Chapter 6
Climate and Sustainability

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Abstract Projected change in climate in the coming decades adds a layer of complexity in the search for sustainability. Warming temperatures, rising sea levels, changing precipitation patterns and their impacts on natural and human systems could threaten the attainment of development goals. Many countries in Asia and the Pacific are among the most vulnerable to the impacts of climate change and there is growing recognition that climate change adaptation must be tackled as an integral part of the development process, for example in mainstreaming climate change adaptation into national plans and programmes. The aim of Chap. 6 is to explore linkages between sustainable development and efforts to address climate change in

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Asia and the Pacific, particularly focussing in two areas of low carbon development (LCD) pathways for the region, and the importance of natural ecosystems in sustaining the delivery of ecosystem services that are essential for climate change adaptation and mitigation. The challenges posed by climate change will be felt in the coming decades in Asia and the Pacific. In parallel, nations in the region will continue to aspire for sustainable development. Policy makers and development workers must find ways to ensure that both these concerns are addressed synergistically while avoiding negative outcomes. One way to mitigate climate change while pursuing sustainable development is through LCD, which will require negotiations across many stakeholders of governments, non-government agencies, industry and broader communities. In Asia and the Pacific natural ecosystems will continue to play a critical role in addressing climate change adaptation and mitigation. Nations in the region will have to find innovative ways to manage and rehabilitate natural ecosystems for a multiplicity of functions and services. This will involve greater collaboration and communication between scientists and policy makers as well as between natural and social scientists. In many developing countries, there is still very limited empirical information and research needs to be ramped up. North-South and South-South partnerships could help fill the gap.

Keywords Climate and ecosystems • Integrated assessment models • Low carbon development • Climate and sustainability

6.1 Introduction

Sustainable development has occupied a place in the global agenda since 1987 when the World Commission of Environment and Development (Brundtland Commission) released its report 'Our Common Future' (WCED 1987).

The Commission defines sustainable development as "*development that meets the needs of the present without compromising the ability of the future generations to meet their own needs*."

Now, 25 years later, sustainable development has become mainstreamed into national and international development discourse. Indeed, it is one of the almost universal aspirations of all nations today. This happened in spite of the proliferation of and

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disagreements over numerous definitions, frameworks and methods to operationalize it at various scales (Baumgartner 2011; Jabareen 2008; Sneddon et al. 2006).

The essence of sustainable development can be viewed as meeting fundamental human needs while preserving the life support systems of the planet (Kates et al. 2005). It involves efficient management of resources and creation of options for natural ecosystems to support social and economic development. To sustain this capacity requires a full understanding and effective management of feedbacks and interrelations between the system's ecological, social and economic components across temporal and spatial scales (Gunderson and Holling 2002; Kates et al. 2001; cited in Folke et al. 2002).

Ironically, the degree to which sustainable development has been embraced by the global community is not matched by the state of the world's environment. Greenhouse gas (GHG) emissions continue to increase (Friedlingstein et al. 2010). The landmark assessment of the world's ecosystems in 2005 revealed that many of the world's forest, freshwater, coastal and marine resources have been exploited severely (Millennium Ecosystem Assessment 2005). On the other hand, others contend that while the global picture is bleak, there have been many local success stories. In fact, the degree to which the concept of sustainable development has entered mainstream thinking is simply astonishing in itself. In the future, there may be broad international agreement that the goal should be to foster a transition toward development paths that meet human needs while preserving the earth's life support systems and alleviating hunger and poverty (Mexico City Workshop 2002).

There is wide spread concern that the world's development pathway is not sustainable in the long term. This has led to the emergence of what has been called "sustainability science", which seeks to improve on the substantial, but still limited, understanding of nature-society interactions (Statement from Friibergh Workshop on Sustainability Science 2000; de Vries and Petersen 2009). It is premised on the need for a better understanding of the complex and dynamic interactions between society and nature. As such, it will require fundamental advances in our ability to address such issues as the behavior of complex self-organizing systems as well as the responses of the nature-society system to multiple and interacting stresses (Kates et al. 2000). There is also a need to integrate across the full range of scales from local to global and thereby combine different ways of knowing and learning. Increasingly, there is more focus also on examining the contemporary relevance of traditional practices and exploring ways to integrate them with modern approaches for better environmental management (Berkes 2008; Bélair et al. 2010; Arico and Valderrama 2010). This also feeds into the broader issues of equity and the need for participatory planning involving various actors with a stake in the ecosystem (Goma et al. 2001; Kenter et al. 2011).

The projected change in climate in the coming decades adds another layer of complexity in the search for a sustainable development path. Warming temperatures, rising sea levels, changing precipitation patterns and their impacts on natural and human systems could threaten the attainment of development goals, such as those expressed in the Millennium Development Goals (Yohe et al. 2007). Many countries in Asia and the Pacific are among the most vulnerable to the impacts of climate

change, such as Bangladesh and the small islands states (Cruz et al. 2007; Mimura et al. 2007). As a result, there is growing recognition that climate change adaptation must be tackled as an integral part of the development process (Munasinghe 2010; Schipper 2007; Robinson et al. 2006; Adger 2003). In many cases this has been expressed in terms of mainstreaming climate change adaptation to national plans and programs (Lasco et al. 2009).

Even climate change mitigation can have strong links with sustainable development. For example, energy utilization typically rises (and thus GHG emissions) with rising economic development as can be seen in fast developing countries in Asia. However, more efficient energy use will lead to lower emissions (i.e. decarburization) while promoting sustainable development (Halsnaes et al. 2011).

The aim of this Chapter is to explore the link between sustainable development and efforts to address climate change in Asia and the Pacific. In Sect. 6.2 we discuss the feasibility and challenges of low carbon development pathways for the region. In Sect. 6.3 we present how natural ecosystems are necessary to sustaining delivery of ecosystem services that are essential for climate change adaptation and mitigation.

6.2 Climate and Economy: Towards Low Carbon Development

6.2.1 Introduction

Low carbon development aims not only to reduce carbon dioxide (CO_2) emissions but also to promote economic development and enhanced community well-being.

Low Carbon Society (LCS) or Low Carbon Development (LCD) has become a familiar notion for anyone involved in climate change policies in the last decade. An LCS or LCD (hereafter LCD) is a comprehensive image that covers both "hard" and "soft" aspects of society that would lead to reduction of CO_2 emissions. The "hard" part includes infrastructure, technology in terms of hardware, buildings and houses, transportation, etc. The "soft" part includes policies, knowledge, people's lifestyles and behavior, institutions, rules, etc.

LCD pathways are not intended just to achieve a certain level of CO_2 emissions reduction only. The notion includes poverty reduction, economic development and fulfillment of people's welfare while reducing greenhouse gas (GHG) emissions.

An LCD society can be defined as one that:

- Takes actions that are compatible with the principles of sustainable development, ensuring that the development needs of all groups within society are met;
- Makes an equitable contribution towards the global effort to stabilize atmospheric concentrations of carbon dioxide and other GHGs at a level that will avoid dangerous climate change through deep cuts in global emissions; and
- Demonstrates high levels of energy efficiency and uses low-carbon energy sources and production technologies (LCS-RNet 2009).

In a way LCD seeks to achieve sustainable development that reaches economic, environmental and social dimensions of development simultaneously. The present section aims at explaining current arguments and research on LCD, especially in the Asia-Pacific region. To reach this aim "integrated assessment" will be considered.

Integrated Assessment Model (IAM) is a tool that contributes to the assessment of complicated policies such as related to climate change mitigation. In the later part of this section, institutional dimensions of integrated assessment are discussed.

6.2.2 Roles of Integrated Assessment Models

6.2.2.1 Integrated Assessment Model (IAM)

Integrated Assessment (IA), when used in conjunction with climate change policies, is a methodology to assess economic development from various policy perspectives. Integrated Assessment Models (IAMs) are large-scale computer simulation models that assimilate a variety of factors and disciplinary inputs to address IA. As CO_2 emissions, energy use and economies are interlinked in a complicated manner, IAMs have been used to assess climate change mitigation policies. Future GHG emissions depend heavily on the development pathways that future societies choose in terms of economic, demographic, technological, land-use, agricultural and energy mix changes. The interactions between these primary driving forces are complex and have profound regional circumstances.

The first trials of IAM model developments can be observed in the early 1970s (Meadows et al. 1972; Mesarovic and Pestel 1974), followed by formal IAM development in the late 1970s for assessment of energy use and economies, and climate change (Nordhaus 1979; Edmonds and Reilly 1985). Full IAM development came of age in the early 1990s, after the Intergovernmental Panel on Climate Change (IPCC) was established in 1988 (Alcamo et al. 1990; Morita et al. 1994).

The IPCC special report on emission scenarios describes four alternative futures that may evolve to change how we view and emit global GHG emissions (SRES 2000). Each scenario is an alternative image of how the future can develop and is an appropriate tool with which to analyze how driving forces such as population and level of economic development may influence future emission outcomes and to assess the associated uncertainties. These scenarios do not include any additional climate initiatives, which mean that no scenario assumes any explicit climate policy intervention by any region or country.

