Status, trends and future dynamics of biodiversity and ecosystems underpinning nature's contributions to people (IPBES AP Chapter 3)

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Regional and subregional assessments of biodiversity and ecosystem services: regional and subregional assessment for Asia and the Pacific

Chapters of the regional and subregional assessment of biodiversity and ecosystem services for Asia and the Pacific

Note by the secretariat

1. In paragraph 2 of section III of decision IPBES-3/1, the Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) approved the undertaking of four regional and subregional assessments of biodiversity and ecosystem services for Africa, the Americas, Asia and the Pacific, and Europe and Central Asia (hereinafter referred to as regional assessments) in accordance with the procedures for the preparation of the Platform's deliverables set out in annex I to decision IPBES-3/3, the generic scoping report for the regional assessments of biodiversity and ecosystem services set out in annex III to decision IPBES-3/1, and the scoping reports for each of the four regional assessments (decision IPBES-3/1, annexes IV–VII).

2. In response to decision IPBES-3/1, a set of six chapters (IPBES/6/INF/3–6), together with a summary for policymakers (IPBES/6/4–7), were produced for each of the regional assessments by an expert group, in accordance with the procedures for the preparation of the Platform's deliverables, for consideration by the Plenary at its sixth session.

3. In paragraph 6 of section IV of decision IPBES-6/1, the Plenary approved the summary for policymakers of the regional assessment for Asia and the Pacific (IPBES/6/15/Add.3) and accepted the chapters of the assessment, on the understanding that the chapters would be revised following the sixth session as document IPBES/6/INF/5/Rev.1 to correct factual errors and to ensure consistency with the summary for policymakers as approved. The annex to the present note, which is presented without formal editing, sets out the final set of chapters of the assessment for Asia and the Pacific including their executive summaries.

4. A laid-out version of the final regional assessment report of biodiversity and ecosystem services for Asia and the Pacific (including a foreword, statements from key partners, acknowledgements, a preface, the summary for policymakers, the revised chapters and annexes setting out a glossary and lists of acronyms, authors, review editors and expert reviewers) will be made available on the website of the Platform prior to the seventh session of the Plenary.

Annex

Chapters of the regional assessment report on biodiversity and ecosystem services for Asia and the Pacific of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

Disclaimer on maps
The designations employed and the presentation of material on the maps used in this report do not imply the expression of any opinion whatsoever on the part of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystems Services concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. These maps have been prepared for the sole purpose of facilitating the assessment of the broad biogeographical areas represented therein.

Chapter 3. Status, trends and future dynamics of biodiversity and ecosystems underpinning nature's contributions to people

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Executive summary

Biodiversity at the species and ecosystem levels is currently under multiple threats almost everywhere in the Asia-Pacific region, and in many areas the situation is now critical (*well established*). Of the various ecosystems, lowland evergreen forests, alpine ecosystems, limestone karsts, inland wetlands, and estuarine and coastal habitats are most threatened (*well established*). Genetic diversity within species, both wild and domestic, is also decreasing in many cases as a result of decreasing ranges (*established but incomplete*). In several countries there has been a small increase in the forest cover which is mostly attributed to monoculture forestry plantations and enabling policies of the governments. Forest fires associated with rapid loss of forest cover is leading to enormous environmental and socio-economic loss (*well established*) {3.2.1; 3.2.2; 3.2.3; 3.2.4; 3.2.5; 3.3.1}.

There has been a steady decline in the populations of large vertebrates due to poaching and illegal trade in wildlife parts and products in the Asia-Pacific region (*well established*). As a result, most of these species now survive only in the best-managed protected areas (*well established*). Widespread loss of large vertebrates has had a measureable impact on several forest functions and services, including seed dispersal (*established but incomplete*). Australia has the highest rate of mammal extinction (>10 per cent) of any continent globally. Bird extinctions on individual Pacific islands range from 15.4 per cent to 87.5 per cent for those with good fossil records, and these extinctions have resulted in the loss of many ecological functions previously performed by birds (*well established*). Besides wildlife, there is a massive regional trade in timber, traditional medicines and other products (*well established*). Without adequate protection, remediation and proper policies, the current decline in biodiversity and nature's contributions to people on land, in freshwaters, and in the sea will threaten the quality of life of future generations in the Asia-Pacific region {3.2.1.1; 3.2.1.2; 3.2.1.4; 3.2.1.7; 3.2.2.1; 3.3.1}

With the current rate of human population growth, expansion of urban industrial environments, transformation of agriculture in favour of high yielding varieties, transforming forests to uniform plantations of oil palm, rubber or timber trees, the biodiversity and nature's contributions to people in the Asia-Pacific region are likely to be adversely affected in the coming decades (*well established*). It is predicted that most of the biodiversity in the next few decades may be confined to protected areas or in places where the local communities have taken the lead in local level conservation *in lieu* of economic incentives and equitable compensation by the stake-holders. Unprecedented increase in human population of the Asia-Pacific region has stressed the fragile ecosystems to their limits; while arable cropping has been extended to sites which were not entirely suitable for it, resulting in soil degradation and erosion (*well established*) {3.2.1.1; 3.2.1.2; 3.2.1.5; 3.2.2.2; 3.2.2.4; 3.3; 3.3.1; 3.3.6; 3.4}.

Freshwater ecosystems in the Asia-Pacific region support more than 28 per cent of aquatic and semi-aquatic species but nearly 37 per cent of these species are threatened due to anthropogenic and climatic drivers (*well established*). Cumulative impacts of global warming and damming of rivers in some of the river basins will have significant negative impacts on fish production and environmental flows (*well established*). Likewise, degradation of wetlands has had severe negative impacts on migratory waterfowl, fish production and local livelihoods (*well established*). However, there are scientific data gaps on the current status of biodiversity and nature's contributions to people in most of the river basins, inland wetlands and peatlands of the region {3.2.2.1; 3.2.2.2; 3.2.2.3; 3.2.2.4}.

Coastal and marine habitats are likewise threatened due to commercial aquaculture, overfishing, and pollution affecting biodiversity and nature's contributions to people (*well established*). Detailed analyses of fisheries production in the region have shown severe decline in recent decades. It is projected that if unsustainable fishing practices continue, there could be no exploitable stocks of fish by as early as 2048. This could lead to trophic cascades and collapse of marine ecosystems (*established but incomplete*). Loss of *seagrass beds* which forms main diet of several threatened species such as dugong is a major concern (*well established*). There is a need to conduct systematic and region-wide assessment of fisheries stocks and coastal habitat in the region to aid conservation, management and restoration. {3.1.3.1; 3.2.3.3; 3.2.3.6; 3.2.4.6; 3.4}.

Mangrove ecosystems in the Asia-Pacific region are most diverse in the world. They support a rich biodiversity and provide a range of provisioning, regulating and supporting services, which are crucial for the livelihood of local communities (*well established*). Both mangrove and intertidal habitats form a buffer from siltation for offshore coral reefs protection hence affecting productivity of reefs including seagrass. However, up to 75 per cent of the mangroves have been degraded or converted in recent decades (*well established*). The conversion of mangroves to aquaculture, rice, oil palm, and other land-use changes is leading to the loss of the buffer between sea and land which can reduce the impact of natural disasters such as cyclones and tsunamis. It is projected that rise in sea level due to global warming would pose the biggest threat to mangroves, thereby affecting nature's contributions to people especially in Bangladesh, Philippines, New Zealand, Viet Nam and China (*well established*) {3.2.3.1; 3.2.3.2; 3.3.4}.

There has been a steady increase in the number, abundance and impacts of invasive alien species in the Asia-Pacific region, negatively affecting native biodiversity, ecosystem functioning and socio-cultural environments (*well established*). The total annual loss caused by invasive alien species has been estimated at US$35.5 billion in SE Asia and US$9B in Australia. Costs to agriculture due to invasive alien species are likewise immense in the region {3.2.1.1; 3.2.1.2; 3.2.1.4; 3.2.1.5; 3.2.1.6; 3.2.1.7; 3.2.2.1; 3.2.2.2; 3.2.2.3; 3.2.3.6; 3.3.5}.

There has been a nearly 30 per cent decline in biocultural diversity in the Asia-Pacific region since the 1970s (*well established*). Decline of linguistic diversity has been catastrophic in the indigenous Australian and Trans-New Guinean families, as a result of a shifting away from small indigenous languages towards larger, national or regional languages (*well established*). Linguistic and biological diversity often coincide in the Asia-Pacific region and parallel strategies need to be developed for their conservation. National conservation priorities should take into consideration the bioculturally rich areas that are facing great threats {3.2.5; 3.2.5.2; 3.2.5.4; 3.4}.

Protected Area coverage in the Asia-Pacific region has increased substantially since last three decades. Despite this progress, however, at least 75 per cent of Key Biodiversity Areas remain unprotected, suggesting that the region is not on track to conserve areas of particular importance for biodiversity, as called for under Aichi Target 11 (*well established*). Oceania has the highest overall Protected Area coverage in the region. North-East Asia has the highest proportion of Key Biodiversity Areas covered by Protected Areas, but only 1 per cent of its marine area is protected (*well established*) {3.2.5.6; 3.2.6; 3.2.6.1}.

The Asia-Pacific region has high levels of endemism, and some 25 per cent of the region's endemic species are facing high extinction risks as per the IUCN Red List. Endemic species in some subregions face an extinction risk as high as 46 per cent of endemic species threatened in South Asia (*well established*). South-East Asia has the greatest number of threatened species and the fastest increases in extinction risk (Red List Index) in the Asia-Pacific region. North Asian endemic species extinction risk is also higher than the regional average; the high percentage of Data Deficient species (36 per cent) indicates that more research and conservation action are needed for endemic species in this subregion (*well established*) {3.2.1; 3.2.2; 3.2.6.2; 3.3.4}.

Some aspects of biodiversity have recently started to recover in several countries in the Asia-Pacific region (*established but incomplete*). This recovery has resulted from various changes, including population concentration in cities, increased agricultural production per unit area, increasing conservation awareness among citizens, and the enabling policies of the governments. Future trends of biodiversity in the Asia-Pacific region will largely depend on whether other countries will follow this recovering trajectory by stabilizing land/sea use change, manage their natural resources sustainably, and cooperating with each other in meeting the Aichi Targets and the Sustainable Development Goals {3.2.1.5; 3.2.3.5; 3.3.1; 3.3.3; 3.3.6}.

Given that the scientific information on the status and trends of biodiversity and nature's contributions to people is not available uniformly across all ecosystems and habitats in the region, the national governments are encouraged to initiate systematic documentation and monitoring of health of ecosystems and ecosystem flows (*established but incomplete*). Saving terrestrial fauna especially big mammals and other fauna that require large roaming areas such as Orangutans, proboscis monkey, hornbills, tigers, Sumatran rhinoceros, gaurs and Asian elephants can be done by connecting large tracts of forests with wildlife corridors or through rehabilitation projects; the same goes for coastal and marine, freshwater and other ecosystems in the region {3.2.1.1; 3.2.2.4; 3.3.4; 3.4}.

3.1 Introduction

3.1.1 Background and context

The Asia-Pacific region is among the most diverse regions of the globe with unique biodiversity, multitudes of ecosystems and highly-valued habitats spread across terrestrial, marine and freshwater biomes. The natural as well as human engineered ecosystems such as agroecosystems in the region provide numerous goods and services to the diverse ethnic groups and societies in the region which are crucial for sustaining the human civilizations (Chapter 2). With steady growth of human population and economy, there is increasing demand for these services resulting in altered land use, disruption of biogeochemical cycling and ecosystem functioning. This region varies considerably in terms of documentation of biodiversity and analysis of trends. Moreover, valuation of nature's contributions to people in the region is still at the infancy. This means our understanding of the contributions of ecosystem processes to human well-being and our ability to quantify the services is limited. Given that the scientific information on the biodiversity and nature's contributions to people is not available uniformly across all taxonomic groups, subregions and habitats in the region, this assessment relies on the past and current trends within subregions and major ecosystems.

This chapter deals with trends and the current state of biodiversity in the Asia-Pacific region, and how these components affect the nature's contributions to people. Based on the review of recent (past 15-20 years) scientific publications and reports from this region, and current trends, both positive and negative, in biodiversity are presented. The chapter addresses policy question 3 of the Asia-Pacific region, i.e., “What are the status, trends and potential future dynamics of biodiversity, ecosystem functions that affect their contributions to the economy, livelihoods and well-being in the Asia-Pacific region?” Essentially these aspects and all ecosystem services cover the ‘Nature and Nature's contributions to people (NCP) in the region. Given the dynamic nature of these contributions drawn by the society in different parts of the Asia-Pacific region and lack of quantitative information on their state, it has not been possible to cover contributions from all ecosystems. We recognize that much of the published literature on the ecosystem services is based on bio-physical and ecological aspects and there has been very little research on bio-cultural aspects of ecosystem services. The chapter identifies information gaps and areas of future research on the status and trends of biodiversity.

3.1.2 Methodology of assessment

The status and trends of biodiversity in the Asia-Pacific region and the potential impacts of loss across various scales are based on scientific information and other knowledge systems. These data sets are given in Chapter 1. The relevant datasets from ongoing activities were drawn from a wide range of sources, including global, regional, national, local institutions and used for this assessment. Some examples include: national biodiversity strategies and action plans, national reports and data portals; National Specimen Information Infrastructure (NSII); the Global Biodiversity Information Facility[42]; the Indian Bio-resource Information Network[43]; the Group on Earth Observations Biodiversity Observation Network[44] with regional components; the Asia-Pacific Biodiversity Observation Network[45] and subregional or national components; the Japanese Biodiversity Observation Network[46] and the Korea Biodiversity Observation Network[47]; the Atlas of Living Australia and Species Profile and Threats Database[48]; Threatened Island Biodiversity Database[49]; regional initiatives: the

[42] https://www.gbif.org/

[43] http://www.ibin.gov.in/

[44] https://geobon.org/

[45] http://www.esabii.biodic.go.jp/ap-bon/index.html

[46] http://www.jbon.org/eng

[47] http://www.k-bon.net/

[48] https://www.ala.org.au/

[49] http://tib.islandconservation.org/

Economics of Ecosystems and Biodiversity for South-East Asia[50]; regional research institutes: Bioversity International[51] (Asia-Pacific Oceania division), Ocean Biogeographic Information System[52], the World Resources Institute[53], the CGIAR Consortium for Spatial Information[54], the International Centre for Integrated Mountain Development[55], the International Union for Conservation of Nature[56]; government research institutes and non-governmental organizations. Datasets from both published scientific literature and grey materials, along with indigenous and local knowledge sources, were used for this assessment.

The ecosystem-based hierarchical layers of classification was adopted with case studies for all five subregions in the Asia-Pacific region (Chapter 1). For specific habitats especially unique and threatened, box items and trends are given as examples of fine scale assessments. At the species level, examples were chosen from the IUCN Red List of Threatened Species that are presented in most of the subregions and globally monitored; at the country level, significant declining populations of plants and animals were selected. Traded wildlife and plants that also appeared in CITES Appendix 1 & Appendix 2 were also chosen for this assessment.

It is clarified that there are no data available for the vast majority of species/biodiversity, since Red Lists generally and particularly in the Asia-Pacific region (maybe with the partial exception of Australia and New Zealand) are focussed on plants and vertebrates that jointly are likely to account for < 5 per cent of species.

3.2 Status and trends in biodiversity and nature's contributions to people

Status of biodiversity in the Asia-Pacific region has been assessed and described under the following major biomes, namely, terrestrial, freshwater and inland wetlands, coastal, marine, and agro-ecosystems. Of these, the terrestrial biomes are diverse particularly in terms of biophysical features comprising high mountains, plateaus, vast deserts, alluvial plains and low-lying forested tracts. Status of freshwater and inland wetlands have been assessed separately for lentic (lakes and ponds), lotic (rivers and streams) and inland wetlands. Likewise, coastal and marine ecosystems have been assessed under finer habitat classes. Agroecosystems, urban environments and biocultural diversity have been dealt with separately. An approximation to the current status of biodiversity in the Asia-Pacific region was obtained by disaggregating global biodiversity information products (T. M. Brooks *et al.*, 2016). The IUCN Red List of Threatened Species includes 14,249 species in taxonomic groups that have been comprehensively assessed, of which around 21 per cent are considered threatened, which is similar to the global percentage of 23 per cent. Plants have not been comprehensively assessed yet, but a random global sample of 7000 land plant species gives a similar estimate of 16-21 per cent threatened in the Asia-Pacific region, compared with 22 per cent globally (Brummitt *et al.*, 2015). Currently 14 per cent of the land area of the Asia-Pacific region is in areas protected for the conservation of nature, which is equal to the global mean (T. M. Brooks *et al.*, 2016).

3.2.1 Terrestrial biomes

3.2.1.1 Forests and woodlands

The current status of forests and woodlands in the Asia-Pacific region varies among subregions (Table 3.1). According to Global Forest Resources Assessment (FAO, 2015c), which uses a 10 per cent

[50] http://www.teebweb.org/countryprofile/asean/

[51] https://www.bioversityinternational.org/

[52] http://iobis.org/

[53] https://www.wri.org/

[54] https://cgiarcsi.community/

[55] http://www.icimod.org/

[56] https://www.iucn.org/

canopy cover and 5 m height threshold for 'forest' and thus includes woodland, two-thirds of the approximately 7.8 million km^2 of forest in the Asia-Pacific region in 2015 occurs in China, Australia, Indonesia, and India. In percentage terms, forest cover was highest (c. 50 per cent) in South-East Asia, which has adequate rainfall for forest almost throughout the subregion, while it was lowest (1 per cent) in Western Asia, which is mostly too dry. Forest cover was more than 70 per cent in Bhutan, Brunei, Lao PDR, Papua New Guinea, Solomon Islands, and on several small islands in the Pacific, while it was less than 25 per cent in Afghanistan, Australia, Bangladesh, China, India, Iran, Maldives, Pakistan, Singapore, and all countries in Western Asia.

The trends in forest cover also varies among subregions. From 2010-2015, the total forest area increased in North-East Asia, South Asia, Western Asia, and Oceania (for which the forest statistics are dominated by Australia), while it decreased in South-East Asia (Keenan *et al.*, 2015) (Table 3.1). China reported the largest increase in forest area (1.5 M ha/yr) for this period, followed by the Philippines (0.24 M ha/yr), Lao Democratic People's Republic (0.19 M ha/yr), and Vietnam (0.13 M ha/yr) (FAO, 2015c). Indonesia (-0.68 M ha/yr) and Myanmar (-0.54 M ha/yr) reported the highest losses, although Indonesia's rate of loss was only about 40 per cent of the rate in the 1990s. In Australia, reduced clearance resulted in an increase in forest area before 2000, while fires, droughts, and urban and agricultural development have caused fluctuations since (Department of the Environment and Energy, 2016).

