy driven primarily by population growth, but the magnitude and scale of these increasing demands are enormous in Asia due partly to its rapid demographic changes, economic development, and monsoon climate variability and change. The exploitation of these limited natural resources of fossil fuels, arable lands and freshwater is occurring at a rate that is clearly not sustainable. Further, the existing pattern of production and consumption of food, water and energy have resulted in significant implications to global environment that further escalate climate change, foster disease outbreaks, deteriorate human and ecosystem health, reduce global biodiversity, affect human well-being and threaten sustainability of human beings.
Future directions

Advances in science, technology and human development over the past centuries have significantly improved our understanding of the dynamics of the earth system and our ability to increase efficiencies of production and consumption of food, water and energy. However, these advances are insufficient to solve new, emerging global challenges of sustainability. New, innovative pathways are needed in order to ensure a sustainable future earth. These may include ways of changing consumption patterns for food, water and energy, while seeking alternative renewable resources. Developing new technologies to increase food and energy productions while ensuring sustainable use of natural resources are needed. Mainstreaming new information and technologies in the management of these natural resources is necessary in order to achieve a sustainable society.

Research priorities

(1) A sustainable supply of food, water and energy for the benefit of human development requires a system approach that balances demand and supply while ensuring economic prosperity and environmental conditions, as the three are interconnected. For example, food production relies on the availability of arable lands, water and fertilisers at the farmer level but requires energy to process to the consumable form and packaging for distribution.

(2) Construction of hydro-power dams for energy alters water availability for crop production, adding further stress on cropping systems resulting from changing precipitation patterns as well as surface and groundwater. These interactions are not necessarily occurring at the same place; they are remotely connected through hydrology, transportation, and food dissemination systems. As the demand for food, water and energy varies with population distributions, it is also necessary to consider rapid urbanisation and migration in many of the developing countries in Asia.

(3) Potential impacts on the environment must be considered as a key
component in the systems approach as it has significant implications for human health. Therefore, while it is important to develop advanced technologies for improved food, water and energy supplies, new research on the integration of all components in a sustainable way is needed to ensure a balance across supply, demand, the environment and the economy.

5.8 Safeguarding ecosystems

Current status

Ecosystems underpin many of the basic services on which our societies depend, including our supply of drinking water, food and fibre, fuel, carbon uptake, biodiversity, recreational and aesthetic values. These ecosystem services are particularly important in Asia, as this region is one of the richest biological regions of the world, but it is facing an ecological crisis due to population pressure and climate change. However, it is human development that has caused the destruction of the ecosystem services that societies need for sustainability. A collapse of major ecosystems will have significant impacts on the livelihoods for billions of Asians, causing major environmental disasters including floods, landslides, droughts, desertification, and pollutions of soil, water and air. This controversial dilemma was recognised long ago but ways to safeguard ecosystems while deriving services have not been fully developed.

Future directions

While ecosystem degradation has occurred in many places in Asia, protecting and preserving pristine ecosystems in order to safeguard ecosystem services has been recognised by both the science community and the general public as an important step toward long-term human sustainability. There is a need to analyse and quantify tipping points where ecosystems would collapse under human disturbances and changing climate, so that objective assessment of ways to balance economic development and ecosystem services can be achieved. Existing efforts on safeguarding ecosystems have been supported by
numerous programs; however, their effectiveness in preserving the core values of an ecosystem needs to be assessed, evaluated and communicated with stakeholders.

**Research priorities**

To effectively safeguard ecosystems while maximising ecosystem services for human development, a trans-disciplinary effort to develop a systems framework that includes stakeholders, scientists, and policy makers is required in order to ensure a common understanding of issues addressed and the needs of different sectors and communities. The framework should include evaluation of ecosystems from different user perspectives and discussion of policy and its implications, including options for pay-for-ecosystem services, as well as implementation plans. The framework will need to include potential external factors including climate change and tele-connections where ecosystems may be threatened by remote drivers, such as market demands from other communities or countries.

5.9 **Pathways guided by Asian traditions and cultures**

**Current status**

Asia is characterized by a complex mosaic of social and ecological diversity developed through a long history of human interaction with nature. Many customary but large-scale systems of resource management, such as paddy-rice, agro-pastoralist and agro-forestry systems, have contributed to agro-biodiversity and maintained intensive food production, employment opportunities and community livelihood over long periods of time. These systems have supported the basic needs of local populations without suffering the so-called “tragedy of commons”, although they have sometimes been damaged or threatened by natural disasters in the long history of this region.