For its Fifth Assessment Report, the IPCC has introduced a slightly modified approach to scenario development. Four representative concentration pathways (RCPs) have been prepared to describe a comprehensive dataset with high spatial and sectoral resolution out to 2100 (van Vuuren et al. 2011).

The IAM studies continue to be developed and the direction of these developments can be categorized into three areas (Kainuma et al. 2003). The first group of IAM models aim at dealing with a wide scope with more detailed data. As IAMs

need to support broader audiences, new policy needs and new scientific knowledge, modeling targets and phenomena have become wider and more detailed. The second category involves the application of IAMs to participatory IA processes where stakeholders communicate with each other to determine the priority of information and decisions.

Policy makers are in need of tools to facilitate communication with scientists, industry sectors, and environmental NGOs to reach a consensus on climate change policies. In this case, IAMs are used as a communication tool. The third direction of IAM development is to apply IAMs to regional and local assessment rather than global scale assessment. By focusing on smaller scales, various policy targets can be dealt with simultaneously. Altogether, IAMs have been widely recognized as useful tools to quantitatively assess development of human activities.

6.2.2.2 Case Studies of Countries in Asia by IAM

Studies on future emission scenarios are necessary to support studies of potential anthropogenic impacts on the climate system, to serve as the basis for further analysis, as well as to estimate the consequences of climatic events and define better strategies for adaptation. They provide inputs to climate models and assist in assessing the relative importance of GHGs in changing atmospheric composition and hence climate. Scenarios also have an important role to play as baselines for comparison with stabilization scenarios in order to calculate the required mitigation effort. They have been useful for a multitude of purposes by governments, industry, researchers, and social organizations.

The long-term goal for LCD is to reduce the amount of GHG emissions while maintaining desired lifestyles. The Asia-Pacific Integrated Model (AIM) is one of the IAM models that have been developed for the purpose of assessing climate policies especially focusing on the Asia Pacific region (Kainuma et al. 2003). The AIM model was used to calculate the technological feasibility of achieving 70 % emissions reduction from 1990 levels in Japan (NIES et al. 2008). The figure "70 %" was chosen because, at the time of the study, the G8 summit meeting called for halving global GHG emissions by 2050. If the world was to head for this global target, then industrialized countries would have to reduce their emissions by more than 50 %. Japan announced that it would seek ways to achieve 60–80 % reduction by 2050. As such, two scenarios (A and B, as shown in Figs. 6.1 and 6.2, respectively) were developed to design Japanese LCD by two different approaches.

In both scenarios, it was shown that 70 % GHG emissions reduction was technologically feasible (Figs. 6.1 and 6.2). In the first scenario, Scenario A, development and wide use of fuel cells, photovoltaics, heat pump air-conditioners, etc., is anticipated. Much of the electricity supply will be made by nuclear power plants. Power generation and hydrogen production are combined with CCS technologies.

The second scenario, Scenario B, anticipates that there will be much less demand for energy as a result in changes in societal behavior that will require far less energy consumption. A change in the people's mind would slow down overall consumption,

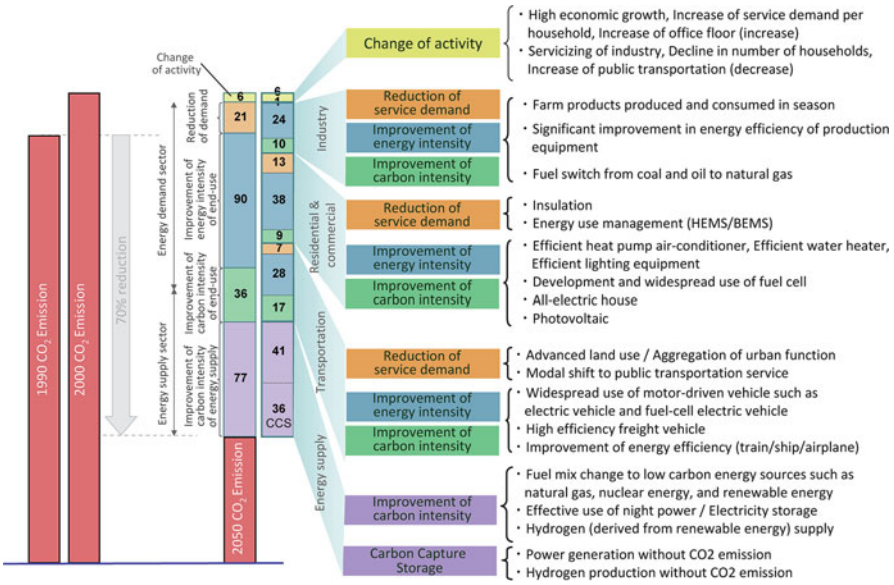

Fig. 6.1 Scenario (A) assumes a high-technology lifestyle where all sorts of energy efficient technologies and non-carbon technologies would be fully installed. This scenario included carbon capture and storage (*CCS*) to play a major role in electricity generation (Source: NIES et al. 2008)

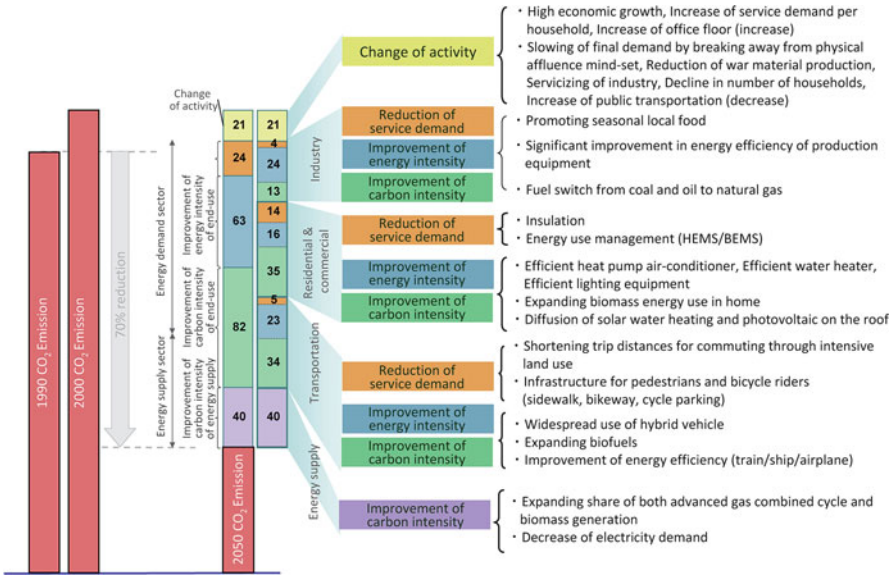

Fig. 6.2 Scenario (B) assumes less high-tech, carbon-intense society where people live in local communities. People would seek a simple and ecological lifestyle, with less eagerness for economic growth. In such a scenario, demand for energy will be less than in Scenario A and society would try to save energy to reduce GHG emissions (Source: NIES et al. 2008)

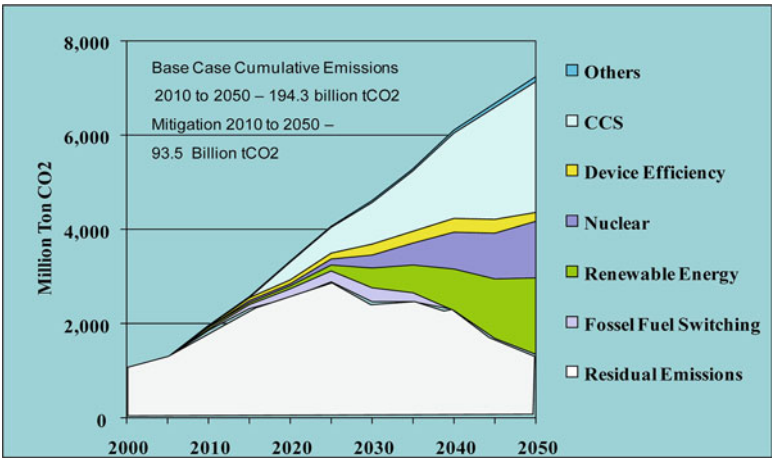

Fig. 6.3 India's carbon tax scenario (Source: IIMA et al. 2009)

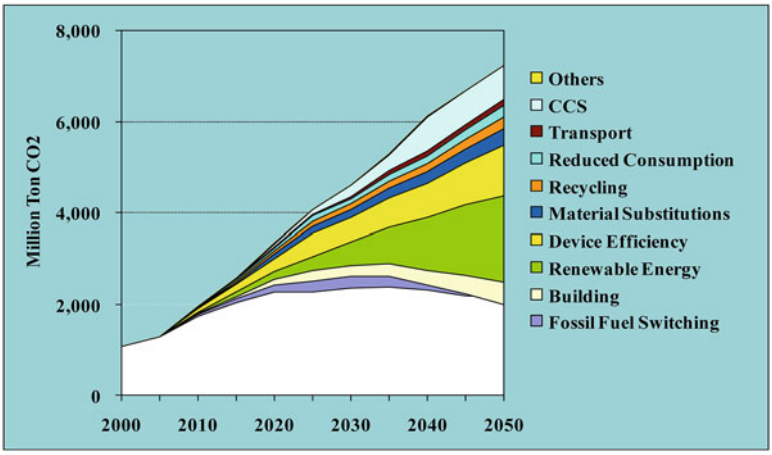

Fig. 6.4 India's sustainability scenario (Source: IIMA et al. 2009)

with the notion of not seeking material affluence but rather mental happiness. Biomass energy will be installed in residential sectors. People will consume food originated in their neighborhood, rather than imported from other countries. The remaining question was whether the people or policy makers are willing to choose such scenarios.