Table 3.1 Recent trends in the change of forest cover in the Asia-Pacific region. Source: FAO (2015c).

	Forest area (1000 ha)					Annual rate of change							
						1990-2000		2000-2005		2005-2010		2010-2015	
Region	1990	2000	2005	2010	2015	1000 ha/yr	%	1000 ha/yr	%	1000 ha/yr	%	1000 ha/yr	%
East Asia	209,198	226,815	241,841	250,504	257,047	1762	0.81	3005	1.28	1733	0.70	1309	0.52
South Asia	87,995	88,348	91,518	93,405	94,086	35	0.04	634	0.70	377	0.41	136	0.15
South-East Asia	242,030	220,956	217,107	214,578	210,742	-2,107	-0.91	-770	-0.35	-506	-0.23	-767	-0.36
West Asia	3,182	3,323	3,368	3,403	3,409	14	0.43	9	0.27	7	0.21	1	0.03
Oceania	176,825	177,641	176,485	172,002	173,524	82	0.05	-231	-0.13	-897	-0.51	304	0.18

The subregional rates of forest change hide high percentage losses in some countries and forest types. While an overall decline in forest cover in insular South-East Asia between 2000 and 2010 was 1%/yr, the highest deforestation rates is shown by peat swamp forests at an average annual rate of 2.2 per cent while the lowland evergreen forests declined by 1.2%/yr (Miettinen *et al.*, 2011). Further, the rate of loss exceeded 5%/yr in the Sumatran lowlands and the peatlands of Sarawak, Malaysian Borneo, where around half of the forest cover in 2000 was lost by 2010 (Miettinen *et al.*, 2011). Approximately 35 per cent of Indonesia's remaining forests are located within industrial concessions, and thus vulnerable to loss in the future (Abood *et al.*, 2015).

The FAO statistics used above are based on the national data reported by each country, which have been collected by various methods, but independent assessments by remote-sensing data show broadly similar trends in most, but not all, cases (Keenan *et al.*, 2015). Many of the discrepancies reflect the wide range of definitions of 'forest', with the minimum canopy cover cut-off ranging from the 10 per cent used by the FAO to 60 per cent used by the International Geosphere-Biosphere Programme (Sexton *et al.*, 2015). Other differences reflect variations in the time period covered, in the area cut-off for the inclusion of forest fragments, and in the inclusion or exclusion of tree crops. The latter issue is a particular problem in South-East Asia, where large areas of tropical rainforests have been replaced by monoculture plantations of oil palm, rubber, and trees grown for pulp or timber. The FAO definition of forest excludes oil palm, but includes rubber and other tree plantations, although the areas of planted forests and primary forests, without obvious signs of human influence, are also reported (FAO, 2015c). Japan (41.1 per cent of the total forest area), China (37.9 per cent), and Vietnam (24.8 per cent), reported the highest percentages of planted forests, while Brunei (69.3 per cent), Papua New Guinea (52.4 per cent), and Indonesia (50.6 per cent) reported the highest percentages of primary forest. Papua New Guinea and Indonesia reported the highest primary forest losses for 2000-2015 (Morales-Hidalgo *et al.*, 2015). On some of the small islands in Oceania, such as the atolls of Tuvalu, Kiribati, Tokelau, the Marshall Islands, and the main island of Tongatapu in Tonga, there is very little remaining original forest.

Rapid forest loss is associated with fires in Sumatra and the Indonesian part of Borneo (Kalimantan) where forests and secondary vegetation are often burned to develop oil palm and pulpwood plantations (see Chapter 4). The extensive and persistent fires that can result impose enormous environmental and economic costs (Chisholm *et al.*, 2016; Drake, 2015) and the associated haze seriously threatens human health (Sahani *et al.*, 2014). Fires are particularly extensive and serious when strong El Niño events coincide with positive Indian Ocean Dipole conditions, which both promote drought (Koplitz *et al.*, 2016). The 1997/98 and 2015 events burned around 11 million hectares (Wooster *et al.*, 2012) and 4.6 million hectares (Lohberger *et al.*, 2018) respectively, and one recent study estimated that the haze in 2015 caused 11,880 (6,153–17,270) excess deaths in Equatorial Asia (Koplitz *et al.*, 2016).

Rapid forest loss has direct negative consequences for survival of forest-dependent vertebrate species. In Sundaland (the Malay Peninsula, Borneo, Sumatra, and Java), (Wilcove *et al.*, 2013) projected that in the lowland forests as many as 29 per cent of the bird species and 24 per cent of the mammals are likely to go extinct in coming decades if the rate of forest loss continues at the present rate. The extinction risks are disproportionately high in some hot spots including Borneo (Betts *et al.*, 2017). The faunal depauperation can also lead to decline in the population of large seeded animal-dispersed trees in tropical forests. A simulation study (Osuri *et al.*, 2016) estimated that aboveground carbon stocks will be lost by up to 5 per cent under the 50 per cent removal scenario. In lowland forests where wind-dispersed trees such as dipterocarps are dominant, the loss of carbon stocks may be insignificant but the capacity of many tree species to track shifts in suitable habitat under climate change may be markedly reduced (Mokany *et al.*, 2014).

In Australia, woodland bird sightings have declined between 11 and 51 per cent over the past 20 years (Morton *et al.*, 2014). Plant species are also under threat, since the highest plant diversities in the Asia-Pacific region are in the tropical lowlands of Sundaland (Pimm & Joppa, 2015; Raes *et al.*, 2009, 2013). Whereas there have been few other quantitative assessments of plant extinction risks in the Asia-Pacific region, it has been estimated in Japan that 370-561 taxa of vascular plants from all habitats are likely to face serious threats of extinction during the 21st century despite an increase in forest cover (Kadoya *et al.*, 2014). Both natural regeneration of forest (Zou *et al.*, 2016) and active reforestation (Korea Forest Service, 2014) can provide habitats for many forest-dependent species, but the extent and regional importance of these new forests has not yet been assessed for the Asia-Pacific region.

In addition to deforestation, forest degradation is driving biodiversity loss and a decline in ecosystem services (Haddad *et al.*, 2015). Logging (i.e. timber harvest) and hunting are the most pervasive impacts on native forests that have not been cleared. Although logging has adverse impacts on sensitive species, logged forests still retain a relatively high conservation value and this increases over time if they are protected (J. F. Brodie *et al.*, 2015; Edwards *et al.*, 2014; Ewers *et al.*, 2015; Wilcove *et al.*, 2013). Even forests that appear intact in high-resolution satellite images, without logging roads and large canopy gaps, have often lost much or all of their large vertebrate fauna as a result of hunting (Harrison *et al.*, 2016). As a result, many large vertebrate species (for example, elephants, tigers, and most primates) now survive mainly in the best-managed protected areas and few, if any, areas in the Asia-Pacific region support all the species they did 100 years ago. This widespread loss of large vertebrates has had a measureable impact on many forest functions and services, including seed dispersal (Harrison *et al.*, 2013, 2016). While some hunting is for subsistence or local markets, there is also a massive regional trade in wildlife and wildlife products for food, traditional medicines, ornaments, and pets (Hughes, 2017; Wilcove *et al.*, 2013). Valuable plant species (medicinal plants and orchids, in particular) may also be threatened by overcollection in some areas (Phelps & Webb, 2015). In Australia, long-term grazing pressure from exotic livestock threatens understory plants in forests that appear intact in satellite images (Auld *et al.*, 2015), while invasive alien species, including the fungal pathogen myrtle rust (*Puccinia psidii*) from South America, threaten native forest trees (Carnegie *et al.*, 2016).

Under rapid forest loss and degradation, within-species genetic variation is expected to be decreasing under the power low relationship between genetic diversity and population size (Mimura *et al.*, 2017), but this decrease remains poorly documented. Despite a large population of the threatened timber tree *Dalbergia cochinchinensis* being fragmented into smaller populations with the lack of gene flow between them, the species still maintains a fair amount of genetic diversity at the nuclear loci (Moritsuka *et al.*, 2017). This could be due to only several generations have passed since the beginning of artificial logging. Long-term monitoring as well as efforts for studying more species are needed to assess trends of genetic diversity in threatened species. As for animals, a recent discovery of the third species of Orangutan from Sumatra (Nater *et al.*, 2017) demonstrated that even single taxonomic "species" include multiple lineages that are threatened under forest loss.

Whereas the FAO reports that forest area is increasing in the Asia-Pacific region, this largely reflects a massive increase in plantation forests—usually monocultures and usually of non-native species—while loss of natural forests often continues (S. Liu *et al.*, 2017; Zhai *et al.*, 2017). Both economic development and state policies have been important in driving these changes. Plantations typically support fewer native species than natural primary or secondary forests, particularly in tropical Asia and particularly when the plantations are intensively managed (Phillips *et al.*, 2017).

3.2.1.2 Grasslands and savannas

Grasslands in the Asia-Pacific region occur in a wide range of eco-climatic conditions such as flood plains of Gangetic and Brahmaputra in India, semi-arid and arid regions of west and central Asia, sub-tropical and temperate regions of Australia and New Zealand (Dixon *et al.*, 2014; Rawat & Adhikari, 2015; Suttie *et al.*, 2005) For the purpose of this assessment we separate the tropical and temperate grasslands and savannas from the alpine rangelands including the alpine scrub and desert steppes of Tibetan plateau and the Greater Himalaya which are described under 3.2.1.3. The geographical spread of grasslands in the Asia-Pacific region varies considerably across the region, from nearly 70 per cent in Australia (McIvor, 2005) to smaller areas. Savannahs are distributed between semi-arid thorn scrub and dry sclerophyllous forests in sub-tropical Asia and Australia. Both grasslands and savannah are amongst the most dynamic terrestrial ecosystems providing numerous contributions to people (Suttie *et al.*, 2005; White *et al.*, 2000). They are home to a diverse assemblage of flora and fauna. Typical and in many cases even emblematic are grass species such as feather grasses (*Stipa* spp.), and obligate grassland herbivores such as antelopes, rhinoceroses, equids, rodents and associated carnivores. Grasslands of Australia are rich in marsupial kangaroos and also harbour the highest diversity of lizards in the world (Morton *et al.*, 2014). Grasslands support a large number of bird species including partridges, quails, floricans, larks, pipits and several raptors (e.g., Suttie *et al.*, 2005). Rodents and a large number of invertebrates including termites and nematodes depend on underground biomass and contribute to ecosystem functioning in the grasslands (Borer *et al.*, 2014; Maestre *et al.*, 2012; Reich *et al.*, 2012).

The biodiversity of natural grasslands in the Asia-Pacific region are threatened largely due to (i) conversion of this habitat into agriculture and habitation, (ii) climate change, (iii) invasive species, and (iv) CO_2 and N-enrichment. Under the land conversion in Australia, grasslands with the lowest percentage of undisturbed ecosystems have been reduced to the south-east (Department of the Environment and Energy, 2016; Morton *et al.*, 2014). It is estimated that over 60 per cent grasslands in the tropics of the Asia-Pacific region are degraded or encroached for other land uses (Rawat & Adhikari, 2015). Land use, climate change and invasive species have resulted in rapid decline in obligate grassland fauna including keystone species mammals and birds (Dutta *et al.*, 2011). Under global CO_2 and N-enrichment (M. Lee *et al.*, 2010), from 2000 to 2013, productivity increased in large parts of the Asia-Pacific region grasslands in the West, and North of the region, New Zealand,

and eastern Australia while other parts, especially western Australia show decreased productivity. The increase in primary productivity especially in temperate grasslands can lead to decrease in biodiversity (C. M. Clark *et al.*, 2007; Hautier *et al.*, 2009), with light competition by plants as the underlying mechanism (Hautier *et al.*, 2009). This decrease is, however, predicted from findings derived in small scale experimental settings (though in global networks), and it remains unclear whether the observed NPP increases already have led to biodiversity loss on the scale of the Asia-Pacific region.

Among grassland animals, most of the large ungulates especially in temperate grasslands have declined in number. Much of these declines in larger mammals are attributed to massive poaching, but more recently infrastructure development (fences, traffic lines; Batsaikhan *et al.*, 2014) and agricultural expansion (Berger *et al.*, 2013) have become major obstacles. For other species long-term trends (decadal scale) are less clear, and sound data such as Red Lists are hardly available. An exception is China, where the national Red List for plants indicate that a number species in southeastern Xizang are threatened (Zejin Zhang *et al.*, 2015). In Australia, feral cats in combination with changing fire regimes are causing widespread declines in native small mammal populations in grasslands and savannas across the north (Frank *et al.*, 2014; J. C. Z. Woinarski *et al.*, 2015). Australia has the highest rate of mammal extinction (>10 per cent) of any continent globally accounting for 30 per cent of the world's mammal extinctions in the last few hundred years, mainly from predation by alien foxes and cats (Morton *et al.*, 2014). The most recent mammal extinctions were from islands in 2009 and 2016 (Department of the Environment and Energy, 2016).

In Australia, where >60 per cent of the country is grazed by livestock, trampling and compaction of soil has been reported leading to loss in primary productivity . Here, native grassland plant communities have not evolved with ungulate grazers (Fensham *et al.*, 2014) and there are many feral populations of twelve invasive alien grazing ungulates (E. J. Ens *et al.*, 2016). In many areas the native herb layer is gone or made up of exotic plants. In some of the best surveyed parts of Australia, 25 per cent of herbaceous species are rare, endangered or vulnerable (Morton *et al.*, 2014). Grazing exclusion proved a suitable measure for soil restoration in most Chinese grasslands (Z. Hu *et al.*, 2016). Chronic pressure of livestock grazing reduces N availability due to indirect removal via livestock use, collection of dung for fuel and accelerated soil erosion (Giese *et al.*, 2013; Tang *et al.*, 2017). A review of N-fertilizaton experiments shows that most grasslands are nitrogen limited (Tang *et al.*, 2017). Addition of N in natural grasslands could enhance biomass productivity, but may have negative effects on biodiversity.

Savannhas in the Asia-Pacific region have existed for over 1 million years, and have high level of C4 grass endemism and diversity (Ratnam *et al.*, 2016). Its distinct functional ecologies reflect fire- and herbivory-driven community assembly. For maintenance of savannahs, appropriate fire management system is a clear need to have in-depth understanding on spatio-temporal effects of burning (Dexter *et al.*, 2015). Savannahs in the Asia-Pacific region are heavily threatened due to: (i) land-use changes including conversion to agriculture and plantations, (ii) mismanagement of fire and herbivory which could otherwise be helpful in maintaining ecosystem health and diversity provided these are used judiciously; (iii) invasion by alien plant species such as *Prosopis juliflora* and *Lantana camara* that leads to changed physiognomy (Lunt *et al.*, 2007), and (iv) likely changes in precipitation regimes under changing climate scenario (Klein *et al.*, 2004; Ratnam *et al.*, 2016). A recent study has revealed that in Indian sub-continent sub-tropical and tropical savannahs are in particular risk of biome shift under changing precipitation regimes (Rasquinha & Sankaran, 2016). Continuous commercial livestock grazing, particularly in arid and semi-arid savannas and other rangelands is known to have changed vegetation structure and composition and increase in proportion of unpalatable woody cover (Yun Wang & Wesche, 2016). Grazing induced changes in abundance of various faunal groups such as small mammals (G. Li *et al.*, 2016; Zhibin Zhang *et al.*, 2003), grasshoppers (Hao *et al.*, 2015; Zhu *et al.*, 2015) and microbial diversity (Qu *et al.*, 2016) have been documented in various grasslands but clear trends cannot be deducted at present.

3.2.1.3 Alpine ecosystems

The alpine ecosystems are generally located in high mountains between the upper limits of tree growth (alpine treeline) and snowline, characterized by highly seasonal environment with short growing season and treeless vegetation. The alpine treelines in the Asia-Pacific region can be as low as 1000 – 1200 m asl in New Zealand (Wiser *et al.*, 2001) and reach an elevation of 4200 m asl $\pm$ 200 m in the eastern Himalaya. Spread over a considerably large area in the Asia-Pacific region (Olson *et al.*, 2001; Wesche *et al.*, 2016), the alpine ecosystems encompass alpine moist and dry meadows, moist and dry scrub, and steppes of Iran, Pamir, Hindu Kush Himalayan region, Hengduan, Tian Shan, Altai and Sino-Japanese mountains. In the Pacific region, alpine zone is distributed in Java, Papua New Guinea, New Zealand, and Australia. These ecosystems harbour a rich array of floral and faunal diversity and provide a variety of nature's contributions to people. Besides the outstandingly rich biodiversity and endemism in the Himalayan alpines, especially in its eastern part as shown for vascular plants by Mutke and Barthlott (2005), plant diversity of the upper vegetation belts is often composed of a high degree of locally endemic species in other areas, such as in the mountains of Iran (Noroozi *et al.*, 2011), New Guinea (Hope, 2014), Australia (Costin *et al.*, 2000) and New Zealand (Mark & Adams, 1995). Most of these alpine areas are intimately linked with local culture and tradition thereby providing bio-cultural services. For example, many of the sacred mountains in the region are located in the alpine regions. However, in many parts of the Asia-Pacific region, especially in the Himalayan region, the alpine habitats are rapidly changing due to anthropogenic and climatic drivers (Chapter 4). Simulation models, experimental studies and empirical evidence show that the rising temperature and increasing extreme climatic events are likely to alter the vegetation structure, ecosystem processes and biogeochemical cycling in the alpine region of the Asia-Pacific region affecting ecosystem services including hydrology and local livelihoods (Shrestha & Aryal, 2011; Xu *et al.*, 2009). Extent and drivers of the change are, however, under debate as shown for the case of the Tibetan Plateau where commonly quoted estimates of up to 90 per cent of degraded land may be far too large and are in any case subject to large uncertainty (R. B. Harris, 2010; P. Wang *et al.*, 2015).