In the history of agricultural development, many organisms evolved/adapted to agro-environment, illustrating the importance of local production
systems, evolved over many generations, in contributing to agrobiodiversity and intensive food production, employment opportunities and community livelihood. Such systems show less negative impact on surrounding environment than large-scale agriculture based on cultivation of monocultures.

Through the long historical process of the human-nature interaction including occasional disturbances by natural disasters, traditional culture and knowledge have been developed to manage and sustain the human-nature system of this region. We should keep in mind that this system is fundamentally different in many aspects from the Western system.

**Future directions**

Human activity is increasing industrial pollution, land-use change, and greenhouse gas emissions in the region and is leading to changes in monsoon patterns that may significantly harm social and economic development in the region. Particularly in recent decades, the combined effects of globalization and climate change are threatening terrestrial and aquatic ecosystem productivity throughout the region, undermining resource-based livelihoods and communities and exacerbating social inequity.

Most extensively, forest disruption and conversion continues in developing countries, particularly those of the tropics, though some countries have experienced a “forest transition” characterized by forest re-growth in the late 20th century. Over-extraction of surface and subsurface water sources and pollution, diversion and obstruction of waterways have significant negative impacts on ecosystems and human populations at local, regional and continental scales.

Asia-Pacific needs to find a different path to sustainable prosperity. Fortunately, the Asia-Pacific has the vitality and creativity to blaze a new sustainable path for the world. It is fully capable of kick-starting transformations that put humanity on a pathway to sustainability.

**Research priorities**

As for deforestation, multiple-scale and transnational analysis is required
to determine the specificity of such trends and whether they reflect gross reduction or displacement of forest resource use and degradation to other countries or regions. A grand challenge of sustainable water resources management is to secure the access to quality water necessary to meet basic human needs, such as health and sanitation, food production and renewable energy, taking account of the linkages between ecological change, land use, urbanization, industrial activities, and water systems. Existing traditions and wisdom, as represented by the traditional Chinese saying, “温故知新”, which means “keep cherishing old wisdom and knowledge while continually learning anew to serve others”, may plausibly guide these processes. Achieving this spirit of wisdom at a regional level amid on-going social and cultural inter-generational changes may be the fundamental bottleneck.

5.10 Social equity and inclusion

Current status

Understanding the links between sustainability and equity is critical for sustainable development. Sustainability and equity are mutually reinforcing, and research under the umbrella of Future Earth for human development cannot ignore the question of equity and inclusion. The UNDP Human Development Report (2011) suggests that failure to reduce social inequalities and enhance inclusion and security will slow progress towards sustainability and human development. Indeed research has confirmed that inequality is divisive and socially corrosive (Wilkinson and Pickett, 2011).

In Asia it has been shown that investments that improve equity in access, for example to renewable energy, water and sanitation, and reproductive healthcare, can advance the trend towards sustainability and human development. Transparent accountability and democratic processes also have strong roles in ensuring equitable access to facilities and resources. Such transparency and accountability are usually driven by civil society and media
organizations. According to the UNDP Human Development Report (2011), successful approaches rely on community engagement and management, the development of inclusive institutions that pay particular attention to disadvantaged groups, and cross-cutting approaches that coordinate budgets and mechanisms across government agencies and development stakeholders.

The Human Development Report (2011) suggests that rising longevity around the world is associated with greater equity, and health inequality measured by life expectancy, declined across the board. This trend was led by very high HDI countries closely followed by improvements in East Asia and the Pacific. Progress with reducing inequalities in educational opportunities has been substantial in Asia. Education inequality declined most in Central Asia (almost 76%), followed by East Asia and the Pacific (52%). However, income inequality has deteriorated in many countries. For example, income has become more concentrated among top earners in China and India. In China, the top quintile of income earners had 41% of total income in 2008, and the Gini coefficient for income inequality rose from 0.31 in 1981 to 0.42 in 2005. The worst deterioration of income inequality was in Central Asia.

**Future directions**

Societies across the world are affected in many and different ways by global environmental change. Many are undergoing deep transformational change that is opening new opportunities for exchange and dialogue. In developing Future Earth, countries need support in designing and implementing policies of inclusion and access to ensure equitable development. There is still a strong need to raise the social impact of what is undertaken in education, science, culture, communication and information. According to Wilkinson and Pickett (2011), the intertwined issues of equality, social justice, sustainability and economic balance now receive greater attention throughout the world. They even conclude that the more equal societies have lower carbon footprints and can cope better with the challenges of climate change. We need to reduce the higher ecological footprints of countries with less equitable distribution on
incomes and opportunities. The evidence suggests that the more equal societies foster a greater sense of collective responsibility, which is crucial for political action to address climate change and other sustainability issues. With Future Earth, business leaders and the private sector are expected to provide stronger support to their governments in accepting and implementing the national and multilateral environmental agreements. This is more likely to happen in countries where development is more equitable and inclusive.