Another study was conducted for India (IIMA et al. 2009). This exercise also assumed two types of scenarios. The first pathway (Fig. 6.3) assumed the conventional development pattern together with a carbon tax that aligns India's emission to an optimal 450 ppmv CO_2 equivalent stabilization global response. The second emissions pathway (Fig. 6.4) assumed an underlying sustainable development pattern characterized by diverse response measures typical of the "sustainability" paradigm.

Under the first scenario (Fig. 6.3), the mitigation target of 93.5 billion tonnes CO_2 is achieved through extensive use of advanced technologies such as CCS and nuclear energy. Meanwhile, the second scenario envisaged the same mitigation target to be achieved by a combination of initiatives on both supply and demand sides. In these scenarios, people in India will benefit not only through climate change mitigation, but also via other co-benefits. For instance, emissions of various gases due to fuel combustion contribute significantly to local air pollution in urban and industrial areas. The control of local air pollutants such as sulphur dioxide (SO_2) has been a major target of environmental policies and programmes in developed countries. Thus, during the low carbon transition, the conjoint policies can deliver benefits of improved air quality through the reduction of costs to achieving air quality targets.

6.2.3 Sustainable Development in Asia and the Pacific

Countries in Asia and the Pacific are facing an expanding future in terms of economy and energy use. Such expansion will affect GHG emissions of these countries, as well as their future for LCD. Especially, energy use in China and India will affect GHG emissions at the global level. This is why we need to look carefully at these two major economies in the region.

6.2.3.1 Sustainable Development in China

As China expects rapid economic development in the years to come, it has been keen on establishing national policies related to energy and environment. After the National Program on Climate Change was released by the Chinese government, China sought ways to deal with GHG emissions mitigation, energy security and economic growth simultaneously (Xiulian and Kejun 2008).

At the same time sustainable development is recognized as an important issue. Agenda 21 for China,[1] whose adoption was announced by the Chinese government in 1994, explicitly states that "*Taking the path of sustainable development is a choice China must make in order to ensure its future development in the century. Because China is a developing country, the goal of increasing social productivity, enhancing overall national strength and improving people's quality of life cannot be realised without giving primacy on economy development. At the same time, it will be necessary to conserve natural resources and to improve the environment, so that the country will see long-term, stable development*."

Since 1994, Agenda 21s objectives have been translated into other policy plans, including the successive 5-Year plans. Other objectives include reducing large

[1] During the 1992 Environment and Development Summit, the UN launched the Agenda 21 programme to guide sustainable development. As regards China, the government published a specific Agenda 21 for the country in order to implement the broader UN programme.

differences in wealth in different areas (especially rural areas and the regions in the west of the country), and hence to more generally reduce poverty and to control population growth.

Tree-planting and afforestation, together with enhancing ecology restoration and protection, have constituted long-term policies in China since the 1970s. According to the Sixth National Forest Assessment in 2005, the acreage conserved artificial forests in the country was 54 million hectares – ranking top in the world – and the amount of growing stock was 1,505 million cubic meters. The total area covered by forests was 174.91 million hectares, and the percentage of forest cover increased from 13.92 % to 18.21 % from the early 1990s to 2005. In addition to tree-planning and afforestation, China initiated many other policies for ecology restoration and protection, including natural forest protection, converting cultivated land to forest or grassland, pasture restoration and protection, further enhancing the capacity of forests as sinks of GHGs. Meanwhile, urban greening also grew rapidly in China. By the end of 2005, total greenery in built-up urban areas reached 1.06 million hectares with 33 % green coverage and 8.1 m^2 of public green area per capita. These green areas act as carbon sinks and aid the absorption of CO_2 present in the atmosphere.

6.2.3.2 Sustainable Development in India

As electricity becomes available in India, households will be able to enjoy more developed and healthy lifestyles. There are studies that calculate the future of electricity use in India (Shukla et al. 2005; Menon-Choudhury et al. 2006). The electricity power sector consumes about 40 % of the primary energy and nearly 70 % of coal use. The result is that the power sector contributes about half of India's carbon, sulphur, and nitrogen oxide emissions. Electricity consumption in India has more than doubled in the last decade, outpacing economic growth. Without any specific policy to change its trend towards LCD, the power capacity in 2015 will grow 2.5 times the 1995 level. Coal technologies will continue to account for the largest share of new additions to capacity, but will decline from 62 % in 2000 to about 55 % in 2015. CO_2 emissions will more than double from the 1995 level by 2015.

This trend can be changed through several types of policies (Shukla et al. 1999). Market liberalization in India, which has been developed since the 1990s, has led increasing direct foreign investment into India. If such a trend continues, it will lead to minor changes to the power supply profile compared with a "business-as-usual" case, but less power capacity will be needed due to greater energy efficiency and utilization of existing capacity.

One environmentally-aware development scenario is a case in which local governments take stricter action against nitrogen dioxide, sulphur dioxide and particulates. Capacity additions closely resemble the business-as-usual scenario, but fitting coal technologies with sulphur control equipment will cut sulphur dioxide by 40 % in 2015, but CO_2 emissions will remain or even increase in this scenario.

An alternative to the previous development scenario is a combination of progressive policy options, including decentralized governance, environmental

conservation, efficiency and renewable energy promotion, and regional cooperation. Requirements for electricity capacity additions fall 22 % from the business-as-usual scenario, but will lead to drastic reduction of both sulphur and CO_2 emissions.

In case studies in any country, there are several paths that lead to a sustainable low carbon future. It is up to the people and decision makers to choose which paths they wish to follow. Some paths require more investment than others. In any case, it is less expensive to start today than to delay investment for the future. It might be good to start from policies that can be considered as no-regrets policies.

6.2.4 International Institutions to Achieve Low Carbon Development

6.2.4.1 Multilateral Institution Set Up Under the UNFCCC: Cancun, Durban and Beyond

Emissions reduction and limitation targets have been negotiated multilaterally under the UN Framework Convention on Climate Change (UNFCCC). As for the GHG emission mitigation, many countries in Asia and the Pacific have pledged their emission reduction targets around the time of the 15th Conference of the Parties to the UNFCCC (COP15), held in Copenhagen in late 2009. Those targets are considered to be voluntary targets and not international commitments, but such target-setting by developing nations is a major initiative that was not observed several years ago.

However, multilateral negotiations under the UNFCCC faced difficulty for many years even after COP15. Countries' emission reduction targets shown in Table 6.1 are voluntary targets which were submitted to the UNFCCC Secretariat to respond to the Copenhagen Accord, noted at COP15. The emissions reduction targets, when summed, are considered to be insufficient to reach the long-term target which had been discussed under the agenda called "shared vision." The Cancun Agreement, agreed at COP16 in 2010, calls for aiming at a maximum 2 °C rise in temperature from pre-industrial levels. It states "deep cuts in global GHG emissions are required according to science, and as documented in the Fourth Assessment Report of the IPCC, with a view to reducing global GHG emissions so as to hold the increase in global average temperature below 2 °C above pre-industrial levels, and that Parties should take urgent action to meet this long-term goal, consistent with science and on the basis of equity." In order to reach the long-term temperature stabilization target, global GHG emission needs to peak as soon as possible. The IPCC report indicates that emissions in the industrialized countries need to be reduced 25–40 % from 1990 levels by 2020 to reach the target. At present the total amount of emissions reduction target set by Annex I countries is not sufficient to achieve the 25–40 % reduction. Further strengthening of emissions reduction by industrialized countries is needed.