A few authors have predicted that global warming is likely to induce upward shifts in alpine timberline or poleward shift of boreal forests (e.g., Holtmeier & Broll, 2007; Panigrahy *et al.*, 2010; Parmesan, 2006). However, to date no long term studies have yet proven such shifts (Bharti *et al.*, 2011). Cao *et al.*(2015), based on an experimental study, concluded that with increasing temperature, a native voracious grassland caterpillar (*Gynaephora menyuanensis*) is likely to increase which may further reduce production of grasslands and negatively affect livestock production. A study in alpine regions of Sikkim, India, has revealed that the plant assemblages of endemic species have been affected by ongoing global warming through species range shifts and are likely to result in species extinctions, particularly at mountaintops (Telwala *et al.*, 2013). Expansions of dwarf bamboo and dwarf pines into alpine meadows and associated impacts on alpine species diversity were observed in northern Japan (Amagai *et al.*, 2015; Kudo *et al.*, 2011). Climate change has also affected vegetation seasonality (phenology) with most sites across Tibetan Plateau showing earlier onset and later offset of the vegetation period and thus increased net primary production (Siyuan Wang *et al.*, 2017). Patterns do, however, differ between local climatic regimes. A recent remote sensing study with improved local calibration showed that trends in vegetation cover over time differ across the Tibetan plateau (Lehnert *et al.*, 2016). Trends were associated with changes in precipitation rather than with grazing pressure, and declining precipitation may reduce rangeland productivity in western and southern Tibetan plateau. Of all the alpine habitats, mesic *Kobresia pygmaea* at the transition between the moist east and the drier west of the Tibetan plateau mats are most vulnerable due to changes in hydrology and grazing intensity (Yun Wang *et al.*, 2017) and decline in native herbivores (Batsaikhan *et al.*, 2014). However, much of the decline in larger mammals are attributable to massive poaching, but more recently infrastructure development (fences, traffic lines) and agricultural expansion have become major obstacles. For other species long-term trends (decadal scale) are less clear, and sound data such as Red Lists are hardly available. Exceptionally, the national Red List for plants in China indicated that a number species in western and southern Xizang are threatened (Zejin Zhang *et al.*, 2015).

Compared to degraded meadows, intact alpine meadows provided more economic benefits from carbon and nutrient maintenance when compared to degraded meadows as shown by a study in the Tibetan plateau (Wen *et al.*, 2013) . Destruction of the alpine grasslands led to economic loss of about $198/ha due to decrease in biomass. Also, the economic cost caused by carbon emissions and nitrogen loss on severely degraded grassland was up to $8 033/ha and $13 315/ha until 2008, respectively. Actions to maintain nature's contributions to people, especially hydrological functions of alpine habitats, are urgently required in all the alpine regions of the Asia-Pacific region (Shaheen & Mashwani, 2015).

The coverage of protected area is increasing in the alpine ecosystems (Figure 3.1), although the reserve system has important gaps such as in NW-China / Xinjiang and South-eastern Tibetan plateau (Wesche *et al.*, 2016; Zejin Zhang *et al.*, 2015). Most of the large reserves are located in Xizang, where the coverage of reserves is >30 per cent (Wesche *et al.*, 2016), the Changthang Nature Reserve being the largest (UNEP-WCMC & IUCN, 2017). Grazing is strictly controlled and often not allowed in these reserves, and large parts of the plateau outside the protected areas are also subjected to governmental schemes for reduced grazing and sedentarization (Bai *et al.*, 2010; Gongbuzeren *et al.*, 2015; J. Huang *et al.*, 2016; Yang Wang *et al.*, 2014; Yun Wang & Wesche, 2016; Wesche *et al.*, 2016).

Name	Countries	Trends in cover of protected areas (%)	Trends in RLI of Key Vertebrate Species	Grassland conversion	Grazing degradation	Climate change effects
Steppes and dry steppes of Mongolia	Mongolia	↑ WE	↓ WE	↔ WE	↑ UR (locally)	↑ UR
Steppes and dry steppes of northern China	China	↑ WE	↓ WE	↑ WE	↑ WE	↑ UR
Alpine steppes and pastures of Tibetan plateau	China	↑ WE	↓ WE	↑ WE	↑ UR (locally)	↑ IC
Alpine steppes and pastures of western Himalaya-Tien Shan	India, Afghanistan, Tajikistan	↑ WE	↓ WE	↑ EI	↑ IC (locally)	↑ UR

Figure 3.1 General trends in alpine rangelands of the Hindu Kush Himalayan region over 50 years, assessed using the Red List Index (RLI).
Note: Arrows indicate direction: increasing - ↑, declining - ↓, largely unchanged - ↔. Confidence of estimated impact: well established - WE, unresolved - UR, established but incomplete - EI, inconclusive – IC (see IPBES confidence levels, IPBES, 2016). Shadings indicate magnitude of trend (very high / high / moderate / low)

3.2.1.4 Deserts and semi-deserts

Deserts and semi-deserts occupy almost 20 per cent of the land area of the Asia-Pacific region and provide important ecosystem services. They are located between 15° and 40° north and south of the equator and characterized by low and infrequent precipitation, high rates of evapotranspiration, poorly developed soil, and very low (<5 per cent) vegetation cover (Figures 3.2 and 3.3).

In north-eastern Asia and rain-shadow zones of the Himalaya, there are extensive cold deserts. Despite their low primary productivity, both hot and cold deserts harbour rich faunal assemblages, including some globally threatened species, most of them exhibiting special adaptive features. Deserts and semi-deserts cover more than 1 million km^2 of northern China and southern Mongolia. The conservation status of some flagship species in this biome is endangered and their status has not been improved, e.g. snow leopard; *Panthera uncia* (R. B. Harris & Reading, 2008; R. Jackson *et al.*, 2008). This region supports the world's largest remaining populations of the Near Threatened khulan; *Equus hemionus hemionus* (Moehlman *et al.*, 2008), the Critically Endangered wild Bactrian camel; *Camelus ferus* (Bannikov, 1974; Hare, 2008; Kaczensky *et al.*, 2014), and the Vulnerable goitered gazelle (*Gazellus subgutturosa*) (Kingswood & Blank, 1996). This ecoregion has experienced thousands of years of apparently sustainable land use by traditional nomadic herders, with wild herbivores playing an important role for local livelihoods as meat supply (World Bank, 2006). However, the wildlife and pastoral livelihoods of this area are threatened by rapid growth in mining and related infrastructure (The Nature Conservancy, 2012). The number of planned and constructed large infrastructure projects has increased rapidly over the last 10 years (Lkhagvasuren *et al.*, 2011), resulting in major habitat loss for wild ungulates, as well as cutting off critical animal movements, and reducing substantial portions of all of their population ranges (Batsaikhan *et al.*, 2014). The northeastern deserts of the Asia-Pacific region suffer largely from overgrazing, increased mining, and other developmental projects. The cold deserts of the Trans-Himalaya have undergone local level changes in land use and land cover due to increased livestock densities and forage use, and the sedentarization of herders. Since 1991 substantial plant species shifts and losses occurred in the regions and few have crossed an irreversible threshold of ecological change (Fernández-Giménez *et al.*, 2017).

The Arabian Desert in western Asia extends from Yemen to the Persian Gulf, and Oman to Jordan and Iraq. One of the largest bodies of continuous sand in the world, Rub'al-Khali or 'The Empty Quarter' is located in this region. The Arabian Deserts hosts several endangered native mammals, including the likely Critically Endangered Arabian leopard; *Panthera pardus nimr* (Spalton & Hikmani, 2006), and the Vulnerable Arabian oryx; *Oryx leucoryx* (IUCN SSC Antelope Specialist Group, 2011). There are also several endangered bird species in this desert whose populations have declined drastically during the last 15 years, including the Endangered Saker falcon; *Falco cherru* (BirdLife International, 2017a; Shobrak, 2015) that winters in the region, and the Critically Endangered sociable lapwing; *Vanellus gregarius* (BirdLife International, 2016). Plant species in the region are also under heavy anthropogenic pressures. According to one assessment, 36 per cent of desert plant species in the northwestern Red Sea region are at the risk of extinction (Lovett-Doust *et al.*, 2009) and even date palm trees; *Phoenix dactylifera* has been degraded in several countries (El-Juhany, 2010). The Arabian deserts have undergone rapid degradation, especially in the countries where the share of agriculture in the gross domestic product (GDP) is high, such as Syria and Yemen (Abahussain *et al.*, 2002; ACSAD *et al.*, 2004; SRAP, 2007). Rapid industrial development in the Gulf countries has similarly led to degradation of desert and specifically semi-desert ecosystems (Edgell, 2006; Gardner & Howarth, 2009; Mubarak, 2004).

There are several other desert biomes in the South Asia subregion. The status of the fauna and flora of the region has not been assessed comprehensively in the last decade, though they exhibit signs of degradation. Overgrazing by domestic livestock and introduction of fast growing plant species have led to habitat degradation (Amiraslani & Dragovich, 2011). Species which have suffered most from habitat degradation in this region include the Critically Endangered Asiatic Cheetah; *Acinonyx jubatus venaticus* (Jowkar *et al.*, 2008) and several endemic endangered medical plants (T. I. Khan *et al.*, 2003). Weaponry, war and political conflicts pose a risk directly and/or indirectly to the environmental stability of the area. This region is geo-politically sensitive and prone to political conflicts and military activities. Hence, environmental issues are not given high priority at the national levels (El-Showk, 2016; Van Damme, 2011).

The Australian deserts are vast, unique and diverse. They support more lizard species than any other comparable environment, and exhibit the highest diversity of soil arthropods such as termites and nematodes (Steffen, 2009). More than one-third (22 species) of the terrestrial mammal species of the central deserts of Australia have vanished since the 1900s (Burbidge *et al.*, 1988; J. C. Z. Woinarski *et al.*, 2015), which has had significant consequences for native plant communities via the decrease in ecological functions (Fleming *et al.*, 2014) (e.g., bioturbation) and seed dispersal (Murphy *et al.*, 2005). There are several threats to these deserts, such as invasive alien species, especially vertebrate predators including feral cats that have been largely responsible for native mammal extinctions and have put extinction pressure on 124 extant but threatened species including the iconic night parrot (Department of the Environment, 2015) and feral wild camels (Saalfeld *et al.*, 2010). Increase in exotic plants, particularly buffel grass; *Cenchrus ciliaris* has led to altered fire regimes (M. L. Brooks *et al.*, 2004; Burrows *et al.*, 1991; Russell-Smith *et al.*, 2003) which together with predation has caused further decline of certain species, e.g. greater bilby; *Macrotis lagotis* (Cramer *et al.*, 2016), and the desert bandicoot; *Perameles eremiana* (Atchison, 2009; J. C. Z. Woinarski *et al.*, 2015). Climate change is another key threat to Australian deserts and not only to the wildlife (McKechnie & Wolf, 2009), but also regarding psychosocial determinants of human health (D. Campbell *et al.*, 2008) and the adaptive capacity of human communities (Race *et al.*, 2016). Pastoralism has had the greatest impact on the desert landscape, with the introduction of permanent herds for commercial exotic ungulates and artificial water sources, which have artificially increased kangaroo populations. These have led to severely degraded areas surrounding these water points, overgrazing, changed plant community structure, loss of soil nutrients and increased soil erosion (Letnic, 2007). In turn there is increased competition between native species and livestock, altered species distributions due to increased habitat openness and pest control, e.g., historical baiting of the dingo, *Canis lupus dingo* (Letnic, 2007). Finally the growth in mining activities have negatively impacted some arid regions (160 000 ha affected by mining from 1986 to 2002; (Brueckner *et al.*, 2013; Environmental Protection Authority, 2008; Mudd, 2007; Nicol, 2006), but with this has come regional funding for environmental monitoring and management through offset programs (Morton *et al.*, 2014).

More than 16 per cent of the deserts and semi-deserts in the Asia-Pacific region are protected, of which, 22 per cent of the area has been classified as IUCN category I and II (UNEP-WCMC & IUCN, 2015). In terms of area, the total coverage of protected desert and semi-deserts increased by 25 per cent in the Asia-Pacific region from 1990 to 2014. Recent changes in the deserts of the Asia-Pacific region have been noticed mostly along their boundaries as a result of desertification or changes in the land use (Ezcurra, 2006; UNCCD, 2008). Adeel (2005) has estimated that nearly 20 per cent of the deserts and semi-desert in the Asia-Pacific region have undergone rapid degradation owing to imbalance between demand and supply of ecosystem services. Overgrazing by domestic livestock, soil erosion, urbanization, and formation of caliche (a hardened natural cement) are major drivers of change affecting the desert ecosystem functions (J. F. Reynolds *et al.*, 2007).

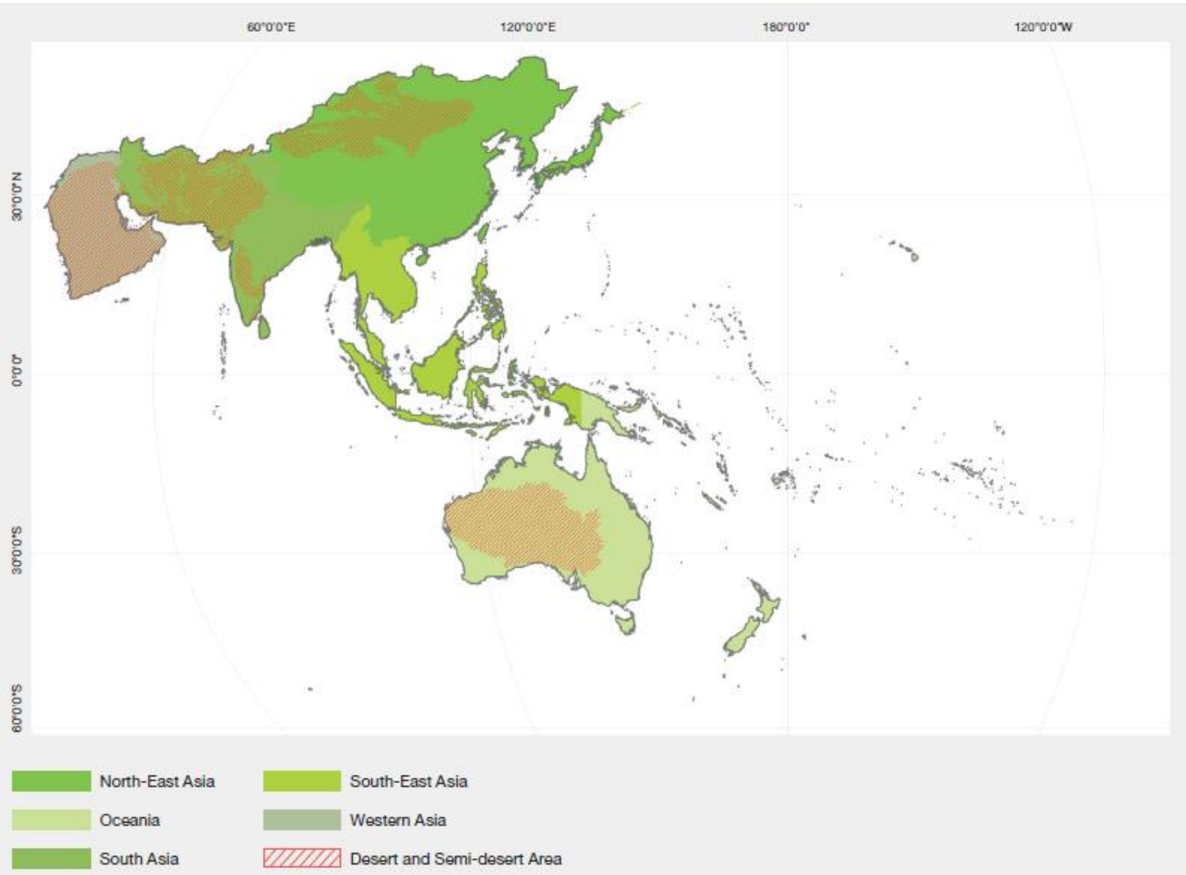


Figure 3.2 Desert and semi-desert area of the Asia-Pacific region. Source: WWF Terrestrial Ecoregions of the World (Olson *et al.*, 2001).

Name	Area (1000 km^2)	Countries	Trends in PAI (%)	Trends in RLI	Trends in SHI
1 - Arabian Peninsula coastal fog desert	80	Oman, Yemen, Saudi Arabia	5 ↑	↓	–
2 - Gulf of Oman desert and semi-desert	61	Oman, UAE	1 ↑	↓	↓
3 - Persian Gulf desert and semi-desert	71	Saudi Arabia, Kuwait, Qatar, UAE, Bahrain	4 ↑	↓	↓
4 - Red Sea Nubo-Sindian tropical desert and semi-desert	640	Saudi Arabia, Yemen, Oman, Iraq, Jordan	5 ↑	↓	↓
5 - Gibson desert	155	Australia	60 ↑	–	–
6 - Great Sandy-Tanami desert	820	Australia	32 ↑	↓	↓
7 - Great Victoria desert	423	Australia	30 ↑	–	–
8 - Simpson desert	583	Australia	22 ↑	↓	↓
9 - Tirari-Sturt stony desert	376	Australia	10 ↑	↓	↓
10 - Badghyz and Karabil semi-desert	55	Afghanistan, Iran	14 –	↓	↓
11 - Central Persian desert basins	577	Iran, Afghanistan	9 ↑	↓	↓
12 - Indus Valley desert	19	Pakistan	63 ↑	↓	↓
13 - Mesopotamian shrub desert	206	Iraq, Syria, Jordan, Iran	3 –	↓	↓
14 - Registan-North Pakistan sandy desert	277	Afghanistan, Pakistan, Iran	2 ↑	↓	↓
15 - South Iran Nubo-Sindian desert and semi-desert	349	Iran, Pakistan, Iraq	5 ↑	↓	↓
16 - Thar desert	238	India, Pakistan	17 ↑	↓	↓
17 - Alashan Plateau semi-desert	674	China, Mongolia	15 ↑	↓	↓
18 - Junggar Basin semi-desert	273	China, Mongolia	11 ↑	–	–
19 - Qaidam Basin semi-desert	192	China	8 ↑	↓	↓
20 - Taklimakan desert	742	China	9 ↑	↓	↓

Figure 3.3 Deserts and semi-deserts in AP region by area and countries, current percentage coverage, and 50-year trends in areas covered by protected areas (PAI)[57], trends in Red List Index (RLI) [58] and Species Habitat Index (SHI)[59] for key vertebrate species.

Note: Arrows represent either positive (green) or negative (red) trends. No change has been shown in grey. There was not enough evidence to support the RLI and SHI trends quantitatively. Hence, the assigned trends are based on expert knowledge, personal communication, and grey literature.