**Research priorities**

To achieve a major narrowing of income differences while responding effectively to global environmental change requires transformational change in societies (Wilkinson and Pickett, 2011). Future Earth must catalyse a continuous stream of small changes in a consistent direction that will make a more sociable society that has a greater sense of security and inclusiveness, where everyone feels that they have the opportunity for a more fulfilling life. More people now believe that greater equality is the gateway to a society that is able to improve its quality of life, an essential step towards global sustainability. The third sub-theme of Future Earth deals with the transformative pathways towards global sustainability with regard to economic and developmental options, innovation and ideas and global and regional governance. It should however be noted that there are many different ways of reaching the same goal of sustainability. How to generate the necessary political will to achieve greater equity and social inclusion would be a common research question in many countries. Understanding the integral links between equity and sustainability is a fundamental step towards enhancing the quality of human life today and in generations to come. Global sustainability cannot be achieved without taking steps to reduce inequality and enhance social inclusion.
5.11 Institutions and governance

Current status

Institutions and governance are interrelated concepts that refer to the rules (both formal and informal) that inform, guide, and constrain people’s and organizations’ behavior with regard to the resources, sinks, and other aspects of the environment (Poteete and Ostrom, 2004). This encompasses a wide range of rules, structures and processes, including for example the tenure regimes and entitlements (private, state, common pool), emerging markets for carbon and ecosystem services, and bilateral and international collaborations and conventions. One of the important lessons that emerged from Rio + 20 was that “institutions play a critical and fundamental role in implementing sustainable development policies, and a strong governance structure is critical for advancing sustainable development” (UNCSD, 2012). Governance discussions often center on transparency, accountability, stakeholder involvement, corruption, enforcement, etc. While these aspects are important, there is also a need for exploration of the effectiveness and design principles of institutions, and for a deeper understanding of the path-dependence of their historical development and their mutual interrelatedness in specific contexts. All these have implications for availability of space for reform, the engagement of different stakeholders in such reform, and the suitability of models introduced from elsewhere. While recent research has pointed to the importance of governance reform at the global level for the transition to sustainability (Biermann et al., 2012), local, national and regional level governance should not be neglected (IGES, 2012). In fact, for the rule-setting in environmental governance, the national level is predominant in Asia. Effective local institutions are central to society’s ability to respond to the impacts of climate change as (i) institutions develop policy on impacts and vulnerability (Adger et al., 2003), (ii) they mediate between
individual and collective responses to climate impacts and thereby shape outcomes of adaptation (Thomas et al., 2006), (iii) they act as the means of delivery of external interventions and resources to facilitate adaptation to climate change, and thus govern access to such resources (Howard, 2012), and (iv) institutions constitute the mechanisms that will be inevitable for translating the impact of future external interventions to facilitate adaptation to global change. In view of this, the role of local institutions will be critical as adaptation to climate change is inevitably local (Debsu, 2012; Agrawal, 2010). This implies that local capacity building and strengthening is important to respond to the changing context and to enable the innovation of institutions and governance.

**Future directions**

Institutions and governance are at the crux of the transition to sustainability; without profound institutional reform and innovation, it is unlikely that Asian societies will be able to navigate the challenges of the 21st century. Overall, the state of the resources and environment suggests that governance regimes still struggle to bring about positive resource management and pollution control outcomes. Sometimes, institutions have been changed based on notions of economic effectiveness rather than long-term improvement of natural capital, which in practice encouraged unsustainable resource use, as the experiences with rangeland privatization in several parts of Asia suggest. Nevertheless, good examples of alternative arrangements can be gleaned from experiences across Asia. In resource tenure, cases such as the common pool regime of coastal fisheries in Japan, recent reforms of forestry tenure and forest conversion program in China, and experiments with PES mechanisms in a range of sectors in many Asian countries may be pointing the way ahead. Positive examples of cross-border collaboration include the Indus Waters Treaty, the Abu Dhabi Dialogue and the Mekong River Commission.
**Research priorities**

Two strategies are promising. 1) Linking “traditional” GEC research to governance to assess the effectiveness of different institutional regimes in sustainably and equitably managing resources, sinks, and related environmental processes. Contextualized case studies will help in understanding the specific choices, constraints and pathways that underlie current institutional arrangements. A conceptual toolkit to analyze institutional cooperation and its impact on resource access of vulnerable groups could be developed. 2) Gearing environmental governance research towards the transition to sustainability, among others by exploring institutional alternatives and innovations through scenarios, action research, developmental evaluation and adaptive management.