COP17, held in Durban, South Africa in late 2011, established a new negotiating process called the "Durban Platform." This process calls for an agreement to be reached by 2015 on "a protocol, another legal instrument or a legal outcome under

Table 6.1 Emission targets of countries in Asia and the Pacific, submitted to the UNFCCC Secretariat by 31 January 2010 (summarized by the author)

Country	Voluntary target
Australia	Reduce GHG emission by 5 % by 2020 compared with 2000 levels unconditionally, and will reduce 20 % by 2020 if the world agrees to a global goal to stabilize GHG concentration at 450 ppm
China	Reduce CO_2 per GDP by 40–45 % by 2020 from 2005
India	Reduce CO_2 per GDP by 20–25 % by 2020 from 2005
Japan	Reduce GHG emission by 25 % by 2020 from 1990 on condition that major emitting countries participate in international mitigation agreement
Republic of Korea	Reduce CO_2 emission by 30 % by 2020 compared with Business as Usual
Indonesia	Reduce CO_2 emission by 26 % by 2020 compared with Business as Usual. With international assistance, the target will be changed to 41 %
Singapore	Reduce CO_2 by 16 % by 2020 compared with Business as Usual
Papua New Guinea	Reduce GHG emission by 50 % by 2030 (base year not defined), and carbon neutral by 2050
New Zealand	Reduce GHG emission by 10–20 % by 2020 compared with 1990 levels by if the world agrees to a global goal of 2 °C.

the Convention applicable to all Parties." The new negotiation process is likely to review the gap between the long-term target and the short-term emission reduction target, and to negotiate ways to fill the gap.

(a) *Means to secure transparency*

The multilateral negotiations deal with other important elements. The schemes for monitoring, reporting and verifying (MRVs) have become another core element of negotiation since after the Copenhagen Accord.

Some industrialized countries hesitate to accept legally-binding emission reduction targets and they prefer to commit to voluntary, non-binding targets. Such relatively loose targets need to be monitored to ensure that countries make serious efforts to achieve their targets. It was therefore decided in the Cancun Agreement to conduct a series of processes to increase transparency of mitigation actions taken by industrialized countries. First, developed countries should submit annual GHG inventory reports and biennial reports on their progress in achieving emission reductions. The developed countries should also report on the provision of financial, technological and capacity-building support to developing country parties. A process for international assessment and review was established under the UNFCCC's Subsidiary Body for Implementation (SBI), with a view to promoting comparability and building confidence.

In many developing countries, methodologies for accurate data collection are needed to accumulate statistical data related to climate change. The MRV process is a way to secure emission limitation targets in each country. In the Cancun Agreement, developing countries are invited to submit to the UNFCCC secretariat information on nationally appropriate mitigation actions (NAMAs) for which they are seeking support, along with estimated costs and emission reductions, and the anticipated timeframe for implementation.

Developing countries are also requested to submit their national communications to the UNFCCC COP every 4 years. They are further requested to submit biennial update reports containing updates of national GHG inventories, including a national inventory report and information on mitigation actions, needs and support received. Internationally-supported mitigation actions will be reviewed domestically and will be subject to international MRV in accordance with guidelines to be developed under the UNFCCC. Domestically supported mitigation actions will be reviewed domestically in accordance with general guidelines to be developed under the UNFCCC. International consultation and analysis of biennial reports will be conducted by the SBI, in a manner that is non-intrusive, non-punitive and respectful of national sovereignty, aiming at increasing transparency of mitigation actions and efforts in developing countries.

(b) *Financial mechanisms*

Financial mechanisms are another key item under the current negotiations, because the level of emission mitigation efforts to be taken by developing nations depends on the amount of financial support by developed countries. Both short-term and mid-term financial support was agreed under the Copenhagen Agreement in 2009 (COP15). For the short term, US$30 billion for the period 2010–2012 was agreed, the allocation of which was to be balanced between adaptation and mitigation. For the mid-term, US$100 billion per year by 2020 was agreed to address the needs of developing countries.

The funds themselves may come from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources. The Green Climate Fund (GCF) under the Cancun Agreement is to be designated as an operating entity of the financial mechanism of the UNFCCC under Article 11. A Transitional Committee is appointed to manage the Fund and, at the time of writing, a decision on how the existing funds under the UNFCCC and the Kyoto Protocol will be merged with the newly established GCF has yet to be made.

Although multilateral negotiations under the UNFCCC have not made substantial progress in the last several years, many countries acknowledge the importance of taking climate change mitigation action even without an agreement being reached at the international level. National actions toward LCD are prerequisite for domestic planning and economic development.

(c) *Co-benefits of climate mitigation policies*

Mitigation policies in many cases have co-benefits. In fact, co-benefits are becoming a major driving force for countries in Asia and the Pacific to set voluntary emission limitation and reduction targets.

First, many countries in Asia will benefit from energy-efficiency improvements. As explained earlier, most countries in the Asia-Pacific region import energy resources such as coal and oil. As demand for energy increases in these countries, improving energy efficiency is beneficial through minimizing costs of imports and improvements in energy security. Even for energy-exporting countries, saving energy at the household level will result in increases in exports, which is beneficial.

Second, mitigation can help improve people's health. For countries that use a lot of coal, installing clean coal technology will minimize local air pollution and health hazards such as respiratory diseases will be reduced due to improved local air quality. Indoor air pollution is also a serious issue in many developing countries. Traditional biomass fuel use has led to the destruction of forests. Shifting from traditional biomass fuel to renewable energy or electricity in households will reduce indoor air pollution in these countries.

Third, many countries in the region are interested in the recent debate on REDD (Reducing Emissions from Deforestation and Degradation in Developing Countries) and REDD-plus (Conservation and Sustainable Forest Management). Countries such as Indonesia and Papua New Guinea have incurred rapid deforestation and the REDD scheme has paved a way for those countries to be involved in emission mitigation policies. Chapter 6.3 provides more detail on the impact of REDD on ecosystem services.

Adaptation is also an important dimension of climate change policies, especially for countries in the Asia-Pacific region. Many small island states will be affected by sea-level rise. Some low-lying countries such as Bangladesh will be affected by floods. Nepal and India are concerned with the melting of glaciers in the Himalayas. Being fully prepared for extreme weather patterns will protect communities even if the extreme weather is not caused by climate change. Mainstreaming adaptation policies within development policies is imperative.

6.2.4.2 Regional Cooperation for LCD Pathways

While major international institutions to deal with climate change have been developed at multilateral levels under the auspices of the United Nations, cooperation at regional levels also has merit. First, each region has its regional circumstance that is hard to be shared with other regions. In the case of Asia, the region is different from other regions because of its rapid economic growth, as well as its rapid urbanization. As a consequence, Asia alone is responsible for more than 30 % of global GHG emissions. This means that any regional policy to reduce emissions in Asia could make a difference to one third of global emissions.

(a) *Asia and the Pacific Economic Cooperation (APEC)*
Asia and the Pacific Economic Cooperation (APEC) is an organization that mainly deals with economic cooperation in the region. Energy and climate change has become one of APEC's main issues in recent years. In the APEC Energy Ministerial Meeting held in May 2010, a joint ministerial declaration called "Fukui Declaration – *Low Carbon Paths to Energy Security: Cooperative Energy Solutions for a Sustainable APEC*" was agreed. The declaration included an aspirational energy-intensive reduction goal to reduce the ratio of energy use to economic output by at least 25 % from 2005 levels by 2030. The Energy Working Group (EWG), set up under APEC, has been instructed to increase analysis of the potential for further energy intensity improvement with a view to recommending an enhanced goal.

(b) *Association of South East Asian Nations (ASEAN)*
The Association of South East Asian Nations (ASEAN) plus three (China, Japan and Republic of Korea) is another group of countries in the Asian region that seeks economic cooperation. The 8th ASEAN+3 Ministers on Energy Meeting (AMEM+3) was held in Brunei Darussalam in September 2011. Ministers at this meeting noted good progress of ASEAN's aspirational goals of reducing regional energy intensity by 8 % and achieving its 15 % target for regional renewable energy in total power-installed capacity by 2015. The Ministers lauded the accomplishments of the CDM programme.

(c) *Asian Development Bank (ADB)*
The Asian Development Bank (ADB) is a financial organization established for the region. Expanding the use of clean energy, encouraging sustainable transport in urban areas, managing land-use and forests for carbon sequestration, promoting climate resilient development, and strengthening policies, governance and capacities are the areas of priority in ADB. Approved in 2008, ADB's Strategy 2020 reaffirms both ADB's vision of the region (freedom from poverty) and its mission to help its developing member countries improve their living conditions and quality of life (Asian Development Bank 2008). The ADB also started its "Pacific Climate Change Program" focusing on 3 main areas of small island countries:

- Climate proofing of on-going and planned ADB infrastructure projects with contributing development partners;
- Promoting renewable energy through new technology and research and development, and
- Working with partners to manage land, water, forests and costal and marine resources.

US$250 million was secured for the period 2010-2012. In addition, the ADB supports individual member countries by loans. In November 2011, the ADB decided to support Indonesia's drive to reduce GHG emissions and strengthen its resilience against climate change by providing a loan for US$100 M. Indonesia has pledged to cut its GHG emissions by 26 % over business-as-usual by 2020, and will aim to increase that to over 40 % with international assistance. Achieving the 26 % reduction will require an investment of billions of dollars between now and 2020. ADB's loan will be used to develop a national action plan to reduce GHG emissions, establish forest management units, establish a legal timber verification system, and promote geothermal energy.