[57] See IPBES Core Indicators: Percentage of areas covered by protected areas - (1960 – 2010) Calculated based on (IUCN & UNEP-WCMC, 2015)

[58] See IPBES Core Indicators: Red List Index - (1960 – 2010)

[59] See IPBES Core Indicators: Species Habitat Index - (1960 – 2010)

3.2.1.5 Agro-ecosystems

Agriculture represents humankind's largest engineered ecosystem, providing food and nutrition to the ever-increasing human population. The Asia-Pacific region accounts for about 30 per cent of the world's agricultural lands (approximately 1.5 billion ha; FAO, 2014a) and about 60 per cent of its human population (UNESCAP, 2014). While agricultural land expansion occurred throughout the world during the period from 1970 to 2007, it was more rapid in the Asia-Pacific region. For instance, agricultural lands increased by about 6 per cent in the Asia-Pacific region, whereas it was only 1 per cent for the other regions of the world (UNEP, 2011), which however, slowed down subsequently (UNEP, 2016). Per capita food availability has increased in the region over the last two decades due to increased production (FAO, 2015a). However, it is projected that owing to pressing issues such as health insecurity and environmental degradation, Asia is likely to face with daunting food problems (McKay, 2009). According to Ravanera & Gorra (2011), there is a change in food demographics in the Asia-Pacific region and the growing middle class is now consuming more meat. In particular, intake of non-vegetarian diet (meat and fish) increased nearly two-fold in the Asia-Pacific region from 15 to 26 g per person per day over the period between 1990-1992 and 2011-2013 (FAO, 2014a).

A prominent structural feature of agriculture in the Asia-Pacific region is the prevalence of smallholder production systems, which use labour-intensive methods (Otsuka *et al.*, 2016). This region accounts for approximately 87 per cent of the 500 million small farms (less than 2 ha) world-wide with 193 million and 93 million farms in China and India respectively (Thapa & Gaiha, 2011). The smallholder agriculture systems in the Asia-Pacific region are significant sources of agricultural production, and contribute substantially to food security, rural poverty alleviation, and conservation of biological diversity notwithstanding the problems they encounter in respect of accessing inputs and service delivery. There is, however, widespread use of chemical fertilizers on these small farms leading to great pressure on agrobiodiversity (NEPAC, 1997; Zaizhi, 2000). It is evident that the traditional agriculture and homegardens have helped in preservation of various landraces and cultivars (Kumar, 2011). In a typical homegarden, there are intimate, multi-story combinations of several trees and crops, often in association with livestock (Mohan Kumar & Nair, 2004), and they combine ecological and socioeconomic aspects of sustainability (Peyre *et al.*, 2006).

Agricultural ecosystems both provide and rely upon various nature's contributions to people to sustain production of food, fibre, and other harvestable goods (Garbach *et al.*, 2014; W. Zhang *et al.*, 2007). While many of these contributions benefit the farmers and other stakeholders on-site, broader community benefits and some contributions that benefit both groups are plausible (Garbach *et al.*, 2014). In general, greater innate biological diversity within a given agroecosystem is related to augmented levels of ecosystem services (Balvanera *et al.*, 2006; Cardinale *et al.*, 2012; Garbach *et al.*, 2014). Agroecosystems in the Asia-Pacific region include a diversity of meadows, pastures, arable lands, croplands, and agroforestry systems. Among them, 65.4 per cent consists of permanent meadows and pastures, 30.8 per cent is arable, and 4 per cent is used for permanent crops (FAO, 2014a).

Under the increasing global demand for food, fodder and bioenergy crops, many agricultural systems are facing risks of biodiversity loss as well as soil fertility depletion and water shortage (Beddington *et al.*, 2011). On the whole, agricultural lands in the Asia-Pacific region suffer from two potential problems: intensification and abandonment. Intensive agriculture currently in vogue has caused degradation of some ecosystem services (H. Sandhu *et al.*, 2013; H. S. Sandhu *et al.*, 2012; Settele *et al.*, 2015) and exerts a range of negative impacts on the environment (T. W. Reynolds *et al.*, 2015). While these trends are widely found in the Asia-Pacific region, those are particularly well documented in Japan. First, intensification of rice farming, such as chemical usage and efficient drainage systems, has threatened aquatic plants, invertebrates, frogs, fish and birds since the 1960s in Japan (Ministry of the Environment, 2014). Second, abandonment of flooded rice fields in Japan has adversely impacted farmland species diversity, due to loss of habitat heterogeneity and altered vegetation successional pathways (Katayama, Osawa, *et al.*, 2015). Despite these problems, organic or wildlife friendly farming has increased in some parts of Japan and it has led to recovery of threatened species

(Miyashita, Yamanaka, *et al.*, 2014). However, organic farming is practised in <1 per cent of geographical area of Japan and there is a decline in winter-flooding of rice fields which is known to provide foraging and resting habitats for waterfowl. Moreover, abandoned farmlands are increasing in Japan (10 per cent of agricultural lands) and South Korea since the 1980s, where vegetation succession has often changed the dominant species in rice fields from aquatic to terrestrial species, including invasive grasses (Katayama, Baba, *et al.*, 2015; Queiroz *et al.*, 2014). On the other hand, there was recovery of the threatened species at up to 40 per cent abandoned sites where citizen volunteers managed and monitored biodiversity under the “Monitoring sites 1000 SATOYAMA” program (Ministry of the Environment, 2014). Thus, restoration of old fields, especially those in a degraded state, poses a major ecological and policy challenge (Cramer *et al.*, 2008). Without restoration, however, such degraded systems are less likely to contribute to the sustainability of biodiversity and ecosystem services.

Agriculture development (‘high inputs/high outputs’ model of industrial agriculture) has also resulted in the loss of crop genetic diversity such as rice land races which have been replaced by relatively few high yielding varieties (HYVs) of rice (Rerkasem *et al.*, 2009). A study by Young (2007) revealed that 30 traditional rice varieties grown in swidden systems have been lost due to shift towards HYVs of rice in South-East Asia. Likewise, commercial plantations have increased cash crops and decreased plant diversity in the Indonesian (Abdoellah *et al.*, 2006) and southern Indian home garden systems (Kumar & Nair, 2004).

There has been a growing concern about gradual degradation and loss of production potential of agricultural soils in many parts of Asia-Pacific region. In India alone, currently about 121 million hectares of land is facing various kinds of degradation (Eswaran *et al.*, 2001; ICAR - NAAS, 2010). In northern China, the river basins of Hei and Tarim have seen disruption in hydrology and degradation in the form of salinization, low water tables and reduced discharge volumes (UNEP, 2011). Use of heavy machinery, exhaustive cropping, short crop rotations, over grazing, and improper management allied with intensive farming has led to soil compaction in many parts of the Asia-Pacific region (Hamza & Anderson, 2005). A solution to this problem is to increase soil organic matter content and reduce tillage or grazing at high soil moisture content (Hamza & Anderson, 2005). Conservation Agriculture (CA), emerging as a promising strategy to sustainably manage agroecosystems for improved productivity and profitability (Valbuena *et al.*, 2012), is based on three cardinal principles: (i) minimum mechanical soil disturbance, (ii) adequate surface soil cover and (iii) crop diversification. This has significance for several subregions of the Asia-Pacific region and is considered as an alternative to conventional agricultural production systems in India (Srinivasarao *et al.*, 2015), China (Zheng *et al.*, 2014), Australia and New Zealand (Bellotti & Rochecouste, 2014).

While pesticide and fertiliser contributed to the increase of crop yield, those had some negative effects on biodiversity and also agriculture itself. First, excessive use of pesticides in parts of the Asia-Pacific region triggered pest outbreaks as in the classic example of the brown plant hopper (*Nilaparvata lugens*) (Kenmore *et al.*, 1984; Naylor & Ehrlich, 1997). Subsequently, farmers in some Asian countries adopted an integrated pest management approach that advocates use of natural pesticides which have to be used only when damage exceeds critical economic thresholds (Naylor & Ehrlich, 1997). More recently, there is increasing awareness on sustainable pest regulation by enhancing diversity of natural enemies (Bianchi *et al.*, 2006). Second, pesticide is regarded as a driver of global pollinator decline (Potts *et al.*, 2016), although wild pollinator data is lacking in the Asia-Pacific region (IPBES, 2016) and the effects of pesticide remain to be assessed. Third, biodiversity of soil has been severely affected by fertiliser and pesticide use, changing the natural rhizosphere microbiomes that assist plant growth by absorbing minerals and preventing colonization by pathogens (Berendsen *et al.*, 2012). Conversely, organic farming increased diversity of the soil microbiota in comparison to soils solely under mineral fertilization (Hartmann *et al.*, 2015).

There is a rising demand for managing agricultural landscapes as ‘multifunctional’ systems, which creates novel obligations and prospects, to preserve and augment nature's contributions to people as part of productive agroecosystems (Kremen *et al.*, 2002; W. Zhang *et al.*, 2007). The Asia-Pacific region, however, has undergone a major shift in land use patterns from diverse croplands including the swidden fields to monocultures of rubber, palm oil and cloves that have led to decline of agrobiodiversity (V. K. Bhatt & Singh, 2009; Mahendra Dev, 2011; Rerkasem *et al.*, 2009). In particular, the large-scale transformation of natural rainforest into plantation of oil palm and others is regarded as a major driver of the current biodiversity loss in South-East Asia (Fitzherbert *et al.*, 2008; Immerzeel *et al.*, 2014), further driving losses in ecosystem functioning (Edwards *et al.*, 2014), degradation of ecosystem functions such as pollination success, and the impairment of soil fertility and water quality (Cardinale *et al.*, 2012; Dislich *et al.*, 2017).

A promising feature of agriculture in the Asia-Pacific region is the increasing interest in organic farming practices. The region with largest organic agricultural land in the world is Oceania with 17.3 million ha, which accounts for about 40 per cent of the total organic agriculture area in the world (Willer & Lernoud, 2016). Asia accounts for 3.6 million ha of organic agricultural land (8 per cent) with China and India leading the group with 1.9 million ha and 0.9 million ha respectively (Willer & Lernoud, 2016). Growth in organic industry in the region is driven by rapidly growing overseas and domestic demands. Awareness of the health problems caused by the contaminated food products and environment degradation, and appropriate support by the governments and organizations like the International Federation of Organic Agriculture Movements (IFOAM) also contribute to the relatively high success of organic farming in some countries (P. K. Ramachandran Nair, 2014). Apart from the organic agricultural land, there are further organic areas such as wild collection areas.

Climate smart agriculture

Effects of climate change on agriculture are being experienced all over the world. In the Asia-Pacific region, such impacts will differ by region, with several areas experiencing a drop in crop productivity. Many studies have reported a high sensitivity of major cereal and tree crops to differential temperature, moisture, and carbon dioxide regimes (Aggarwal & Swaroopa Rani, 2009; Byjesh *et al.*, 2010; Devendra, 2012; Knox *et al.*, 2012; Srivastava *et al.*, 2010). Simulation models, using an array of General Circulation Models (GCMs) and Special Report on Emission Scenarios (SRES), demonstrate that increasing temperature regimes will reduce paddy yields due to reduced length of growing periods (e.g., (Aggarwal & Mall, 2002; Krishnan *et al.*, 2007; Soora *et al.*, 2013). Climate-smart agriculture (CSA) represents an approach for transforming and repositioning farming under the new challenges of climate change (Lipper *et al.*, 2014). The three main pillars of CSA are productivity, adaptation and mitigation. Furthermore, to evolve and focus suitable adaptation strategies to areas that are increasingly affected by climatic variability, district level vulnerability atlases were prepared in several countries in the region, e.g., India (O'Brien *et al.*, 2004; Rama Rao *et al.*, 2016) and Bangladesh (Shahid & Behrawan, 2008). There also exists significant potential for increasing the adaptive capacity of agricultural systems through agroforestry, which promotes integration of trees and crops on the agricultural landscape (van Noordwijk *et al.*, 2014).

Trees outside forests and agroforestry

Trees outside forests represent trees on land not demarcated as forest or other wooded areas (Bellefontaine *et al.*, 2002). This may include agricultural land as meadows and pasture, built-on land as settlements and infrastructure, and barren land as sand dunes and rocky areas. Trees outside forests abound in all ecoregions of the world and play crucial environmental, economic, and social functions at all scales (i.e., local, national, and global scales; de Foresta *et al.*, 2013). Zomer *et al*. (2014) estimated that about 40 per cent of agricultural lands all over the world possesses more than 10 per cent tree cover and in most parts of the Asia-Pacific region, the percentage of tree cover on agricultural lands has increased in the recent past. For example, in South Asia, the area of >10 per cent tree cover increased by 6.7 per cent, in East Asia by 5 per cent, in Oceania by 3.2 per cent and in South-East Asia by 2.7 per cent between 2000 and 2010 (Zomer *et al.*, 2014). Many of these are smallholder production systems. Significantly, in Bangladesh, the total extent of trees outside forests on small holdings roughly corresponded to the total extent of trees outside forests on larger operational holdings (de Foresta *et al.*, 2013).

Trees outside forests represent a significant natural resource that augments nature's contributions to people including biomass stocks and carbon sequestration and improves the livelihood security of people (George *et al.*, 2012; Schnell, Altrell, *et al.*, 2015; Schnell, Kleinn, *et al.*, 2015). For instance, in Kerala State, India, trees outside forests accounted for about 90 per cent of the local timber production, besides providing 89.2 per cent of the rural fuelwood supply (Krishnankutty *et al.*, 2008). However, rapid urbanization in the post-economic liberalization era (between 2000 and 2010) has led to a 12.54 per cent decline in the suite of trees in the urban homegardens of Kozhikode city in Kerala, implying the loss of urban sustainability (Balooni *et al.*, 2014), despite the increasing role of homegardens in complementing urban livelihood sustainability.

The estimated contribution of trees outside forests to the total aboveground tree biomass, however, vary widely among countries (for e.g., 72.8 per cent in Bangladesh and 26.5 per cent in Philippines), owing mainly to differences in overall forest cover (Schnell, Altrell, *et al.*, 2015). Significantly, the contribution of trees outside forests to national biomass stocks and C stocks has been increasing since late 1970s. For example, China’s total biomass C stock of trees outside forests grew from 823 Tg C (1 Tg=10^{12} g) in 1977–1981 to 1339 Tg C in 2004–2008, which corresponded to a 62.7 per cent increase, and the country’s annual biomass C sink of trees outside forests accounted for 19.1 Tg C yr^{-1}, counterbalancing 2.1 per cent of the current fossil-fuel CO_2 emissions (Guo *et al.*, 2014).

The practice of managing and integrating trees outside forests with crops and livestock is known as agroforestry, implying significant overlap between trees outside forests and agroforestry (FAO, 2014b). Agroforestry systems abound in the Asia-Pacific region. The South- and South-East Asian region is often described as the cradle of agroforestry in its long history of the practice under diverse agroecological conditions (Mohan Kumar *et al.*, 2012). Prominent systems in the Hindu Kush Himalaya include improved fallows, alley cropping, scattered trees on cropland, live fences, wind breaks, trees along boundaries, contour vegetation strips, trees and shrubs on terraces, shifting cultivation, and cultivation of tea, cardamom, coffee and medicinal plants under trees (Bhattarai *et al.*, 2016). Most agroforestry systems provide an array of products such as food, fuel, fodder, green manure, timber, and medicines (P. K. Ramachandran Nair & Garrity, 2012). Agroforestry systems are, however, not only the sources of household food, but also provide supplementary incomes to the land managers and enhance their dietary quality (Jamnadass *et al.*, 2013). Homegardens in West Java and elsewhere are reported to provide up to 56.0 per cent of the family’s income (Kumar & Nair, 2004). Maintenance of soil fertility, erosion control, watershed protection, and microclimate modification are generally associated with agroforestry practices (Van Noordwijk *et al.*, 2015). Asdak *et al*. (2005) reported that the average surface runoff in bamboo-tree garden was 0.40 litre/m^2 compared to 0.99 litre/m^2 in cash crop gardens in West Java. Yet another contribution from the homegardens and bamboo-tree gardens of West Java is biodiversity conservation (Kaya *et al.*, 2002; Okubo *et al.*, 2010). Various domesticated and wild plant species originated from the forest usually inhabit the different vegetation strata of these unique land use systems. Floristic and structural complexity of homegardens and bamboo-tree gardens also provide resources for wildlife as well as livestock (Gunawan *et al.*, 2004). It is probable that a complex vegetation assemblage provides habitat for bird species too (Parikesit *et al.*, 2005).

In many parts of the Asia-Pacific region, indigenous agroforestry systems harbour an array of food plants and other culturally and ecologically cherished trees, within the milieu of basic food crops and vegetables (Thaman, 2008; Thaman *et al.*, 2014). However, there has been a collapse of the indigenous tree-dominated agroforestry systems in many parts of the Asia-Pacific region. This process, termed as ‘agro-deforestation’, is considered by many communities as the main reasons for the endangerment or loss of economically or ecologically important flora and fauna associated with agro-ecosystems (Thaman, 2008). For a large proportion of people in the Asia-Pacific region, the remaining trees and the diverse range of agroecosystems, remain the most important foundation for the delivery of diverse and irreplaceable nature's contribution to people. Growing trees in the agricultural landscape also helps to promote the livelihoods of smallholder farmers and to modify micro-climate (van Noordwijk *et al.*, 2014). Apart from this, agroforestry is now perceived as an approach for implementing REDD-plus concepts which will ultimately help meet the commitments made under the Nationally Determined Contribution (NDC) plans (Bhattarai *et al.*, 2016).

Agroforestry is being increasingly acknowledged as an advantageous route for offsetting greenhouse gases under the Kyoto Protocol, an important mechanism to enhance carbon sequestration (Kumar & Nair, 2011). Even at low densities, trees aggregate carbon to help combat climate change owing to the great spatial coverage (Verchot *et al.*, 2007). In India, the National Climate Change Action Plan through the Greening India Mission envisages 1.5 million ha of degraded agricultural lands and fallows to be brought under agroforestry (Ministry of Environment and Forests, Government of India., 2010). The prospects of extending the ideas of nature and natural resources conservation that existed in Japan to other parts of Asia and even globally are focused under the Satoyma Initiative. It is now recognized as a source of public goods e.g., scenic beauty with considerable recreational values and potential for biodiversity conservation (Fukamachi *et al.*, 2001; Mohan Kumar & Takeuchi, 2009; Takeuchi *et al.*, 2003, 2016). While the traditional agroforestry systems conserving site resources and agrobiodiversity are sustainable production systems , these are not always supported by comprehensive public policies (Guillerme *et al.*, 2011). Indeed, the commodity-centric agricultural policies and the forestry policies favouring exotic species have negatively affected the prospects of agroforestry as a land management system (P. K. Ramachandran Nair, 2014; Nath *et al.*, 2016). India, however, has recently launched a National Agroforestry Policy to overcome such shortcomings (Chavan *et al.*, 2015).