**References**


Washington DC, USA: The World Bank


ESCAP/UNISDR Asia-Pacific Disaster Report 2012


Howard R J. 2012. Local institutions, external interventions and adaptation to climate change in sub-Saharan Africa. A consultancy report to Oxfam America, Boston.

Human Development Report. 2011. UNDP
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Chapter 6

Conclusions and Key Messages

Asia is a special region of the world, particularly when considering future pathways towards sustainability. The Asian monsoon and the Himalaya-Tibetan Plateau drive a unique climate with global impacts and which, through traditional cultures and practices, have supported a range of sustainable natural ecosystems and human societies for millennia. However, Asia is now in transition. It has a growing population accounting for about 60% of the world total, its economies are growing rapidly, urbanisation is increasing, and poverty is being reduced. This general increase in well-being is accompanied by a number of challenges; air and water pollution is extreme in many areas, unique ecosystems and associated biodiversity are under threat of extinction, inequality of socio-economic well-being, health and education remains high, and the long-term sustainability of these transition economies is unlikely. The Future Earth program, led by ICSU and ISSC, provides a framework for the research communities of Asia to work together with stakeholders to develop the knowledge base underpinning future sustainable ecosystems and societies, and to promote the rapid implementation of practical strategies for sustainability.

In alignment with the international Future Earth program, Future Earth Asia should have three major themes, together with a number of cross-cutting capabilities. The first theme is Dynamic Asia, and it encapsulates much of the current research in the broad disciplines of well-established global environmental change programs. The Asian monsoon climate underpins a
range of ecosystems services that support societies across the region. While the variability of the monsoon has been managed by past communities, climate change is imposing additional stresses that combine with the socio-economic changes across the region to threaten natural ecosystems and human communities. The Asia-Pacific is the most disaster-prone region of the world, with economic losses increasing by sixteen times since 1970 while GDP has increased by only thirteen times. Asia is rich in biodiversity, and it contains 14 of the 35 worldwide biodiversity hotspots. Analysis of the current state of eight types of ecosystems across Asia demonstrates that each type faces challenges from human activities, as well as the impacts of climate change. Moreover, the urban ecosystem is encroaching on older types and increasing threats to their sustainability.

The second theme of Future Earth Asia is Asian Development, and it is focused on the knowledge needed to ensure proper stewardship of natural resources across the region. Much of the research will involve capacity building activities in collaboration with the international development agencies focused on solving the practical challenges facing Asian societies today. It is well recognised that the future of all eight types of ecosystem is threatened, and a range of projects are being carried out to alleviate those threats. A common understanding is that sound measures to reduce poverty in a community invariably lead to improved stewardship of the natural ecosystems associated with that community. The balance between human security and natural ecosystem security is especially delicate when considering the growing needs for water, food and energy in Asia. Each of these needs must be considered at least at the regional (if not global) level. The sustainable provision of water, food and energy to the populations of Asia will require considerable advances in mutual understanding and implementation of governance across national boundaries, as well as advances in science and technology.

As we move towards the third theme of Future Earth Asia, it is clear that
several cross-cutting capabilities will need to be enhanced to support the
required research. The definitive strategy of Future Earth is trans-disciplinary
research. The diversity of culture and governance across Asia poses a
particular challenge for the implementation of research that encompasses co-
design, co-production and co-delivery. The complexity of problems to be
taken up by Future Earth Asia means that data sharing will need to become an
accepted mode of operation for all stakeholders. The fact that observations of
bio-geophysical and socio-economic systems have more value when treated as
public goods (rather than private goods) needs to be demonstrated and
promoted to all stakeholders across Asia. While there has been progress in
basic education in Asia, the transformations needed to achieve sustainability
will require major developments in education within both the research
community and the broader community. These developments will need to be
sensitive to the diversity of culture and governance across the region, and they
will need to continue to reduce inequality across communities and nations. A
key element of Future Earth Asia will be networks that include all
stakeholders and that build on existing links and organisations.