(d) *Low Carbon Asia Research Network (LoCARNet)*
Having recently established a Low Carbon Initiative programme in 2012, the APN is networking with a new regional network – Low Carbon Asia Research Network (LoCARNet) based at the Institute of Global Environmental Studies (IGES), Japan under the guidance of the Ministry of Environment, Japan (MOEJ). LoCARNet (http://lcs-rnet.org/index.html) is an open network of researchers, research organizations that facilitates the formulation and implementation of science-based policies for low-carbon development in Asia. With the UNFCCC's advanced deliberations on a new framework for reducing GHG

Table 6.2 Wide range of disciplines required for research on low-carbon societies

Policy process	Discipline	Examples of application
Low-carbon goal setting	International relations, economics, planning, etc.	National development plan, long-term scenario goal setting, green development plan
Creation of low-carbon development policy	Sciences, engineering, energetics, agriculture and forestry, social infrastructure and urban engineering, economics, sociology, planning, public policy, law, integrated assessment	Preparation of inventories, development of scenarios, selection of technologies, formulation of roadmap, cost accounting, policy options, policy creation, integrated assessment, creation of low-carbon cities, lifestyle analysis
Low-carbon development policy assessment	Economics, public finance, assessment models	Mid- and long-term economic impact assessments, assessment of changes in industrial structure
Low-carbon development policy implementation	Public policy, law, sociology, behavioural science	Policy formulation, formulation of regional plan, consensus building, promotion of public participation
Feedback on assessment of policy outcomes	Public policy	Analysis of policy effects

Source: LoCARNet 2013

emissions in which all nations are expected to participate from 2020, LoCARNet is a timely addition to other ongoing networks, such as the International Research Network for Low Carbon Societies (LCS-RNet) established in 2009 following the G8 Environment Ministers Meeting in Kobe, Japan in 2008.

There are a wide range of disciplines required for research on low carbon societies and the aim of LoCARNet is to promote regional cooperation to facilitate the formulation and implementation of science-based policies for low-carbon growth in the Asian region, together with relevant stakeholders (Table 6.2).

LoCARNet aims to effectively promote research on low-carbon growth policy by enabling a sufficient amount of dialogue between scientists and policy-makers and increase research capacity in the region through knowledge-sharing and information exchange in the context of not only north–south cooperation, but also south-south regional cooperation, as well.

6.2.5 Conclusion

As LCD involves every individual of the region, it is imperative that discussions for LCD need to involve multiple stakeholders. Especially when multilateral negotiation is not making much progress, multi-level activities should be implemented.

This calls for decision-making and the introduction of climate policies at various stages of governance, including international, regional, national and local. Integrated assessments will be needed across these levels of governance.

Recently, the increasing role of non-governmental actors has been observed. Cooperation from the private sector is necessary to achieve LCD. The business sector has voluntarily participated in LCD activities by providing society with energy efficient products. Studies on low-carbon societies are being undertaken by various research groups in many parts of the world and, in Asia, networks of research groups, such as LCS-RNet and, more recently, LoCARNet have been established to provide policy makers with up-to-date scientific findings on visions and pathways toward LCD. These networks serve as platforms for sharing research findings and facilitating collaboration among research institutions and various stakeholders who are interested in scientific research on low carbon development and societies. While these networks involve research institutions from all over the world, most studies consider Asia as one of the most crucial regions in the world that will affect global sustainable development.

6.3 Climate and Ecosystems Management

6.3.1 Natural Ecosystems and Sustainable Development

Natural ecosystems have a critical role to play in sustainable development. This realization is being expressed in the recent move towards a green economy where economic growth is balanced with the conservation of natural capital (UNEP 2011). The term "ecosystem" refers to *a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit* (CBD 1991). Ecosystems are utilized to meet various wellbeing needs that may be of monetary-economic significance or otherwise. Using the Millennium Ecosystems Assessment (MEA) framework, the role of ecosystems to human wellbeing can be viewed in terms of its provisioning, regulating, cultural, and supporting services roles (Millennium Ecosystem Assessment 2005). The provisioning role refers to the products people obtain from ecosystems, and includes food, fuel, fibre, freshwater, and genetic resources. Regulating services are the benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, and water purification. Cultural services are the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences. Supporting services are those that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation.

While every ecosystem provides these different services, the exact nature and degree of the services vary with the type of ecosystem. Thus, for example, forest ecosystems that cover about 31 % of the land area of the earth are home to rich biodiversity.

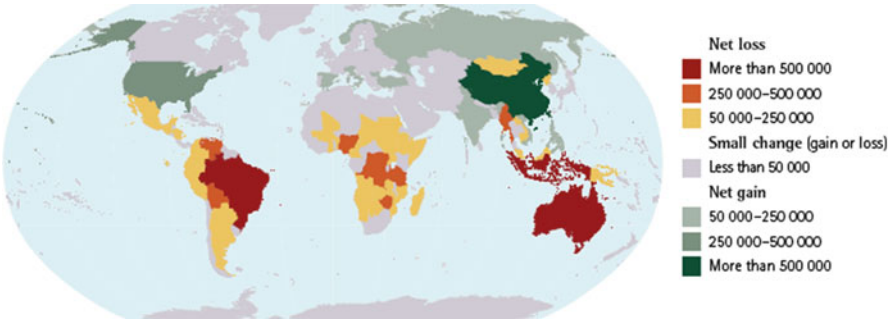

Fig. 6.5 Rate of forest loss and gain in Asia relative to other parts of the world (Source: FAO 2010a)

They contribute to soil formation and water regulation and are estimated to provide direct employment to at least ten million people, apart from being a source of livelihoods to millions more (FAO 2010a). It is estimated that about 410 million people are highly dependent on forests for subsistence and income, and 1.6 billion people depend on forest goods and services for some part of their livelihoods (Munang et al. 2011). Wood and manufactured forest products add more than US$450 billion to the world market economy annually, and the annual value of internationally-traded forest products is between US$150–200 billion.

At the regional and local levels, forests provide services in the form of water purification, flood and drought mitigation, waste decomposition and detoxification, soil generation and renewal, pollination, pest and disease control, seed dispersion, and moderation of weather extremes (Daily 1997). However, conversion of forests for other land use continues to rise, driven by better economic returns or the pressures of increasing space for "developmental" (infrastructure-related) activities (Millennium Ecosystem Assessment 2005; FAO 2010a; Braimoh et al. 2010). The rate of global deforestation is estimated to be around 5.6 million hectares per year (Fig. 6.5), primarily led by forest conversions in Africa (around 3 million hectares per year) and South America (around 3.5 million hectares per year), with Asia showing some gains in forests (around 1.7 million hectares per year) (FAO 2010a).

Similarly, fresh water ecosystems, though constituting only around 1 % of the world's surface area, contribute to food, essential water supply to human and other life for survival and production purposes, in addition to being a refuge for water-based biodiversity, performing various regulating functions such as nutrient recycling, power generation or being the basis of coastal livelihoods (Revenga et al. 2000; Millennium Ecosystem Assessment 2005). The value of these services is estimated to be trillions of dollars (Revenga et al. 2000).

Coastal and marine ecosystems are crucial to life on Earth because they support the livelihoods of billions of people and the economy of many nations (Harvey 2006). These ecosystems are highly productive and act as a repository of biological diversity which is vital to both human wellbeing and survival (Michel and Pandya 2010; UNEP 2006). The vast natural marine ecosystem is comprised of habitats from the productive near-shore regions up to the barren ocean floor. Thus, it includes

oceans, estuaries and salt marshes, coral reefs and other tropical communities (mangrove forests) and coastal areas like lagoons, kelp and sea-grass beds and intertidal systems (for example, rocky, sandy and muddy shores). Coastal ecosystems exist at the interface between terrestrial and marine environments and include some of the most diverse and dynamic environments on earth (USAID 2010). It has great importance due to its ecological and socio-economic functions. It provides a number of livelihoods such as fisheries, ports, tourism, recreation, transportation and other industries (Michel and Pandya 2010; USAID 2010). Besides its economic benefits, it is essential in regulating atmospheric composition, cycling of nutrients and waste removal (Crooks et al. 2011).

More than one third of the world's population resides in coastal areas and they heavily rely on the goods and services provided by coastal and marine ecosystems. In the Asia-Pacific region about 60 % of the population live on or near coasts (Mimura 2006). Despite their great importance to human survival and wellbeing, these ecosystems are threatened by land-use change, over-fishing, pollution, invasion of alien (non-native) species and climate change (UNEP 2006; Millennium Ecosystem Assessment 2005). Productivity and biodiversity are greatly affected by these problems including the growing effects of climate change. This will, eventually, affect the pursuit of the Millennium Development Goals and marine-related goals, which both target sustainable development in the long term (UN 2010).