Integration of crop and animal production is widespread in the farming systems of Asia, especially in small-holder agriculture (Devendra & Thomas, 2002). Livestock (cattle, sheep, goats, poultry, hogs, etc.) is also intentionally combined with trees or other woody perennials. Silvopastoralism is a sustainable production system symbolized by greater biodiversity and multi-functionality, than other livestock production systems (Jose *et al.*, 2017). Although silvopastoralism is most commonly practiced in the developed countries (Sharrow, 1999), it constitutes a significant land management activity in the Asia-Pacific region. For example, in South-East Asia alone, the potential for tree crop-ruminant systems exists over an estimated 210 million ha of tree crops like coconut, oil palm and rubber that could be used also for animal production (Alexandratos, 1995). In India, the rainfed agroecosystem accounts for 68 per cent of the total cultivated lands and provides support for 40 per cent of the human and 65 per cent of the livestock population (A. K. Misra *et al.*, 2009), producing 44 per cent of dietary needs (H. P. Singh *et al.*, 2004).

3.2.1.6 Urban ecosystem and biodiversity

Approximately half of the population of the Asia-Pacific region lives in urban areas, but urbanization varies greatly within and between regions (United Nations, 2015). Oceania and Western Asia are currently most urbanized and Southern Asia least, while Eastern Asia has urbanized most rapidly in the last 25 years (Figure 3.4). In Australia, Israel, Japan, Republic of Korea, Lebanon, New Zealand, and several smaller countries, more than 80 per cent of the population is urban, while in Nepal, Papua New Guinea, Samoa, and Sri Lanka it is less than 20 per cent (United Nations, 2015). Five countries in the Asia-Pacific region, Bhutan, China, Indonesia, Lao PDR, and Nepal, were among the ten fastest urbanizing countries in the world for 1990-2014. Of the world's 28 biggest cities (having over 10 million population), more than half are in Asia, with six in China, three in India, two in Japan, and one each in Bangladesh, Indonesia, Pakistan, and the Philippines. The world's three biggest cities, namely, Tokyo, Delhi, and Shanghai, are all in Asia.

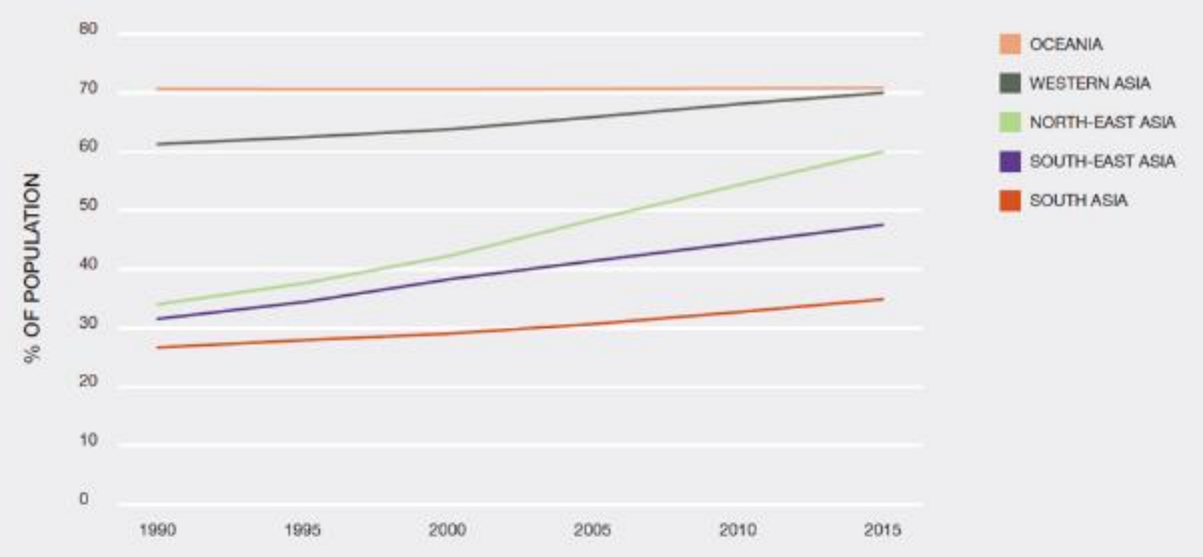


Figure 3.4 Trends in human populations in urban areas of the Asia-Pacific region. Source: United Nations (2015).

Unfortunately, there is no detailed regional map of urban areas in the Asia-Pacific region and the statistics on changes in urban land from different countries are based on a variety of different methodologies, making comparisons difficult. In China the total area of urban and industrial land more than doubled between 1990 and 2010, with growth concentrated in the megacities of the coastal zone (Kuang *et al.*, 2016), while in Vietnam the built-up area increased 880 per cent from 1992 to 2010 (Ouyang *et al.*, 2016). India, in contrast, has seen relatively slow urban growth overall, although expansion was 4.0 and 4.9 per cent per year, respectively, in the southern cities of Hyderabad and Bangalore (Gibson *et al.*, 2015). Even in China and Vietnam, however, the total area of urban land is still less than one per cent of the total land area (Kuang *et al.*, 2016; Ouyang *et al.*, 2016).

Urban growth interacts with global climate change to influence urban climates. The 'urban heat island effect', resulting from a combination of dark heat-absorbing surfaces, heat storage by day and release at night, reduced evaporative cooling from vegetation, waste heat from machinery, and canyon-like streets that trap heat, has contributed a variable proportion to observed urban warming over recent decades. While this proportion is generally less than half, with the rest attributed to global climate change (Jin *et al.*, 2015), it appears to have been as high as 80-85 per cent in Shenzhen, China, which was probably Asia's fastest growing city (L. Li *et al.*, 2015). Rapid urban warming, in turn, has resulted in increased discomfort and health risks for people (Son *et al.*, 2016) and a longer growing seasons for urban plants (D. Zhou *et al.*, 2016).

Biodiversity in cities is concentrated in the remaining green spaces. Because urban green space can provide important ecosystem services and sometimes supports threatened species, balancing conservation and development is becoming an urgent issue (Lonsdale & Fuller, 2005; Tan & Abdul Hamid, 2014). Early urbanization sometimes destroyed primary forests in tropical and subtropical regions, but recent urban sprawl has largely converted agricultural lands into built-up areas (Bagan & Yamagata, 2012; Han *et al.*, 2009; Tan *et al.*, 2013; Zhao *et al.*, 2006; X. Zhou & Wang, 2011). In the last several decades, due to maturation of urban policies, urban green space is increasing in most of the megacities, occupying occasionally up to 30 per cent of urban areas (V. S. Singh *et al.*, 2010; J. Yang *et al.*, 2014). Nonetheless, per capita urban green space generally remains at low levels in megacities in Asian countries, where it is often <10 m^2 (Jim & Chen, 2008; Thaiutsa *et al.*, 2008; Yamamoto, 2010), in comparison to the standard determined by developed countries (20 m^2). Also, because of the huge expansion of built-up areas into suburbs, increasing urban green space in the middle of the cities appears to make little contribution to increasing vegetation areas at the regional scale (J. Yang *et al.*, 2014).

Urban green spaces also differ in quality. Non-native species make up a significant portion of total plant species richness in urban green space, sometimes reaching more than 80 per cent (W. Li *et al.*, 2006; Nagendra & Gopal, 2011; G. Wang *et al.*, 2007). Old urban parks in core city areas occasionally harbour unique native tree species (Nagendra & Gopal, 2011; Zhang & Jim, 2013), but newly established city parks located in peripheral areas often have low native species richness and highly homogeneous species compositions (Thaiutsa *et al.*, 2008). Plant species richness in some Australian cities appears to have an extinction debt, with some existing species predicted to go extinct in the near future (Hahs *et al.*, 2009). Urban residents in the Asia-Pacific region also depend heavily on resources provided by biodiversity and ecosystems in distant locations around the world (Furukawa *et al.*, 2015; Moore, 2015). These resources include timber and other wood products from natural forests, wild-caught fish and other aquatic animals, and products from crops dependent on wild pollinators. Efforts to reduce these "biodiversity footprints" (Lenzen *et al.*, 2012) are required for the sustainability of global biodiversity. Species adapted to human built environments have adapted and spread around the world as urban invasive alien species and also has negative contribution to people, including direct and indirect damages to human health (McNeely, 2001).

Studies of urban birds have shown that open-habitat generalists and non-native species are generally common, while forest specialists are rare. Higher bird diversity in urban green spaces in the Asia-Pacific region is associated with area, complex vertical vegetation structure, native plant richness, nearness to water, and the intensity of human use (Chang & Lee, 2016; Khera *et al.*, 2009; Sasaki *et al.*, 2016; Threlfall *et al.*, 2016; Xie *et al.*, 2016; G. Yang *et al.*, 2015). The status of invertebrates in the Asia-Pacific region is less well known, but old urban parks harbour higher species richness of ants (Yamaguchi, 2004), and species richness of spiders is poorer in isolated urban woodlots (Miyashita *et al.*, 1998). Butterfly communities can be diverse in urban parks and may have some conservation value, as well as contributing to human enjoyment (Jain *et al.*, 2016; Sing *et al.*, 2016; Tam & Bonebrake, 2016). Evidence for an extinction debt in butterflies was found in Tokyo (Soga & Koike, 2013).

Urban and suburban food production in farms, back-yards, community gardens, and on roof tops and balconies, can make a significant contribution to the urban food supply, as well as plant and animal habitats (Gómez-Baggethun *et al.*, 2005). Many cities also depend on freshwater supplies from vegetated catchments on the periphery. Within cities, plants and vegetation contribute to quality of human life by moderating the urban heat island effect, reducing noise, removing atmospheric pollutants, and reducing run-off and flooding(Gómez-Baggethun *et al.*, 2013). Many studies have also shown large health benefits from contact with nature in and around cities (Hartig *et al.*, 2014).

3.2.1.7 Islands

The Asia-Pacific region includes tens of thousands of small islands. Most are oceanic islands in the vast Pacific Ocean that have never been connected to the mainland, but there are also tens of thousands in the Philippines, Indonesia and Japan, which are all island archipelagos, and in the Indian Ocean (Andaman and Nicobar Islands, Maldives, and others). The Hawaiian archipelago—3,200 km from the nearest continent—is the most isolated group of islands on earth. This Archipelago includes volcanic islands and atolls with tremendous landscape diversity endowing it with as many as 10 ecozones – from alpine systems to tropical rainforests – within a 40 km span. Some of the highest concentration of endemic species in the world is brought about by this isolation and landscape diversity. The state of Hawaii is home to approximately 1.4 million people who descend from Polynesian, Asian, and European cultures.

Although the total land area of the small islands in the Asia-Pacific region is small, high rates of endemism and isolated human populations mean that they contribute disproportionately to the region's biological and cultural diversity. Although plant diversities are lower on individual islands, endemism is higher than on continents (Kier *et al.*, 2009) and around 50,000 species of vascular plants globally are island endemics (Sharrock *et al.*, 2014). Moreover, despite their very low tree diversity, Pacific Island forests are similar in density and aboveground biomass to the much more diverse tropical forests in other areas (Ostertag *et al.*, 2014). High endemism is also shown by the animal groups that dispersed to remote islands, including bats, birds, and many groups of invertebrates (Corlett & Primack, 2011). However the diversity is highly threatened with more than half of all recent extinctions occurring on islands, which are haven to over a third of all terrestrial species facing imminent extinction (Ricketts *et al.*, 2005). The signature tree of the Hawaiian forest is the `Ohi`a lehua (*Metrosideros polymorpha*) which grows from sea level to 2900 meters. Genomic analyses of the ohia taken from different environments have shown some genes leading to adaptive divergence along altitudes (Izuno *et al.*, 2017). The forest ecosystems in most of the islands serve as reserves of freshwater and help prevention of sediment runoff that would adversely impact its coastal coral reefs.

Human colonization of the Pacific Islands resulted in the extinction of around 2000 bird species—about 20 per cent of the global avifauna, mostly due to introduced invasive alien species (Blackburn *et al.*, 2004) —and extinctions are still continuing (Arcilla *et al.*, 2015). Since 1500 AD, 95 per cent of all bird extinctions have occurred on islands. Bird species losses on individual Pacific islands range from 15.4 per cent to 87.5 per cent for those with good fossil records, and these extinctions have resulted in the loss of many ecological functions previously performed by birds, including grazing, seed dispersal, and the pollination of endemic plants (Boyer & Jetz, 2014). The services performed by Pacific Island fruit bats also include both pollination and seed dispersal, and studies in Fiji have shown a large overlap between the native plants serviced by bats and those valued by humans for various purposes (Scanlon *et al.*, 2014), highlighting the vulnerability of nature's contribution to people on small islands. Extraordinary rates of extinction have also been experienced by some endemic invertebrates, such as the partulid tree snails (T. Lee *et al.*, 2014).

High human population densities supported by coastal and marine resources can put extreme pressures on terrestrial island ecosystems and the services that these provide. Not surprisingly, therefore, the impacts of global change drivers (climate change, sea-level rise, invasive alien species etc.; See Chapter 4) on small island ecosystems have frequently been greater and more rapid than the impacts of the same drivers on mainland ecosystems. Major current threats include biological invasions, to which naïve island species and ecosystems show little resistance (Pyšek *et al.*, 2017), and climate change (Courchamp *et al.*, 2014). Island floras are accumulating invasive plant species much more rapidly than similar sized mainland regions (Van Kleunen *et al.*, 2015), but exotic plants has caused few native plant extinctions, probably due to presence of dormant stages enabling plants to escape unfavourable conditions over time (Pyšek *et al.*, 2017; Sax & Gaines, 2008). Exotic fungal pathogens in New Zealand and Hawaii are however an increasing threat to iconic native tree species on islands (Mortenson *et al.*, 2016; P. Scott & Williams, 2014). Invasive alien animals are implicated in 86 per cent of island plant and vertebrate extinctions (Bellard *et al.*, 2015; IUCN, 2015). Vulnerability to climate change is greater on smaller, low elevation islands with more homogenous topography, where there is literally nowhere for species to retreat to (Harter *et al.*, 2015). Recent global analyses suggest that thousands of islands are threatened with total immersion in the coming decades, while tens of thousands more risk losing over 50 per cent of their habitat (Bellard *et al.*, 2013, 2014). The Asia-Pacific region has more low-lying islands and atolls vulnerable to sea-level rise than any other region e.g., Maldives, Kiribati, Tuvalu, Marshall Islands and the Tuamotu Archipelago.

3.2.1.8 Special ecosystems

Terrestrial ecosystems that are distinct from the regional type expected for that particular climate, as a result of unusual and extreme geology and/or soils, can make a major contribution to the regional diversity of plants and animals. Whereas these ecosystems have often been treated as wasteland and given no protection, those are now under rapidly increasing threats due to the demand for cement and other products.

Limestone karsts

Limestone karsts are widespread in the Asia-Pacific region, with 408,000 km^2 in South-East Asia (Clements *et al.*, 2006) and 430,000 km^2 in southwest China (S. J. Wang *et al.*, 2004). In South-East Asia, approximately 13 per cent or 52,650 km^2 of karsts are protected (Clements *et al.*, 2006). Karsts in this subregion are mostly found in Indonesia, Thailand and Vietnam and have interesting geological features (Clements *et al.*, 2006). Their complex structures, distinctive chemistry, and isolation from a non-karst matrix have resulted in unique flora and fauna with high endemism. In Peninsular Malaysia alone, nearly 21 per cent of 1216 karst-associated plant species are endemic to limestone hills (BirdLife International *et al.*, 2014; Davison *et al.*, 1991). Caves sustain unique subterranean ecosystems including groundwater animals (Gibert & Deharveng, 2002). Caves also provide nature's contribution to people, such as water, guano as fertilizer, cave-roosting bats as important pollinators of many crops, and cultural and religious sites. Maintaining limestone karsts can also help attract more pollinators for agricultural areas (Sritongchuay *et al*., 2016). Wanger *et al*. (2014) quantified the importance of bats that roost in limestone caves for pest control of rice fields which is crucial for sustaining food security. Until recently, the biodiversity of limestone karsts in the Asia-Pacific region had been protected by the low suitability of these areas for agriculture or by default of being located within the boundaries of protected areas such as national parks or have been accredited World Heritage status (Liew *et al.*, 2016). However, there has been an exponential increase in the demand for cement and marble products in recent decades which is derived largely from the karsts (Clements *et al.*, 2006; Liew *et al.*, 2016). In SE Asia, limestone karsts are often found in areas near development and support remnants of ecosystems which previously had wider distributions but have since been lost to development. The major threat to the survival of karst-associated species is quarrying (Sodhi & Brook, 2006). A conservative figure of globally threatened karst-associated species listed by IUCN as critically endangered, endangered, or vulnerable stood at 143 species and of these 31 species (ca. 21 per cent) occur in South-East Asia (Clements *et al.*, 2006). With good financial returns from karst quarrying for cement manufacturing, it is unlikely this exploitation will be slowed down or halted, more so in some SE Asia countries where karst protection is minimal or non-existent (e.g., Myanmar, Cambodia). Current laws for the protection of limestone karst in several countries in the Asia-Pacific region, if any, are lacking, lax and ineffective (Kiew, 2001; Lim & Cranbrook, 2002). An example is the case of Malaysia, where majority of the limestone hills are classified as State Forest Land and do not have protected area status hence vulnerable to anthropogenic disturbances (Clements *et al.*, 2006; Liew *et al.*, 2016).

Ultramafic outcrops

Other special ecosystems occur on ultramafic rock outcrops in the Asia-Pacific region, particularly in New Caledonia, where ultramafic rocks cover a third of the land area, Sulawesi, the Philippines, and Sabah, and in scattered patches throughout the Asia-Pacific region (Galey *et al.*, 2017). Soils derived from these rocks tend to be shallow and drought prone, low in fertility, and to have high concentrations of nickel, cobalt, chromium, and magnesium (Isnard *et al.*, 2016). Ultramafic rocks outcrop over less than 1 per cent of the Earth's surface and their distinctive chemical and physical characteristics, coupled with their isolation, result in plant species adapted to these conditions with very high levels of endemism (van der Ent & Lambers, 2016). The presence of ultramafic outcrops contributes to the exceptional plant diversities of Mt. Kinabalu, Sabah (van der Ent & Lambers, 2016), and New Caledonia where they support around half the total flora (Isnard *et al.*, 2016). As with limestone karsts, ultramafic outcrops were protected until recently by their unsuitability for agriculture, but some are now threatened by mining for nickel (Losfeld *et al.*, 2014).