The third theme of Future Earth Asia is transformation to Asian
sustainability, and it will build on the outcomes of the first two themes to
promote trans-disciplinary research focused on key challenges for
sustainability across Asia. The strategy for this theme will be guided by the
sustainable development goals that recognise the need for priority to be given
to both poverty reduction and protection of the environment. The priority
research programs for Future Earth Asia will be developed carefully through
consultation and collaboration with stakeholders across the region and with
the international research community. Within this framework, we identify
ten issues that are linked to the cultural diversity of the region and that are
likely to provide appropriate focuses for Future Earth Asia. These issues are:

1. Co-design and co-implementation within diverse cultures
2. Uniqueness of monsoon climate and topography
Chapter 6  Conclusions and key messages

(3) Vulnerability to natural disasters
(4) Rapid economic growth
(5) Continuing urbanisation
(6) Sustainable food, water and energy systems
(7) Safeguarding ecosystems
(8) Pathways guided by Asian traditions and cultures
(9) Social equity and inclusion
(10) Institutions and governance.
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Appendix 3  Acronyms

ACE: ASEAN Centre for Energy  
ADB: Asian Development Bank  
ADO: Asian Development Outlook  
APERC: Asia Pacific Energy Research Center  
APN: Asia-Pacific Network for Global Change Research  
ASEAN: The Association of South-East Asian Nations  
BP: British Petroleum  
CSG: Coal Seam Gas  
DIVERSITAS: An international research programme aiming at integrating biodiversity science for human well-being  
EASM: the East Asia Summer Monsoon  
EDI: The Energy Development Index  
ENSO: El Nino-Southern Oscillation  
ESCAP: Economic and Social Commission for Asia and the Pacific  
ESSPA: Energy Supply and Security Planning in the ASEAN  
EU: European Union  
FAO: Food and Agriculture Organization  
FDI: Foreign direct investment  
FE: Future Earth  
FIELD: Foundation for International Environmental Law and Development  
GBIF: Global Biodiversity Information Facility  
GCOS: the Global Climate Observing System  
GCP: Global Carbon Project  
GDP: Gross Domestic Product  
GEC: Global Environmental Change  
GEOSS: The Global Earth Observation System of Systems  
GHG: Green House Gases  
GLOF: Glacial Lake Outburst Flooding
GLP: Global Land Project
GOOS: The Global Ocean Observing System
GWSP: Global Water System Project
HAB: Harmful Algal Blooms
HC: Hadley Circulation
HDI: The Human Development Index
HTP: Himalaya-Tibetan Plateau
ICIMOD: The International Centre for Integrated Mountain Development
ICM: Integrated Coastal Management
ICSU: The International Council for Science
ICSU-CODATA: ICSU Committee on Data for Science and Technology
ICSU-ROAP: ICSU Regional Office for Asia and the Pacific
ERIA: Economic Research Institute for ASEAN and East Asia
IEA: International Energy Agency
IEEJ: Institute of Energy Economics, Japan
IGBP: International Geosphere-Biosphere Programme
IGES: Institute for Global Environmental Studies
IHDP: International Human Dimensions Programme of Global Environmental Change
IPBES: Intergovernmental Platform on Biodiversity and Ecosystem Services
IPO: International Programme Office
IPO: Interdecadal Pacific Oscillation
ISSC: The International Social Science Council
IUCN: International Union for Conservation of Nature
MA: Millennium Ecosystem Assessment
MAIRS: The Monsoon Asia Integrated Region Study
MCPA: Marine and Coastal Protected Areas
MDGs: Millennium Development Goals
MERS: Middle East Respiratory Syndrome
MPAs: Marine Protected Areas
NGO: Non-Governmental Organization
Appendix 3  Acronyms

NPP: Net Primary Production
OECD: Organisation for Economic Co-operation and Development
PACC: The Pacific Adaptation to Climate Change
PDO: Pacific Decadal Oscillation
PEMSEA: Partnership in Environmental Management for the Seas of East Asia
PES: Payment for Environmental Services
REDD+: The United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
RIHN: Research Institute for Humanity and Nature, Japan
SARS: Severe Acute Respiratory Syndromes
SDGs: Sustainable Development Goals
SOC: Soil Organic Carbon
SPREP: Secretariat of the Pacific Regional Environment Programme
START: The global change SysTem for Analysis, Research and Training
TPES: Total Primary Energy Supply
UNCCD: The United Nations Convention to Combat Desertification
UNCSD: The United Nations Conference on Sustainable Development
UNDP: United Nations Development Programme
UNEP: United Nations Environment Programme
UNESCO: United Nations Educational, Scientific, and Cultural Organization
UNFCCC: United Nations Framework on Climate Change Convention
UNISDR: United Nations International Strategy for Disaster Reduction
UNU: The United Nations University
WCRP: World Climate Research Programme
WDS: ICSU World Data System
WEO: World Energy Outlook
WHO: World Health Organization
WMO: World Meteorological Organization