6.3.2 Ecosystem Change and Impacts

The rapid and extensive ecosystem change (under human influence) in the last century to advance economic development has caused rapid deterioration of natural ecosystems around the world (Millennium Ecosystem Assessment 2005). While this has led to a substantial rise in living standards, it has also caused irreversible loss in the diversity of life on the planet, which is expected to grow even worse in the first half of the present century. Most rivers have been totally restructured; oceans have been severely altered and depleted; coral reefs are near the tipping point of disappearing as functional ecosystems; over half of the land surface is devoted to livestock and crop agriculture, with little consideration for the ecosystem services that are being lost as a consequence (Mooney et al. 2009).

One region that continues to witness rapid change in natural ecosystems is Asia and the Pacific. Parts of Southeast Asia (the Indo-Malaysia and Melanesian landmass) that are host to valuable tropical forests have been classified as biocultural diversity hotspots, based on the threats to their biological and social systems (Maffi 2007). While the FAO reports that forest area in this region is increasing, it is also evident that the threats of degradation are still high (FAO 2010a). This can partly be attributed to demographic changes (Table 6.3) but climate change is expected to further exacerbate these stresses (Braimoh et al. 2010; Fischlin et al. 2007). More specifically, the decline in its ability to perform regulating functions is of special concern because it could lead to its inability to provide other ecosystem services (Carpenter et al. 2009).

Table 6.3 Land area and population of Southeast Asia

Country	Land Area (1,000 ha)	Forest cover (%)	Percent annual rate of forest change (2000–2005)	Population in 2006 (1,000)	Percent urban population (2000)	Percent urban population (2025)	Human development index rank (2006)
Indonesia	181,157	49	–2.0	228,864	42	51	111
Philippines	29,817	24	–2.1	86,263	48	55	105
Vietnam	31,007	40	2.0	86,205	24	41	116
Thailand	51,089	28	–0.4	63,443	31	42	87
Malaysia	32,855	64	–0.7	26,113	62	81	66
Myanmar	65,755	49	–1.4	48,379	28	44	138
Singapore	69	3	0.0	4,381	100	100	23
Cambodia	17,652	59	–2.0	14,196	17	26	137
Lao PDR	23,080	70	–0.5	5,759	22	49	133
Timor-Leste	1,487	54	–1.3	1,113	24	36	162
Brunei Darussalam	527	53	–0.7	381	71	81	30
Southeast Asia	*434,495*	*47*	*–1.3*	*565,097*	*38*	*50*	**nn**

Source: Braimoh et al. 2010

6.3.3 Enhancing Ecosystems

There is increasing recognition of the importance of natural ecosystems as natural capital that provides essential services to humanity. For example, forest cover is increasing in many countries around the world. New forests are regenerating on former agricultural land, and forest plantations are being established for commercial and restoration purposes (Chazdon 2008; FAO 2010a). These artificially-established forests can improve ecosystem services and enhance biodiversity conservation, but they will not be the same as the composition and structure of the original forest cover (Sodhi et al. 2004). This is well illustrated by the proliferation of plantation forests that have arisen in parts of Southeast Asia such as in Malaysia and Indonesia. In 2008, 13.9 % and 60.2 % of the total agricultural land in Indonesia and Malaysia, respectively, were oil palm plantations (FAO 2010b). Such plantations, while providing a canopy cover, have adversely affected primary forest biodiversity (Fitzherbert et al. 2008; Danielsen et al. 2009). Still, there are numerous opportunities for combining forest restoration and regeneration goals to enhance sustainable rural livelihoods, community participation and development goals.

On a wider perspective, there are those who advocate shifting to "ecosystems stewardship." The central goal of this stewardship is to sustain the capacity to provide ecosystem services that support human wellbeing under conditions of uncertainty and change (Chapin et al. 2009).

Three broadly overlapping sustainability approaches are integrated:

– Reducing vulnerability to expected changes;
– Fostering resilience to sustain desirable conditions in the face of perturbations and uncertainty; and

– Transforming from undesirable trajectories when opportunities emerge. Its main strategies include maintaining diversity of options, enhancing social learning to facilitate adaptation, and adapting governance to implement potential solutions.

A key assumption is that the science of ecosystem stewardship is sufficiently mature to make important contributions to all social–ecological systems. The emphasis here is on the principle of adaptive management, which involves adapting to changes and learning to adapt through feedbacks and responses from the environment to better manage resources (Berkes et al. 2000). The concept inherently recognizes the value of integrating mainstream and traditional concepts of resource management to achieve desired objectives.

There will always be trade-offs in natural ecosystems management. In an increasingly resource-constrained world, increases in one ecosystem service or human activity typically result in the reduction in other services or activities (Carpenter et al. 2009). For example, in agriculture, humans have deliberately reduced genetic, stand and landscape diversity to attain greater productivity. Indeed, the general increase in provisioning services over the past century has been achieved at the expense of decreases in regulating and cultural services and biodiversity. However, win–win solutions in the conservation-and-development debate do exist. Table 6.4 illustrates what actions may be necessary to overcome barriers in sustainable management of ecosystems.

A promising approach to ecosystems management is through payments for environmental services (PES) or rewards for environmental services (RES). Efforts are under way to estimate the monetary value of the services that natural ecosystems provide. For example, Perrings (2010) used existing studies to estimate the mean value of both the macro-climatic regulation offered by terrestrial carbon sequestration, and the change in provisioning and cultural services offered by forest systems. The study showed that the mean values of forest ecosystem services, in US$/ha/year, are dominated by regulatory functions: specifically regulation of climate (US$1,965/ha/year), water flows (US$1,360/ha/year), and soil erosion (US$694/ha/year). Several businesses are also adopting environmentally friendly practices and are increasingly acquiring certification for good practices in resource use. The growing membership of certifying agencies that promote sustainable resource-use such as the Forest Stewardship Council, Marine Stewardship Council, Fair Trade Stewardship Council, among others, is testament to the growing realization among consumers and businesses on the need to abide by good and ethical practices of resource sourcing and use.

However, most efforts in environmental service management are not grounded on scientific evidence (Carpenter et al. 2009). While scientific understanding of ecosystem production functions is improving rapidly, it remains a limiting factor in incorporating natural capital into decisions, via systems of national accounting and other mechanisms (Daily and Matson 2008). There is a need for advances in ecosystem service production functions, trade-offs among multiple ecosystem services, and the design of appropriate monitoring programs for the implementation of conservation and development projects that will successfully advance both environmental and social goals (Tallis et al. 2008).

Table 6.4 Sustaining ecosystem services: Barriers, actions, and examples

Barriers	Actions	Examples
People fail to make the connection between healthy ecosystems and the attainment of social and economic goals	Develop and use information about ecosystem services	Perform regular monitoring and assessment Identify and manage tradeoffs Frame messages that resonate with the public Tailor information for citizens, producers, and purchasers
Local people often lack clear rights to use and make decisions about the ecosystem services they depend on for their livelihoods and well-being	Strengthen the rights of local people to use and manage ecosystem services	Ensure that individuals and communities have secure rights to ecosystem services Decentralize decisions about ecosystem services Bring local voices to the table to influence development projects and policies
The management of ecosystem services is fragmented among many different agencies and bodies that often work at cross-purposes and fail to coordinate across levels	Manage ecosystem services across multiple levels and timeframes	Establish the conditions for cooperation with communities Form bridging organizations Use co-management practices Raise priority of working across levels in national institutions
Government and business accountability mechanisms for decisions about ecosystem services are frequently absent or weak	Improve accountability for decisions that affect ecosystem services	Hold elected officials accountable Use public process to track ecosystem investments in meeting development goals Increase corporate transparency
Responsible management of ecosystem services does not always pay	Align economic and financial incentives with ecosystem stewardship	Eliminate perverse subsidies and reform taxation policies Include ecosystem risk in financial evaluations Support markets and payments for ecosystem services Incorporate ecosystem stewardship goals in managers' performance objectives

Source: Irwin and Ranganathan 2007

6.3.4 Natural Ecosystems and Climate Change Adaptation

Natural ecosystems services support substantial components of economies and social systems across Asia and the Pacific and they are keys to enhancing the resilience of local communities to climate change.

Asia and the Pacific harbors many of the world's most diverse and productive natural ecosystems, the world's deepest ocean floor, the world's largest mangroves, vast tropical rainforests, and the highest mountain peaks in the world. The regulating services provided by natural ecosystems are critical for climate change adaptation. These ecosystem services include climate and water regulation, protection from natural hazards such as floods and avalanches, water and air purification, carbon sequestration, and disease and pest regulation (UNEP 2009a). Appropriate protection and effective management of ecosystems are essential for cost-effective mitigation and adaptation for climate stabilization through use of natural carbon sequestration processes and secured delivery of essential ecosystem services; for example, clean air, food and water security (UNEP, n.d.). Therefore, it is important to adopt an ecosystem management approach in planning climate change adaptation and mitigation strategies.