Heath forests (Kerangas or white-sand forests) and scrub/heathlands (Kwongan Mediterranean Sandplains)

Heath forests (Kerangas or white-sand forests) are forests developed on soils derived from sand or sandstone, and are most common near the coast (Corlett, 2014). In the Asia-Pacific region they are most extensive in Borneo, but also occur scattered throughout SE Asia and, less well documented, elsewhere. It is not clear whether susceptibility to drought or shortages of nutrients, particularly nitrogen, are the most important reason for their distinctiveness (Brearley *et al.*, 2011). They are characterized by a lower, more uniform, small-leaved canopy and relatively lower tree diversity than non-Kerangas rain forests, but also harbor high tree diversity including many endemic species (Corlett, 2014). Depending on the soil depth and variability of water and drainage heath forests can be recognised in a series of different types (Brunig, 1965; Wong *et al.*, 1987). Their soils are unsuitable for agriculture, but they are prone to apparently irreversible degradation by logging and/or fire, and some are being mined for sand gold. The Mediterranean sandplains of Western Australia support open, species-rich “kwongan” shrublands on similar nutrient-poor soils derived from eroded sandstone. These communities support over 7000 species of vascular plants with an 80 per cent rate of endemism (L. C. R. Silva, 2014). Over 80 per cent of the original ecosystem has been lost to agriculture and development, and the ecoregion is classed as endangered under the Australian Environmental Protection and Biodiversity Conservation Act.

3.2.2 Inland freshwater and wetlands

3.2.2.1 Status and trends in fresh water biota

Freshwater ecosystems include lakes, ponds, rivers, streams and inland wetlands and peatlands (Ramsar Convention, 2012). Freshwater ecosystems provide several services, of which some are extensively exploited (Vörösmarty *et al.*, 2010). As a consequence of the dense human population, freshwater resources in the Asia-Pacific region is undergoing the most rapid rate of decline globally (McLellan, 2014). Freshwater biodiversity, which represents almost 6 per cent (>163,000 species) of all species on earth contained in 0.01 per cent of the world’s water in ecosystems, appears to be disproportionately at risk (Dudgeon *et al.*, 2006). “The paradox of freshwater biodiversity” (Martens, 2010) is characterized by the fact that freshwater habitats comprise only 0.8 per cent of the earth surface, but harbour 9.5 per cent of all known animal species, including one third of all vertebrate species (Strayer & Dudgeon, 2010). Furthermore, the geographic distribution range of freshwater species is often restricted to small areas, such as river and lake basins (e.g., Dudgeon *et al*., 2006). Habitat loss and fragmentation have reduced genetic diversity and variability within the declining populations (e.g., Ezard & Travis, 2006). Consequently, global extinction rates and extirpations (local/regional extinctions) of freshwater species are roughly twice that of terrestrial and marine ecosystems (Strayer & Dudgeon, 2010; The Millennium Ecosystem Assessment, 2005). Some regional biodiversity data are summarised by Brooks *et al*. (2016).

Of all animal life forms in freshwater ecosystems, arthropods (particularly insects) are by far the most diverse. More than 28 per cent of freshwater species (>35,300) have been recorded in the Asia-Pacific [areas of the Palaearctic Realm that are part of the IPBES Asia-Pacific region are not included in this number] (Balian *et al*., 2008). The true number of extant animal freshwater species is likely to be distinctly higher, for some groups by one order of magnitude. The taxonomic coverage of research efforts is insufficient, including even comparably enigmatic groups such as amphibians (Shabani *et al.*, 2017). This applies to invertebrates in even higher extent, due to lower awareness, or even negative perception in the public and among policymakers (Cardoso *et al.*, 2011).

Hotspots of notably high species diversity of selected key freshwater taxa are: the Philippine archipelago, Sulawesi and coastal areas of China for freshwater shrimps (De Grave *et al*., 2015); the Sundashelf (Indonesia, Malaysia, Brunei), the river basins of the Ganges, Brahmaputra and Irrawaddy as well as the coastal lowlands of southern China and northern Vietnam for freshwater turtles (Carrizo, 2016); Indo-Burma and the Sundashelf for Amphibians (IUCN Global Species Programme Freshwater Biodiversity Unit, 2013). According to the IUCN (2009), about 37 per cent of freshwater species are facing threats of extinction. These including ecologically important predators (e.g., key stone species) like several otters (*Amblonyx cinereus, Lutra sumatrana, Lutrogale perspicillata*), two wetland cat species (*Prionailurus planiceps, P. viverrinus*), the baiji (*Lipotes vexillifer*),the south Asian river dolphin (*Platanista gangetica*), the Chinese alligator (*Alligator sinensis*, the Philippine and Siamese crocodiles (*Crocodylus mindorensis, C. siamensis*) and the gharial (*Gavialis gangeticus*)

(Aadrean *et al.*, 2015; Bezuijen *et al.*, 2012; Malla, 2015; Mukherjee *et al.*, 2016; B. D. Smith *et al.*, 2008; B. D. Smith & Braulik, 2012; van Weerd *et al.*, 2016; Wilting *et al.*, 2015; Wright *et al.*, 2015). This alarming trend does probably not even fully reflect the actual decline of freshwater species, since comprehensive data are hardly available for many parts of the Asia-Pacific region. Across the Asia-Pacific region, roughly one third of freshwater fish species is threatened (Closs *et al.*, 2016). Projected freshwater fish extinction rates are highest in (semi-)arid areas throughout the Asia-Pacific region (especially parts of Australia, Afghanistan, China, Iran, Mongolia and the Arabian Peninsula) due to increasing water ability loss (Tedesco *et al.*, 2013). Land conversion without riparian forest reserves reduces fish diversity substantially (Giam *et al.*, 2015), e.g. in Singapore, deforestation and canalization has caused extinction of 11 (out of 46) native freshwater fish species (Giam *et al.*, 2011).

Recently, chytridiomycosis, an infectious disease in amphibians caused by the fungus *Batrachochytrium dendrobatidis*, has caused dramatic population declines and extinctions of amphibian species in Australia and other parts of the world. However, this has not (yet) affected Asian and New Guinean amphibians in the same extent, either because this threat is newly emerging or its impact was (2011) still at low prevalence (Swei *et al.*, 2011). Habitat destruction through deforestation and land conversion (see Chapter 4) remains to be major threat and cause for population decline in amphibians (Stuart *et al.*, 2004). Water bird populations show the largest decline in the Asia-Pacific region compared to the rest of the world . Freshwater inhabiting reptiles are threatened throughout the Asia-Pacific region by wildlife trade, bushmeat hunting, degradation of habitat, pollution, bycatch mortality, and persecution (e.g. Nijman, 2010; Pacini & Harper, 2008; Shanker & Pilcher, 2003). A massive threat of overexploitation is evident in the South and South-East Asian subregions, were freshwater turtles and other reptiles are excessively traded for decades. Immediate actions were recommended by an expert team (Horne *et al.*, 2012) to prevent the about 64 species (80 per cent threatened) in the region (IUCN Red List, 2017) from extinction.

Threatened species data coverage across the Asia-Pacific region varies widely for freshwater invertebrates. Japan has probably the widest and longest coverage (50+ years). Except for the arthropod orders Decapoda (decapods), Odonata (dragonflies & damselflies), and Mollusca (mollusks), which account together for 4312 out of 4374 freshwater invertebrates assessed, almost no freshwater invertebrate taxa are listed for the Asia-Pacific region (IUCN Red List 2017). However, even for the groups mentioned, population trends are mostly unknown, 137 species of Odonata (8 per cent), 292 Decapoda (20 per cent), and 226 Mollusca (19 per cent) are threatened. More than 1200 truly aquatic vascular macrophyte species (> 46 per cent of 2614 worldwide recognized) are recorded from the Asia-Pacific region [areas of the Palaearctic Realm that are part of the IPBES Asia-Pacific region are not included in this number], with highest diversity in the Oriental realm (25 per cent of world diversity). Most diverse families here are Cyperaceae, Poaceae, Haloragaceae for Australasia and Araceae for the Oriental Region). Their endemism rates are lower than in aquatic animals, with an endemism of 46 per cent for Australia, 43 per cent for the Oriental region and 7.4 per cent for the Pacific Islands (Chambers *et al.*, 2008).

70 per cent of the 256 native freshwater fish species of Australia are endemic, but 37 alien freshwater fish species were introduced, the most impactful being European carp, Nile tilapia and red finned perch (Darwall & Freyhof, 2015). Of 74 (29 per cent) fish taxa listed as threatened, the Galaxiidae are the most threatened (18 of 23 described taxa) (Lintermans, 2013a). Given current trends, extinctions are predicted particularly at northern Australian sites within the next 30 years (Lintermans, 2013b). Roughly half of New Zealand’s distinctive fish species are threatened, including 18 endemic species (Allibone *et al.*, 2014). About one fourth each of the 223 Australian amphibians and of the ca. 20 freshwater inhibiting reptiles (5 turtle species) are threatened (IUCN Red List, 2017). The status of freshwater fish fauna of the Asia-Pacific region is summarised in the following Table (Table 3.2).

Table 3.2 Summary of the level of threat and state of knowledge in 2013 for freshwater fishes in the Asia-Pacific loosely ordered according to their state of coverage for the IUCN Red List
Note: ? = unknown. Source: Darwall & Freyhof (2015), with updates and additions for China and the Philippines based on Froese & Pauly (2017), IUCN Red List (2017), C. Liu *et al*. (2017), and Xing *et al.* (2016)

Parameters Region	Estimated No. of Species in the region	Estimated No. of Endemic species	No. of species in RL	No. of globally threatened species	No. of species thought to be extinct in the wild	State of Coverage for IUCN Red List
Peninsular India	290	189	290	97	0	Good
Eastern Himalayas	520	?	520	70	0	Good
lndo-Burma	1178	~630	1178	112	1 (4 possibly)	Good
New Zealand	41	33	41	20	1	Good
Western Asia	~300	~245	245	105	7	Good
Japan - National RL	~297	~125	?	144	4	Good
Japan - IUCN RL	~297	~125	129	11	4	Medium
Australia	256	~190	169	32	0	Medium
Pacific Islands	?	?	167	12	0	Medium
Central Asia	?	?	82	17	1	Poor
China	1513[3]	877[4]	545	76	2	Poor
Indonesia	1189	125	389	72	0	Poor
Philippines	361[1]	~100[1]	176[2]	28[2]	32[2]	Medium

In South-East Asia, the Indo-Burma subregion and Indonesia have a particularly rich freshwater fish fauna (Darwall & Freyhof, 2015). Indonesia harbours a very high diversity of freshwater fishes for its land area, currently 1230 species are recognized, including 20 recently introduced (Froese & Pauly, 2014). However, the freshwater fish fauna is still poorly documented, with many additional species awaiting discovery. The individual conservation status of all the species of the mega-diverse fish fauna of Indonesia remains to be assessed (Darwall & Freyhof, 2015). In the Philippine archipelago, about 100 (28 per cent) of the freshwater fish species are endemic, 50 introduced and 25 (most of them cyprinids) threatened based on the current IUCN Red List (Froese & Pauly, 2017).

Many freshwater finfish across the SE Asian subregion are vulnerable (S. S. De Silva *et al.*, 2007). *Platytropius siamensis*, the Siamese flat-barbelled catfish, is the oly species of fish from the region considered to be extinct (Ng, 2011). Invasive alien fishes and their likely impacts have been a strong driver of the Indonesian and other governments developing a National Strategy on Invasive Alien Species (CBD COP 9). The amphibian fauna of the SE Asian archipelagoes is also particularlyn diverse; e.g., there are 112 species recorded in the Philippines, 94 (84 per cent) of which are endemic (Diesmos *et al.*, 2015), several of them with unique evolutionary lineages (R. M. Brown *et al.*, 2013). About 45 per cent are threatened and their populations are suspected to be in decline (Diesmos *et al.*, 2014). A special threat has also emerged for water snakes (mostly homalopsids) which are excessively overexploited in some areas of the subregion, e.g. Tonle Sap Lake, Cambodia (S. E. Brooks *et al.*, 2007). Most freshwater turtles and top predatory reptiles in freshwaters of the subregion, such as the Philippine crocodile (*Crocodylus mindorensis*), the Siamese Crocodile (*Crocodylus siamensis*) and the false gharial (*Tomistoma schlegelii*) are particularly threatened and have highly fragmented populations by now (Bezuijen *et al.*, 2012, 2014; van Weerd *et al.*, 2016).

Freshwater resources across island nations in the Asia-Pacific region are limited to rainwater, limited surface waters and shallow groundwater. Freshwater ecosystems – in quantity and quality - are largely in decline due to deforestation in the headwaters, flow alteration (damming), agricultural intensification, invasive species, and fisheries exploitation downstream (SOCO 2013). Freshwater biodiversity data are generally limited for the Pacific Islands but the overall trend is declining for native and endemic species. In the Pacific Islands of Oceania (excl. the Hawaiian archipeago), most freshwater fish (91 species) are widely distributed and 12 are threatened (Pippard, 2012; IUCN Red List, 2017). The amphibian diversity of Oceania is exceptionally low (but also data deficient); among them are three threatened frog taxa that suffer from habitat fragmentation and invasive alien species (IUCN Red List, 2017). In New Zealand, 74 per cent of all native freshwater taxa and 76 per cent of all non-diadromous taxa (i.e. only in fresh water) are threatened. (Elston *et al.*, 2015).

In north-east Asia, there is a high degree of freshwater fish endemism. For example, endemic fish represent 16.9 per cent of the native freshwater species in South Korea (S. S. De Silva *et al.*, 2007) with protected areas tending to have higher fish diversity than more populous regions (Jang *et al.*, 2003). In China, Yunnan Province, including the upper reaches of the Yangtze, Red, Mekong and Salween rivers, has the highest species richness (373) and country-endemic species (216), many of which are specially adapted to high-altitude habitats of this part of the world (Kang *et al.*, 2013). 409 amphibians are listed from north-east Asia by the IUCN Red List (2017) of which 30 per cent are considered threatened. The situation is even more dramatic for freshwater reptiles, with at least 24 threatened out of 66 assessed species (IUCN Red List, 2017). Many taxa need updates on their status. Japan's national Red List of freshwater fishes (Ministry of the Environment - Government of Japan, 2017) indicates that around half of all species are threatened and three extinct. Significant losses of freshwater fish diversity have been observed between the 1950s–2010 and is projected to continue. For example, shoreline reed beds in Lake Biwa were reduced by roughly 50 per cent between the 1950s and the 1990s, resulting in a substantial loss of habitat for many fish species. In the Korean peninsula, a total of 213 freshwater fish species have been recorded. Of these, 61 species (28.6 per cent) are endemic, and occur predominantly in mountain areas; there are also 12 exotic species (Kim & Park, 2002).

In south Asia, the eastern Himalaya and adjacent flood plains including Ganges–Brahamaputra, Chinwin–Irrawaddy, and Kaladan/Kolodyne catchments represent freshwater turtle diversity hotspots (Carrizo, 2016). This also applies to freshwater fish (Allen *et al.*, 2010). The centres of richness are the Tista, Kameng, Dikrong, Subansiri and Siang basins of the Ganges–Brahmaputra system. The critically endangered sawfishes are primarily threatened through overfishing in the marine parts of their ranges. Further critically endangered species are snow trouts (*Schizothorax* spp.), both endemic to Lake Rara in Nepal, where they are threatened by overfishing, pollution and siltation (Darwall & Freyhof, 2015).

India has a distinct freshwater fish fauna (Dahanukar *et al.*, 2004; Kottelat & Whitten, 1996; Lal Mohan & Rema Devi, 2000). An assessment of all known freshwater fish in peninsular India recorded 290 described species (Molur *et al.*, 2011) with 37 per cent of 97 assessed species threatened. No species are known to have gone extinct in the recent past. However, *Batagur baska* (northern river terrapin) has been reported only from Mechua Island and is extinct in large parts of its former range (Bhupathy, 1997). The Western Ghats are considered the centre of species diversity, endemism and threatened species, the area holds the highest number (7) of critically endangered species, all of which are restricted to Kerela State. Of the 96 threatened species endemic to peninsula India, 50 are endemic to the Western Ghats region.

In Iran (and probably in surrounding countries too), the endemism rate of freshwater fish is relatively high (roughly 30 per cent), presumably due to the isolated character of several freshwater basins (Coad, 2006). About 17 per cent of the Iranian freshwater fish are threatened (IUCN Red List, 2017). A high diversity of 405 amphibian species is reported from India, almost half of them just described since 2000 especially from the Western Ghats (Dinesh *et al.*, 2017), 75 of those amphibians assessed are threatened, with decline in populations for very most of them (IUCN Red List, 2017).
Out of 24 species in Pakistan, one fourth are restricted to altitudes above 2000m (M. S. Khan, 2014); 22 species are reported from Iran of which 6 are endemic and 3 critically endangered (Safaei-Mahroo *et al.*, 2015),

In general, the freshwater biodiversity of Western Asia is poorly documented , with few exceptions such as a taxonomic inventory project in the UAE which covers several aquatic arthropods (van Harten, 2008, 2009, 2010, 2011), but has been discontinued. At least 100 species of freshwater fish of Western Asia, possibly many more, are still undescribed (Darwall & Freyhof, 2015). As a consequence of the mainly arid character of this subregion, combined with a dense human population, the fish fauna is highly threatened (Darwall & Freyhof, 2015) and at least 13 species are already thought to be extinct (Closs *et al.*, 2016). Due to its climate, the amphibian and freshwater reptile fauna is not very diverse in western Asia, but probably also not well studied in many parts of the subregion, since many taxa are data-deficient and their status needs to be updated. The IUCN Red List (2017) regards three of the 17 assessed amphibian species and one of approximately four freshwater reptiles as threatened, including the critically endangered tree frog *Hyla heinzsteinitzi* in Palestine and the endangered Euphrates Softshell Turtle (*Rafetus euphraticus*).

3.2.2.2 Lakes and ponds

A survey of Asian lakes showed exceptional biodiversity richness (fish, crustaceans, plankton, amphibians, reptiles), especially in so-called ‘ancient lakes’; e.g. Malili, Poso, and Biwa lakes (Kottelat & Whitten, 1996). Major threats for lakes are pollution by domestic and industrial waste, unsustainable quantities of aquaculture (fish cages), and introduction of exotic, or even invasive species, e.g. Nile tilapia (*Oreochromis niloticus*). Invasive aquatic macrophytes like water hyacinth (*Eichhornia crassipes*) are a serious threat for shallow lakes over most of the region. The status in various subregions is summarized below:

In New Zealand, over 32 per cent of the lakes larger than 1 ha in area (n=4000) are reported to have undergone rapid eutrophication resulting in poor water quality (Verburg *et al.*, 2010). Trends were assessed for 30 lakes, located mainly in Northland and Bay of Plenty. From 2004 to 2013, the eutrophication status increased significantly for 11 lakes (37 per cent), but decreased only for four lakes (13 per cent) (Stats NZ, 2017). In Australia inland lakes include coastal lakes and lagoons including perched lakes; freshwater inland lakes, often ephemeral or swamp areas; glacial lakes; natural lakes (mainly Tasmania); dry, salt lakes in central regions; and old volcanic lakes. Much of northern and remote areas, such as the lake Eyre Basin systems are relatively intact (Cresswell & Murphy, 2017).

The biodiversity of lakes and ponds in Indo-Burma is affected by pollution, overexploitation, habitat modifications that threaten fish, mollusk, crustacean and insect species. However, the indirect impact of habitat loss and degradation in the catchments through logging and land conversion are the major threats for lentic water bodies (Allen *et al.*, 2012). The same applies to insular south-east Asia, where land conversion into oil palm plantation is a major current threat. Ponds in such converted landscapes are reported to support only anuran communities of mainly wide-spread and common taxa (Konopik *et al.*, 2015).

The Sulawesian Lakes viz., Malili and Poso are known to harbour a high number of endemic taxa such as 53 species of *Tylomelania* (endemic snails), 8 Gecarcinucidae (crabs), 18 Caridina (shrimps), 31 Telmatherinidae (sailfin silverside fish) and several freshwater sponges e.g., *Pachydictyum globosum*, *Nudospongilla vasta* (Meixner *et al.*, 2007; von Rintelen *et al.*, 2012). In the Philippines, several animal species are locally endemic in lakes, especially cyprinid fish (Froese & Pauly, 2017). These endemics, also including the Garman's sea snake (*Hydrophis semperi*), one of only two sea snake species known to live in freshwater, are reported to be under pressure by unsustainable fish aquaculture and eutrophication, such as in Lake Taal (Gatus, 2010).

The ancient Lake Biwa (c. 4m years old), the largest lake in Japan (670km^2), not only supports the lives of 14 million people, but also provides a variety of nature's contribution to people. It harbors about 2400 aquatic species, 61 of them endemic including 29 mollusks and 16 fish species (44 species are on Red Lists (Nishino, 2012). It is estimated that 45 introduced exotic species are major threats to the endemic fauna and flora (Nakai & Kaneko, 2012). Global warming is likely to impact the endemic bottom dwelling fauna through reduced dissolved oxygen levels (Ishikawa & Kumagai, 2012). Fish stock and fish species richness has declined over 50 years in lakes of Japan. Invasion of exotic piscivore species is one of the most influential drivers of this decline (S. I. S. Matsuzaki & Kadoya, 2015; S. ichiro S. Matsuzaki *et al.*, 2016). Most of the ponds that were still present in Japan in the 1950s have disappeared due to land conversion and many of the remaining ponds are affected by eutrophication, concrete obstructions, and the invasion of the exotic blue-gill *Lepomis macrochirus* causing continuous loss of biodiversity in these habitats (Kadoya *et al.*, 2011). The demand for sport fishing has increased the spread of invasive fishes in Japan (Kizuka *et al.*, 2014).

In China, thousands of lakes alone were originally found along the Yangtze River (Zeng, 1990), but their number and extent has undergone a dramatic reduction since the 1950s due to imploding for reclamation of additional agricultural land (Fang *et al.*, 2006). Contemporaneously, biodiversity of aquatic plants, fish, and waterfowl decreased substantially at community, population, and species levels, attributed to the integrated effects of habitat degradation, water pollution, eutrophication, and overfishing, as well as the disconnection of rivers and lakes (Fang *et al.*, 2006). In India, the freshwater systems of the Western Ghats, such as the Periyar Lake-Stream System and small lakes in Maharashtra, have been assessed by IUCN standards a decade ago (Molur *et al.*, 2011). Effects of household and agricultural effluents, tourism, fisheries, and particularly introduced and invasive fish species are serious threats to endemic fish species, among them the Critically Endangered species, the Deccan Barb (*Puntius deccanensis*) (Raghavan & Ali, 2013). Though data deficient, the macrophyte *Bonnayodes limnophiloides* endemic to Lake Bhushi may already be extinct (Molur *et al.*, 2011).

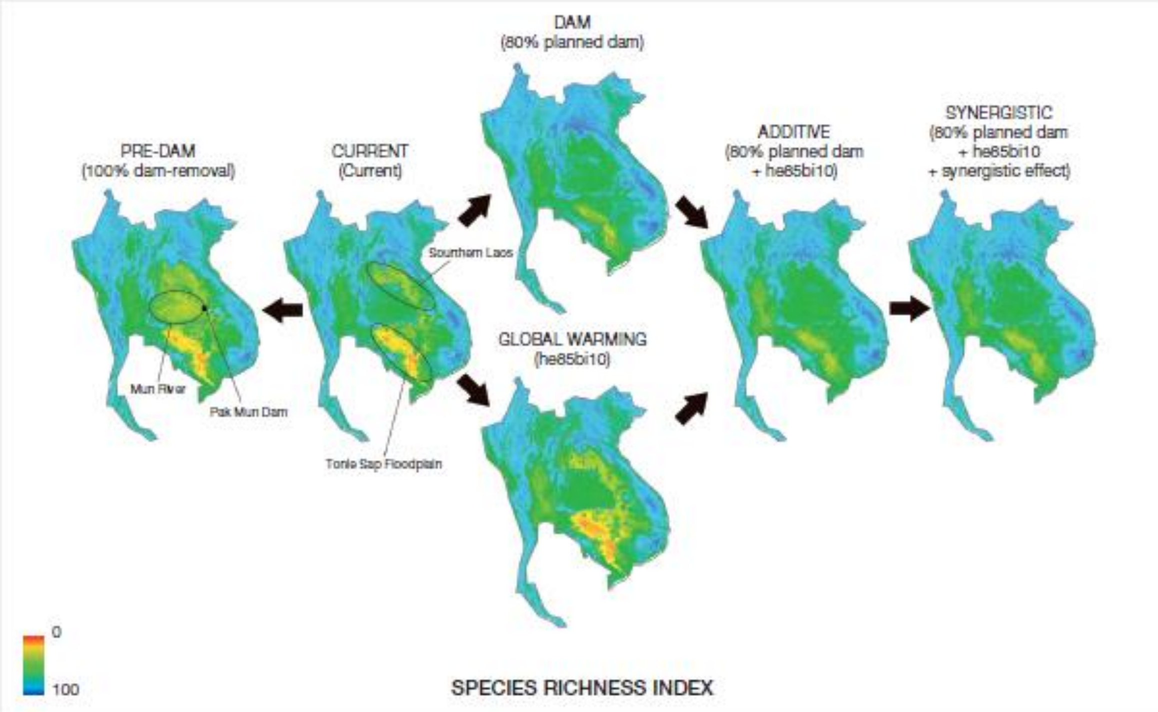
The genetic and species diversity of endemic freshwater invertebrates in glacial lakes of the Tibetan Plateau (and possibly other alpine freshwater habitats in the Asia-Pacific region) is presumed to be fostered by historic separation in glacial freshwater refugia and sub-refugia (Clewing *et al.*, 2016).

3.2.2.3 Rivers and streams

Rivers and streams across the Asia-Pacific region are under heavy anthropogenic pressure due to excessive diversion of water, pollution, habitat degradation and loss (Dudgeon *et al.*, 2006; Yule *et al.*, 2010) The distribution of historic (Pleistocene) and current river basins has shaped the genetic and species diversity of freshwater organisms (Bentley *et al.*, 2010; Bolotov *et al.*, 2017; Qing *et al.*, 2010) and contributed to the high biodiversity in various areas of the Asia-Pacific region. Allopatric speciation processes and thus species diversity and endemism are usually high in riverine freshwater habitats (Ribera & Vogler, 2000) due to reduced gene flow as a consequence of temporal and spatial continuity.

A large fraction of the freshwater-associated large mammals and reptiles, but also endemic fish species, are native to river systems of the Asia-Pacific region and many of them are highly endangered.

Aquatic insects, especially mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), beetles (Coleoptera), and dipterans (Diptera) are important biodiversity components in streams and rivers and commonly used as indicators of ecosystem health in lotic freshwaters (e.g., Blakely *et al*., 2014; Mustow, 2002; Ofenböck *et al*., 2008; Varnosfaderany *et al*., 2010). However, aquatic insects are not assessed herein in detail, due to vast data gaps within the region, except for north-east Asia and Australia (e.g., Bae, 2001; Jäch & Ji, 1995, 1998, 2003; Neboiss, 1986) and some exceptions in tropical countries and subregions of the Asia-Pacific region (e.g., Freitag *et al*., 2016; Jäch, M. A., & Balke, 2010; Malicky, 2010). Figure 3.5 depicts the cumulative impacts of various drivers on the inland freshwater ecosystems in South-East Asia.



Fish biodiversity index	PRE-DAM	CURRENT	DAM	GLOBAL WARMING	ADDITIVE	SYNERGISTIC
Mean species richness index	39.6	37.3	32.8	41.1	36.1	34.2
Mean habitable area index (km²)	637,097	613,626	564,744	586,691	546,480	511,394
Proportion of threatened species	0.0%	4.7%	16.0%	35.0%	39.7%	40.5%

Figure 3.5 Cumulative impacts of various drivers on freshwater fish diversity in the Mekong Basin. Source: Kano *et al*. (2016).

General status and trends in various subregions are as follows:

The largest threats to rivers and streams in Australia, New Zealand and the Pacific islands include water diversion, animal translocations and invasive species (Jenkins *et al.,* 2011). As with other regions in the Asia-Pacific region, there is a significant impact of dams on biodiversity and nature's contribution to people (e.g., Ligon *et al*., 1995). Globally, New Zealand is reported to have the highest percentage of threatened species (Elston *et al.,* 2015). The side-effects of rapid development, IAS and increasing demand for water are the common drivers responsible for the decline.

Australia might have the most complete data coverage including states and trends for key rivers. For example, the Murray-Darling basin is of high concern for freshwater biodiversity with 40 per cent of the river length being impaired, 10 per cent of river length being severely impaired with 50 per cent of species lost. Most rivers have low biodiversity compared to baseline conditions. Despite local trends, there is no overall trend over a ten-year period (Cresswell & Murphy, 2017). Non-arid zone northern Australian rivers are in good condition, while cattle, large feral animals have led to endemic fish and invertebrate losses in the arid zone. In southern Australia where water has been extracted for agricultural or urban use and natural river flows have been altered, significant biodiversity declines have occurred (Department of the Environment and Energy, 2016). Water management for increasing environmental flow benefits is actively managed in the Murray Darling basin from 2012, following major condition decline (1996-2010), but benefits are not systematically assessed (Grafton & Connell, 2013). Native fish are found in only 43 per cent of the rivers where they previously occured (Chapman, 2009).

The Mekong river system is particularly diverse in fish (898 indigenous species) and gastropod mollusks (Lower Mekong: ca. 140 species, 79 per cent endemic), but increasingly fragmented, causing severe biodiversity loss (Darwall & Freyhof, 2015; Strong *et al.*, 2008; Valbo-Jørgensen *et al.*, 2009). The creation of 78 dams across the Mekong River Basin has negatively impacted fish productivity and biodiversity (Ziv *et al.*, 2011). Furthermore, habitat shifts associated with dam creation synergistically enhances the impacts on fish diversity when coupled with global warming (Kano *et al.*, 2016). In most of south-east Asia, agricultural and mining run-offs, untreated municipal and industrial wastes pose additional threats to river biodiversity (e.g. Thailand State of Pollution Report Group, 2011; Yule *et al*., 2010). Iwata *et al*. (2003) reported increased sedimentation and declines in benthic biodiversity (periphyton, invertebrates and fish) associated with riparian deforestation due intensive slash-and-burn agricultural practices.

With exceptional riverine fish diversity and endemism, China has at least 717 freshwater fish species in 33 families inhabiting rivers (Dudgeon, 2000). At the Yangtze River Basin, which is globally significant for aquatic biodiversity with 419 native and 322 endemic fish species (C. Liu *et al.*, 2017; Xing *et al.*, 2016), of which 65 are threatened and included in the China Species Red List (S. Wang & Xie, 2009). Along with anthropogenic disturbance in water pollution, overexploitation, invasive species and habitat degradation, hydrological alterations (such as damming and river-lake disconnection) are the largest threat to fish diversity in Yangtze River Basin (Cheng *et al.*, 2015; L. Huang & Li, 2016; Lu *et al.*, 2016). The Chinese government is making efforts to the ecological restoration of the Three Gorges Reservoir, as well paying salvaging endeavor for aquatic biodiversity protection and conservation (Fu *et al.*, 2010). Japan has the fourth highest dam density in the world (Gleick *et al.*, 2002). However, the Government of Japan has initiated an ambitious project “River Works for Fish Migration” to restore habitat contiguity (Ikeuchi & Kanao, 2003).

The Himalayan mountain ranges are characterised by glacier-fed river systems and the largest river run-off from a single location (UNEP/GRID-Arendal, 2007). Here, biodiversity across freshwater ecosystems of the Eastern Himalaya region is especially diverse and of great importance to local communities. Development pressures in this region are likely to underestimate biodiversity values in planning process due to a lack of readily available information on the status and distribution of freshwater biodiversity, their ecological significance and connection to human health and well-being (Allen *et al.*, 2010).

3.2.2.4 Inland wetlands

Inland freshwater wetlands such as marshes, fens and peatlands are found across the Asia-Pacific region in lowlands and mountainous regions. Due to climate change, land conversion, and other human drivers, wetland habitats are disappearing worldwide (globally 69-75 per cent lost in the past century; (Davidson, 2014)). Unsurprisingly, wetland biodiversity and nature's contribution to people are declining globally and the trend is similar for the Asia-Pacific region (WWAP, 2015). Shallow lentic water bodies of the Asia-Pacific region are mostly prone to conversion into farmland, loss of ecological connectivity, eutrophication, and resulting degradation. For some wetland types (e.g., alpine wetlands) biodiversity is highly related to wetland size so any losses in wetlands will result in a loss of species. Inland wetlands in general support aquatic and wetland-adapted plant communities and lentic animal communities, including endangered water birds and fish (Wetlands International, 2012), some of them exclusively associated with wetland habitats (e.g., 46 per cent of all aquatic macrophyte species are found in wetlands). Rice species and varieties (*Oryza* spp.) have high economic importance in wetlands converted into paddy fields (Chambers *et al.*, 2008).

Across the Asia-Pacific region, trends in biodiversity and ecosystem functioning are following a similar pattern. In the Pacific Islands, tropical freshwater wetlands are often located upland of mangrove forests and under threat from climate change and human activities. Examples of wetland biodiversity and ecosystem service losses have been reported for Kosrae in Micronesia (Drew *et al.*, 2005). As a result, losses in upland forested wetlands may also impact coastal mangrove forests and the biodiversity therein. In Western Asia, water scarcity, climate change, political instability and human/land-use modifications in the region are threatening wetland habitats. Despite this instability, UAE established their first Wetland Protected Area and RAMSAR site, Wadi Wurayah National Park, which has helped to protect the endemic and endangered native fish *Garra barreimiae* found there (UNEP-WCMC, 2016a).

Box 3.1 Alpine wetlands of the Asia-Pacific region

Alpine wetlands are found in the mountainous regions across the Asia-Pacific region and biodiversity attributes have been reported for the Qinghai-Tibetan Plateau, China (Xue *et al.*, 2014), Yunnan Region of China (Y. Yang *et al.*, 2004), northern India (Panigrahy *et al.*, 2012), the upper Yarkund Valley, Pakistan (H. Khan & Baig, 2017), southeastern Australia and alpine valleys of New Zealand (Brinson & Malvárez, 2002; Wissinger *et al.*, 2016). Though typically small in size, they represent swamps, marsh - meadows, fen or peat. Many alpine wetlands across the Asia-Pacific region are of International Importance and identified RAMSAR sites (e.g. Bitahai wetland, Yunnan Province and Gansu Gahai Wetlands Nature Reserve, Xizang, China). The alpine wetlands are also hydrologically significant as major rivers in South-East Asia originate here.

The high altitude lakes in Ladakh, India are the only known breeding grounds for some waterfowl such as the Black-necked Crane (*Grus nigricollis*) and Bar-headed Goose (*Anser indicus*). The lakes and wetlands themselves contribute to local socioeconomies of both settled and nomadic populations in the region with pasture lands surrounding wetlands used for grazing. Nomadic communities generate as much as 90 per cent of their livelyhood from grazing sheep, horses and yak on these wetland pastures. Unfortunately, multiple stressors are threatening these alpine wetland habitats and their biodiversity. Threats include climate change, grazing, eutrophication and introduced fishes. Elsewhere in the Tibetan Plateau, alpine wetlands have high biodiversity values comprised of high rates of endemism spanning fish, birds, amphibian and mammal taxa. Alpine wetlands are the most vulnerable freshwater ecosystem to climate change with impacts to water quality, biological productivity and ecosystem functioning (Chatterjee *et al.*, 2010; WWF, 2006). For example, alpine wetlands of the Tibetan Plateau are predicted to decline by 37.5 per cent with all wet meadow and saltmarsh habitats predicted to disappear completely (Xue *et al.*, 2014). This has implications for flora and fauna that are highly-specialised to these specific climatic conditions, and the ecosystem functions, such as carbon sequestration, water and habitat provisioning which are critical for the wider region. Migratory waterfowl that use these habitats and endemic plants and animals are at risk. A combination of pressures including human activities, cattle grazing, agricultural development, mining and climate change are all contributing to loss of habitat and biodiversity.

The review of wetlands as defined by the Ramsar Convention on Wetlands of the Pacific Islands region revealed that the natural species diversity is highest in the western Pacific region (e.g. Papua New Guinea), and declines towards the eastern Pacific Islands, French Polynesia (Figure 3.6). However, there are still large gaps in the knowledge on drivers of freshwater biodiversity declines. Nevertheless, the community structure is unique in each island nation, with endemic species due to the habitat isolation that is characteristic of Oceania. The Red List Index shows that extinction risk has increased after 2010 in this subregion. Accordingly, biodiversity in freshwater ecosystem of the Pacific islands has experienced drastic decline (Ellison, 2009).