The term "ecosystems-based adaptation" (EBA) is increasingly being used in the international arena and "*relates to the management of ecosystems within interlinked social-ecological systems to enhance ecological processes and services that are essential for resilience to multiple pressures, including climate change*" (Devisscher 2010). EBA includes a range of local- and landscape-scale strategies for managing ecosystems to increase resilience and maintain essential ecosystem services and reduce the vulnerability of people, their livelihoods and nature in the face of climate change (IUCN 2009; Colls et al. 2009). EBA addresses the role of ecosystem services in reducing the vulnerability of natural resource-dependent societies to climate change. EBA is a set of adaptation policies or measures that jointly addresses the vulnerability of ecosystems and the role of ecosystem services in reducing the vulnerability of society to climate change, using a multi-sectoral and multi-scale approach.

Natural ecosystems as natural capital provide provisioning services by enhancing rural livelihoods, especially in developing countries of Asia and the Pacific. Many of the rural communities in these countries rely on forest ecosystems for their livelihoods. In the past 25 years, many countries have overhauled their forest land use rights through some form of community forestry schemes, among them Nepal (Adhikari et al. 2007), the Philippines (Pulhin et al. 2007), and Indonesia (Hindra 2007). This is based on research findings that indicate greater access to forest resources is correlated with enhanced livelihoods and wellbeing in general. For example, in the western Himalayas, higher incidence of land poverty has been observed to be associated with lower forest access rates, while higher incidence of land-rich households is associated with higher forest access rates (Naidu 2011).

In China, poorer households derive greater benefits from non-timber forest products (NTFPs) than wealthier households (Fu et al. 2009). In Indonesia, larger forest areas are significantly correlated to the wellbeing of rural villages

(Dewi et al. 2005). In the Philippines, tenure reform and its associated financial, technical, and livelihood support have seen some promising socio-economic and environmental impacts through the transfer of certain rights to local communities that promote access, use and control of forest resources (Pulhin et al. 2008). In South Asia (India, Bhutan and Nepal), it was reported that higher forest biodiversity is positively correlated with livelihoods (Persha et al. 2010).

However, it must also be recognized that there are many barriers that constrain the full utilization of forest resources to provide livelihoods to the rural poor. Sunderlin et al. (2005) have shown the complex relationship between forests, poverty, livelihoods enhancement and conservation. Ineffective tenure reform, excessive regulatory barriers, poor market access, and weak community capacity, among others, limit the potential of forests to effectively contribute to poverty reduction in many developing countries (Larson et al. 2010). Even in a developed country like Republic of Korea, the benefits local people derive from forests can only accrue if certain conditions exist such as the presence of joint forest management agreements (Yeo-Chang 2009).

In any case, there seems ample evidence to at least suggest that forest ecosystems may provide safety nets in times of food and income scarcity such as may be expected as climate patterns change. More broadly, they provide indirect evidence that the health of natural ecosystems will be a critical ingredient in enhancing the resilience of local communities to climate variability and change. However, there is limited empirical data that provide direct support to this claim.

This is a gap that needs to be addressed by future research.

The importance of forest ecosystems to climate change adaptation coupled with numerous threats to their existence provides strong argument for redoubling efforts to conserve them. This will entail, among others, combining traditional knowledge and scientific knowledge; increasing participatory reform; maintaining and enhancing biodiversity; enhancing robust management strategies; improving inter-sectoral coordination; main-streaming forest adaptation into policy; and incorporating new actors and new modes of governance (Vickers et al. 2010).

At present, some key adaptation options and practices in the forestry sector have been documented in Asia and different parts of the world. These include reforestation and afforestation activities, establishment of early warning systems, use of appropriate silvicultural practices, various forest protection strategies, monitoring of degraded forests, establishment of forest corridors, adoption of soil and water conservation measures, agroforestry, and diversification of local economies and livelihoods through non-wood forest products. If effectively implemented, such adaptation options and practices can enhance community resilience to climate change (Pulhin et al. 2010).

Healthy mangrove ecosystems, which are part of the larger coastal and marine environment, can provide support through protection services from natural hazards like storms and flood, which are expected to increase in strength and frequency due to climate change (AIT/UNEP 2010). Mangroves act as natural revetments or dikes and can mitigate 70–90 % of the energy from wind-generated waves

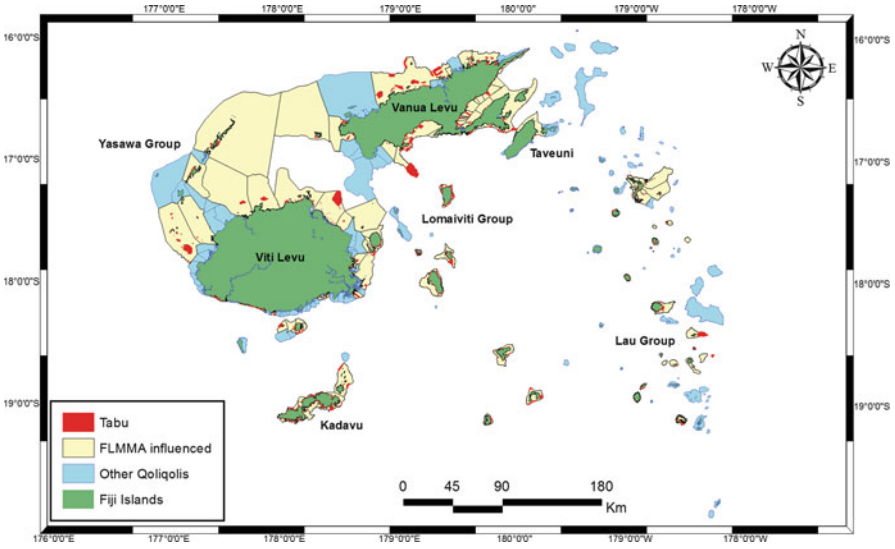

Fig. 6.6 Map showing boundaries of traditional fishing grounds in Fiji (Source: Fiji Locally Managed Marine Protected Area Network)

(UNEP-WCMC 2008). In addition, coastal wetlands can perform carbon sequestration and can transform carbon into sediments that can be stored for millennia (Crooks et al. 2011). Coral reefs provide offshore breakwaters which, reduce the impacts of sea surges and tropical storm waves before they reach the shoreline (UNEP-WCMC 2008).

The Locally Managed Marine Areas (LMMA) of the Pacific countries is a good example of adaptive management of coastal and marine ecosystems. Primarily governed by customary tenure systems, LMMAs are managed using tools, predominantly related to banning of resource sourcing (referred to as "tabu" – see Fig. 6.6) during certain periods and/or from certain areas (Govan 2009). A recent study highlights the successful management of coral, fish and other marine resources by the Pacific country communities, calling for a sensitive approach by scientists and policy bodies when designing interventions related to the ecosystem.

6.3.5 Natural Ecosystems and Climate Change Mitigation

Natural ecosystems in Asia and the Pacific have a critical role in climate change mitigation.

In Asia and the Pacific, natural ecosystems can both help exacerbate and mitigate greenhouse gas emissions. Forest ecosystems influence climate through a combination of physical, chemical, and biological processes that affect planetary energetics, the

hydrologic cycle, and atmospheric composition (Bonan 2008). Tropical, temperate and boreal reforestation and afforestation mitigate climate change primarily through carbon sequestration. Tropical forests mitigate warming through evaporative cooling, but the low albedo of boreal forests is a positive climate forcing. The net climate forcing from these and other processes are not yet known.

Deforestation, degradation and poor forest management reduce carbon storage in forests, but sustainable forest management, planting and rehabilitation, can increase carbon sequestration (FAO 2006). From 1850 to 1995, 75 % of all carbon emissions from South and Southeast Asia were due to the conversion of forests to perennial crops (Vickers et al. 2010). This trend is expected to continue despite the reduction in deforestation rates in the region. Of key concern are the peatlands in Southeast Asia, which contribute 70 % of total emissions from peatlands while occupying a mere 15 % of the total area (Wetlands International 2009). This is equivalent to 1.3–3.1 % of global CO_2 emissions from the combustion of fossil fuel.

At the same time, forest ecosystems in the region provide significant opportunities to mitigate carbon emissions. Using figures from the 1990s, FAO estimates that between 170 and 660 Mt of carbon could be prevented each year if deforestation rates were reduced by 50 % (Vickers et al. 2010). The potential of forest lands to mitigate climate change has been estimated in a number of Asian countries such as India (Ravindranath et al. 2008), Indonesia (Boer 2001) China (Houghton and Hackler 2003) and the Philippines (Lasco and Pulhin 2001).

The emerging carbon market could offer significant financing for forest conservation in the region. Several government and non-government organizations are advocating financial mechanisms such as payments for avoiding deforestation in developing countries under REDD-plus scheme, perhaps in the post-2012 Kyoto Protocol. This is, in part, because it has long been recognized that deforestation, mainly in the tropics, accounts for nearly 20 % of all carbon-based greenhouse gas emissions (Denman et al. 2007). However, it has also been recognized that "the design and implementation of REDD policies will be neither simple nor straightforward, given the complexity of the social, economic, environmental and political dimensions of deforestation. Many of the underlying causes of deforestation are generated outside the forestry sector and alternative land uses tend to be more profitable than conserving forests" (Kanninen et al. 2007). REDD-plus could provide incentives to local communities to be more involved in forest conservation and rehabilitation. For example, in the Philippines, community-based forest management participants are exploring ways to take advantage of carbon finance (Lasco et al. 2010). However, experience with the Clean Development Mechanism (CDM) shows that there are many barriers in implementing them, foremost of which is the high transaction costs (Thomas et al. 2010).

Deforestation, forest degradation and peatlands conversion accounts for 60 % of Indonesia's GHG emissions (Brockhaus et al. 2011). As noted earlier in Sect. 6.2.4, in 2009, the Indonesian government pledged to unilaterally cut its emissions by 26 % by 2020 and by 41 % if given international support. Norway pledged to provide US$ 1 billion in funding to reduce emissions from forests and land-use change.

However, the impacts of REDD-plus projects on livelihoods of the rural poor, although likely to be positive, are still uncertain. A recent review of five pre-REDD projects show that the design, data collection, and analysis methods for understanding the impacts frequently lack sufficient rigor to inform future REDD-plus projects (Caplow et al. 2011). In Indonesia, land allocation policy and processes could negate the good intentions of REDD-plus projects (Brockhaus et al. 2011).

In general, ecosystems management to enhance biological carbon sequestration could lead to other co-benefits. For example, healthy ecosystems protect societies from disasters and improve their ability to cope with the impacts (UNEP 2009b). Agroforestry systems traditionally practiced in different parts of India, in accordance with respective agro-climatic conditions, have been shown to provide multiple benefits. Beyond a diverse income portfolio, such systems, which involve a combination of agricultural and forestry crops, are estimated to sequester about 12–228 Mt per hectare of carbon, which varies due to differences in biomass. These systems also contribute to soil fertility, sustenance of biodiversity, improvement in water-use efficiency, and provide various productive resources to the population (Pandey 2007).

Coastal and marine ecosystems also play a significant role in regulating CO_2 accumulation in the atmosphere. In a recent rapid response assessment of UNEP, it was found out that from all the biological carbon (or green carbon) captured in the world, 55 % was captured by living marine organisms. Blue carbon sinks and estuaries can capture and store from 870 to 1,650 Mt of carbon every year (UNEP n.d.). Oceans provide solutions to help mitigate climate change and opportunities for sustainable development. They generate oxygen and absorb carbon dioxide from the atmosphere, while at the same time provide essential goods and services for sustaining life on Earth. Coastal and marine ecosystems, which include mangroves, salt marshes and seagrass, store up to 70 % of the carbon in the marine environment (UN 2010).

6.3.6 Governance Issues

Successful management of natural ecosystems requires that appropriate governance structures are in place.

Managing ecosystems and building resilience ultimately refers to ensuring appropriate and well-functioning governance systems at the ecosystem level. These systems would be a combination of macro processes (including national, regional and international rights and obligations with attendant institutions and mechanisms) and sub-national processes that include ecosystem-level institutions of both formal and informal character. The non-formal institutions could include traditional forms of leadership institutions that still hold sway in the local contexts. As pointed out by Lebel and Daniels (2009), there are well defined power relations within an ecosystem context between different actors, and while participatory planning enhances better ecosystem outcomes, a system of regulations combined with adequate information and incentives enable better outcomes.

Further, it is important to note that ecosystems do not recognize political boundaries calling for enhanced trans-boundary co-operation in their governance. As highlighted by Badenoch (2002), through an example of flooding in Cambodia due to dam water spill in Viet Nam along the lower Mekong River system, the effects of ecosystem degradation in one part of an ecosystem can have highly damaging consequences in other parts. The same trans-boundary issue holds at the in-country level. In Viet Nam and Indonesia, flooding in the lowland areas has been attributed to deforestation and ecosystem degradation in the upper parts of the watersheds (see for example, Phong and Shaw 2010 for Viet Nam; Lasco and Boer 2006 for Indonesia). An integrated river basin management strategy has, therefore, been recommended to provide a framework for coordination among different stakeholders to tackle complex issues caused by conflicts resulting from multiple users and uses of natural resources (Phong and Shaw 2010).

To effectively respond to the complexity and dynamic changes confronting many natural ecosystems, which in essence constitute both social and ecological components, the notion of "adaptive governance" has recently emerged. Folke et al. (2005) describes adaptive governance as a form of governance that "connects individuals, organizations, agencies, and institutions at multiple organizational levels" where "key persons provide leadership, trust, vision, meaning, and they help transform management organizations toward a learning environment." It focuses on learning and managing resilience or building adaptive capacity where learning can take place at different levels and through various ways including interactions among different stakeholders (Lebel et al. 2010). It departs from the rigid structure traditionally imposed by central governments, but it is often loosely and self-organized as social networks composed of groups that draw on various knowledge systems and experiences. Crucial, however, to successful adaptive governance are enabling legislation, flexible institutions, and the presence of "bridging organisations" like non-government organization that will effectively link local actors and communities to other scales of organizations (Folke et al. 2005).

6.3.7 Outlook

From the foregoing discussion it is evident that some areas need immediate attention to enhance actions that improve resilience of ecosystems and populations deriving ecosystem services. Areas that the research community can contribute to include:

Integrating ecosystem management in climate change action planning.

Science had already proven the importance of ecosystem management in climate change adaptation and mitigation. However, corresponding policies and actions are not yet in place to support proper ecosystem management that also addresses climate change adaptation and disaster risk reduction (UNEP 2009b). Integration of ecosystem management into climate change adaptation and disaster risk reduction

policy frameworks is important to enhance the adaptive capacity of stakeholders, particularly in developing countries vulnerable to climate change impacts.

Communication, education and capacity building.

A study conducted by Futerra Sustainability Communications revealed that different stakeholders respond to different messages. Hence a policy maker tends to weigh the opportunity costs and benefits of any activity, while a conservationist is moved by messages of responsibility to nature (Futerra Sustainability Communications 2010). What also came out was that people respond better when the messages are not playing on the guilt of their actions, but on the need for positive action. This implies the need for developing better social learning tools and educational materials that translate the knowledge on sustainable use of resources and opportunities for win-win scenarios between different stakeholders into user friendly formats. It also raises the need to address capacity gaps at various levels of governance from policy makers to people on the ground.

Increased networking and cross-learning among scientists and practitioners from different disciplines.

Clearly, developing implementable mechanisms to operationalize sustainable development involves the need for trans-disciplinary approaches. This requires fostering scientists and practitioners from different sectors and disciplines and countries to come together to develop solutions appropriate to ecosystems and to dependent populations.

Development and dissemination of tools and methods that capture co-benefits derivable from actions to mitigate and adapt to climate change and to manage sustainable use of ecosystems and resources are required. These need to complement efforts that enable better monitoring and assessment of the status of ecosystems and resource use. It would also be useful to examine how to integrate these approaches with various certification systems developed to ensure sustainable practice in business.

Strengthening inter-linkages among science, policy and practice.

Considering the importance and urgency to address ecosystem management problems as a way to achieve the goal of sustainable development, it is paramount to strengthen the linkages among the scientific and policy communities as well as the local communities to ensure informed decision-making processes at various levels. This requires adherence to the new research paradigm that engages different stakeholders at various levels in all the phases of the research process. Such stakeholder engagement has multiple benefits. It promises to educate the policy makers in current ecosystem issues, problems and solutions and hence to increase the chance of coming up with more scientifically-based policy prescriptions. Similarly, it can empower local communities whose lives are threatened by the adverse impacts of ecosystem degradation to take appropriate actions and avoid or reduce the risks associated with degradation.

6.4 Conclusion and Synthesis

The challenge posed by climate change will be keenly felt in the coming decades in Asia and the Pacific. In parallel, nations in the region will continue to aspire for sustainable development. Policy makers and development workers must find ways to ensure that both these concerns are addressed synergistically while avoiding negative outcomes.

One way to mitigate climate change while pursuing sustainable development is to pursue a low carbon development (LCD) pathway. It is clear that LCD requires negotiation across many stakeholders, including government, non-government agencies, industry and the broad community.

In Asia and the Pacific, natural ecosystems will continue to play a critical role in addressing climate change adaptation and mitigation. Nations in the region will have to find innovative ways to manage and rehabilitate natural ecosystems for a multiplicity of functions and services. This will involve greater collaboration and communication between scientists and policy makers as well as between natural and social scientists. In many developing countries, there is still very limited empirical information and research needs to be ramped up. North–south and South-South partnerships could help fill the gap.

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