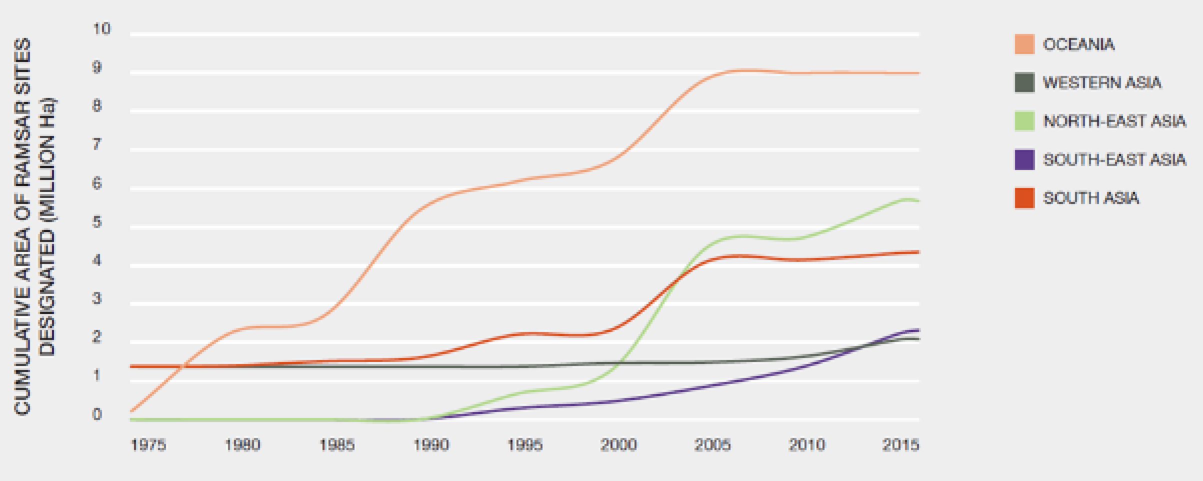


Figure 3.6 Trends in Ramsar site designation in the Asia-Pacific region during the past 40 years. Source: Ramsar Convention Secretariat (2017).

Sixty five Australian wetlands are Ramsar listed covering >8.3 million hectares. The condition of Australian wetlands has deteriorated due to increased water regulation and extraction for increasing levels irrigation agriculture, urban and industrial use. Two wetland ecosystems were listed as endangered and critically endangered since 2011 (Department of the Environment and Energy, 2016). Water bird communities are a good indicator of their condition (Kingsford *et al.*, 2013), and these have been in decline for 33 years and are concentrated in few sites (Cresswell & Murphy, 2017). The cause of decline and deterioration of wetland condition and biodiversity is driven increased water use and extraction for intensifying irrigation agriculture, urban and industrial use across the country. For example, in 2001 almost one-third of the 851 nationally important wetlands were threatened by altered flow regimes. This resulted in the loss of floodplain wetlands in the Murray-Darling Basin (90 per cent loss), coastal wetlands in New South Wales (50 per cent) and Swan Coastal Plain wetlands in southwest Western Australia (75 per cent loss). Unsurprisingly, extensive losses in habitat wetland extent have reduced flood frequency and biodiversity in remaining ones. Waterbirds have been especially impacted (1.1 million 1983 to 0.2 million in 2004) as both population numbers and breeding success of native species are highly dependent on flooding events and associated replenishment of the wetlands. Declines in population numbers and species ranges for macroinvertebrates, freshwater fish and amphibians have also been reported (Davis *et al.*, 2001).

Peatlands such as those in South-East Asia are responsible for storing considerable amounts of carbon while also providing habitat for flora and fauna that include vulnerable taxa such as the false gharial (*Tomistoma schlegelii*) (Bezuijen *et al.*, 2014; Rose *et al.*, 2011). Wetlands of the Philippines (e.g. Naujan Lake, Mindoro; Candava Swamp, Luzon; Agusan Marsh, Mindanao), are important resting and wintering areas for migratory and domestic bird populations (Republic of the Philippines, 2014). Peat swamp forests (PSFs) are inhabited by a highly unique and endemic fish and insect fauna, adapted to the acidic blackwater (Giam *et al.*, 2012; Rose *et al.*, 2011). However, PSFs are deforested at a higher rate (–3.7 per cent per year) than other forests, with highest rates of loss in Sarawak (-8.1 per cent per year) and Sumatra (-5.2 per cent per year) (Miettinen *et al.*, 2011; Wilcove *et al.*, 2013). Only 36 per cent of the original PSF area has remained in South-East Asia. Conversion of low land swamp forests into banana and oil palm plantations in Peninsular Malaysia is a major concern. If current rates of peat swamp forest conversion in Sundaland continues, it is projected that by 2050, 16 per cent of PSF fish species are likely to go extinct (Rose *et al.*, 2011; Wilcove *et al.*, 2013). Paoli *et al.* (2010) have recommended that Indonesian peatlands must be managed and protected under post-Kyoto framework which will in turn help conservation of many endangered vertebrates. The extant peatlands which are still intact in these areas are likely to be logged and drained in the next few decades (Verhoeven & Setter, 2010). Likewise, peatlands of inland Central Asia and Tibetan plateau are facing serious threats due to climate change and intensive land use (Box 3.2).

In Japan, 61.1 per cent of wetlands (not including paddy fields) had been lost from 1920 to 2000 (Geospatial Information Authority of Japan, 2000) as a result of human activities. Irrigation ponds, mostly constructed in 17-19 centuries became refuge for many lentic endangered species (Takamura, 2012). Most of the wetlands on Hokkaido Island, Japan are peat-forming mires of which more than 70 per cent have been lost due to drainage and receiving eutrophic water from rivers and agricultural lands. Mire vegetation has undergone retrogressive succession, affecting further biodiversity components (Fujita, 2007). In Arabian Peninsula, of the 17.5 per cent of assessed species, 8 species of fish, 15 species of Odonata, 5 molluscs and 23 species of aquatic plants are reported to be threatened. Here one species of damselfly is Regionally Extinct due to habitat loss (García *et al.*, 2015).

Box 3.2 Peatlands of continental highland Asia

Peatlands occur in a variety of wetlands and comprise accumulated surface peat with incompletely decomposed plant matter (Joosten & Clarke, 2002; Parish *et al.*, 2008; Rydin & Jeglum, 2013). Peats generally contain at least 30 per cent dead organic matter (by mass) with a minimum depth of 30cm. A peatland with actively accumulating peat is termed as mire. They play a vital role in regulating hydrology, supporting biodiversity and livelihoods, ecosystem functioning and climate regulation (Joosten *et al.*, 2016). Other functions include buffering microclimate of adjacent areas, accumulation and carbon storage and providing unique habitats to several species of fauna especially resident and migratory birds (Minayeva *et al.*, 2017; Parish *et al.*, 2008). The Global Peatland Database[60] reveals that Mongolia, the Tibetan Plateau, and other parts of China have extensive peatlands. Despite an arid climate, Mongolia has diverse and extensive peatlands covering an area of about 27,000 km^2 or over 1.7 per cent of the country (Minayeva *et al.*, 2004, 2005, 2017). They are susceptible to desertification due to low annual precipitation and high summer temperatures. Originally formed in cooler climatic conditions, peatlands in the upland and forest steppe zones have undergone rapid degradation over recent decades. They are also prone to soil erosion and CO_2 emission due to grazing, mining and other human activities (Minayeva *et al.*, 2017). Land use changes, infrastructure development and pollution especially of water greatly affect their resilience.

Increasing aridity in many parts of Mongolia and Central Asia is likely to exert more pressure on moist and peat rich habitats in future especially due to greater concentration of domestic livestock in such areas (Y. Liu *et al.*, 2013). Conversely, intensive use of other habitats such as steppe and woodland, excessive use and diversion of water would make the peatlands more vulnerable. Some areas have become devoid of vegetation and are rapidly losing peat. Adequate attention is required in terms of raising conservation awareness and long term monitoring of peatlands. Other important adaptation measures could be introduction of nature-friendly tools and techniques, excluding of peatlands from economic use and restoration of damaged peatlands (Biancalani & Avagyan, 2014).

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3.2.3 Coastal

Though the biodiversity of nearshore coastal and shelf zones is relatively well understood in the Asia-Pacific region, even in the well-known areas of Japan, Australia and New Zealand, more than 70 per cent of estimated biodiversity remains un-described (Butler *et al.*, 2010; Fujikura *et al.*, 2010; Gordon *et al.*, 2010; Y. Liu *et al.*, 2013). Three coastal ecosystems have been listed as threatened doubling the number in Australia since 2011 (Department of the Environment and Energy, 2016). However, one of the important and distinctive landforms that remains least documented along coastal areas of the Asia-Pacific region is 'Beaches and Rocky Shores'. They include rick shingle beaches and sandbars, rocky headlands and cliffs along subtidal and intertidal habitats. These habitats are reported to be more

[60] Accessible from: http://www.greifswaldmoor.de/global-peatland-database-en.html

threatened due to sand and gravel mining compared to others (Butler & Bax, 2014; Peduzzi, 2014; Thaman, 2013; UNEP/UNCTAD, 2014).

A strong indicator of coastal habitat loss and condition are shore bird communities and these are considered to be in a poor state in Australia declining over the last 5 years. Marine and Estuarine IAS continue to increase in diversity and abundance across the region, with evidence of continued expansion, however the baseline knowledge in parts of Oceania (Australia, New Zealand, Guam and North Asia) is higher than other subregions of the Asia-Pacific region. Marine and Estuarine IAS have highest diversity in temperate regions with lower recognised diversity in the tropics (Byers *et al.*, 2015; M. L. Campbell *et al.*, 2007; Hewitt, 2002). Coastal littoral deforestation including loss of mangroves due to overexploitation or conversion to agricultural, aquaculture and urbanization and industrial uses are major concerns in the region. The following sections deal with the current status of biodiversity and nature's contribution to people in coastal and nearshores.

3.2.3.1 Mangroves

Mangroves represent a unique ecosystem in coastal area supporting a rich biodiversity and providing a range of nature's contribution to people including provisioning, regulating and supporting, crucial for the sustenance of local communities (Thu & Populus, 2007). South-East Asian mangroves are among the most species diverse in the world, having 268 plant species including 52 taxa growing exclusively in mangrove habitat (Giesen *et al.*, 2007; Giesen & Wulffraat, 1998). Recent changes in land use primarily for aquaculture has led to transformation of mangroves (up to 75 per cent in last 3 decades (Primavera, 1997; J. B. Smith *et al.*, 2001). In Oceania alone, there has been a decrease in mangrove area by 9.5 per cent during last 25 years (FAO, 2007). Most of the mangroves have suffered due to rapid urbanization especially in Philippines, Thailand and Vietnam (Giri *et al.*, 2011; Spalding *et al.*, 1997). In other areas anthropogenic pressures as well as changing climate continue to affect the mangrove (Blasco *et al.*, 2001). During the period 2000-2012, South-East Asia lost its mangrove forests at an average rate of 0.18 per cent per year (Richards *et al.*, 2016) with 30 per cent loss due to aquaculture. Other drivers causing the decline in mangrove forests include paddy farming along the coastal habitats of Myanmar and the expansion of oil palm in Malaysia and Indonesia (Figure 3.7). Oil palm is expected to threat the mangrove forests more with new frontiers opening up in Papua, Indonesia (Richards *et al.*, 2016). The die-back of some 7000 hectares of mangroves in the Gulf of Carpentaria, Australia, in November-December 2016 is most likely caused by an extended drought period (Duke *et al.*, 2017). It is projected that rise in sea level due to global warming could pose biggest threat to mangroves especially in Bangladesh, New Zealand, Viet Nam and China (Giri *et al.*, 2011; Polidoro *et al.*, 2010). Although several efforts of conservation and recovery have been conducted recently, the conservation agencies have achieved partial success in Sri Lanka and New Zealand (Thrush *et al.*, 2013).

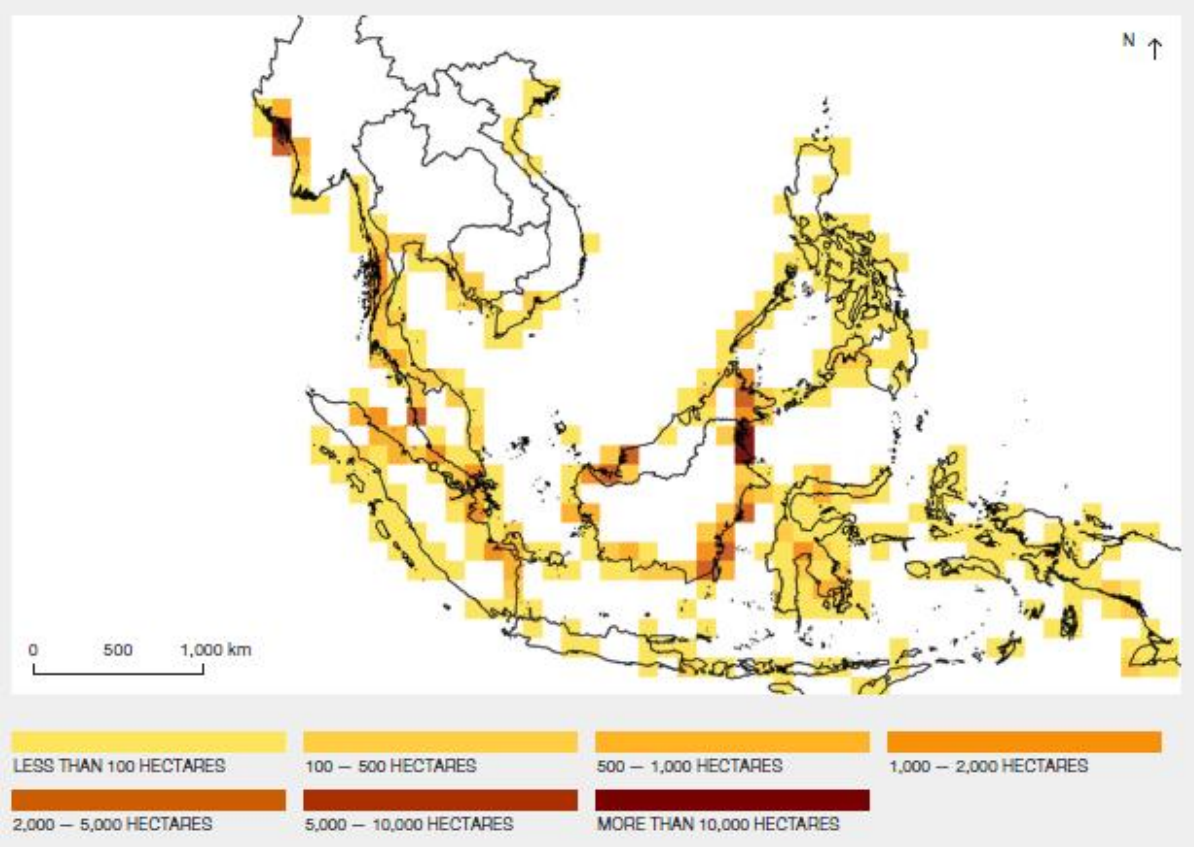

Figure 3.7 Mangrove deforestation between 2000 and 2012. Source: Richards *et al*. (2016).

3.2.3.2 Other intertidal habitats

Both intertidal habitats and mangroves not only provide spawning areas and nurseries for numerous species of fish and crustaceans that provide seafood to the coastal and inland population but also consolidate sediments into fertile new lands protecting offshore coral reefs from siltation and hence increasing the productivity of reefs and inland seas. The intertidal zones along the coasts are very narrow and fragile yet rapidly deteriorating and vanishing due to various anthropogenic factors. Many migrant bird species that travel annually along the East Asian-Australasian Flyway inhabit intertidal habitats. There are indications of serious problems along the Flyway as 89 per cent of all monitored populations of Arctic breeding shorebirds in north eastern Russia now show a decline. Monitoring on beaches of Australia There is a decline in the numbers of monitored Flyway migrant shorebirds wintering on the beaches of Australia (D. I. Rogers *et al.*, 2010). Japanese shorebirds between 1975 to 2008 also show declines in most species but interestingly a much higher proportion among species that are dependent on Yellow Sea stopover sites (Amano *et al.*, 2010). Two extreme habitat specialists: Red Knot (Amano *et al.*, 2010; Wilson *et al.*, 2011) and Spoon-billed Sandpiper (Zöckler *et al.*, 2010) are the fastest declining migratory shorebirds in the Flyway. With the current rates it is projected that for every 100 Red Knots migrating along the Flyway in 1992, only seven will be left in 2020. Despite the ongoing conservation action, Spoon-billed Sandpipers will likely go extinct (Pain *et al.*, 2011). The rate of intertidal habitat loss in Asia are equal to or greater than recorded losses of mangroves (Giri *et al.*, 2011), tropical forest (Achard, 2002) and sea grasses (Waycott *et al.*, 2009). For example, some 51 per cent of coastal wetlands including marshes in China was lost over the past 50 years (An *et al.*, 2007), 40 per cent in Japan, more than 70 per cent in Singapore (Hilton & Manning, 1995), and at least 40 per cent in the Republic of Korea (Koh & Khim, 2014).

3.2.3.3 Seagrass beds

Many of the seagrasses in the Asia-Pacific regions are confined to sheltered areas in the shallow intertidal associated ecosystems, semi-enclosed lagoons and subtidal zones, between mangrove and coral reef ecosystems. Seagrasses are also found around offshore islands with fringing reefs. The seagrass beds measure several hundred metres in width and up to several kilometres long along the coast (UNEP, 2008). The highest seagrass diversity in the world with 24 species is found in Tropical Indo-Pacific (East Africa, south Asia and tropical Australia to the eastern Pacific) (Fortes, 2012; Short *et al.*, 2007; UNEP, 2008).

Loss of the seagrass beds are recorded in many areas, especially in Oceania and South East Asia (Kawaguchi & Hayashizaki, 2011; Waycott *et al.*, 2009). The rate of decrease was over 20 per cent in Vietnam and the Philippines, due to human activities as well as natural disasters such as typhoon, storm, and Tsunami (Coles *et al.*, 2003; Seddon *et al.*, 2000; Thangaradjou *et al.*, 2010). In case of temperate regions of Japan a considerable decrease has been reported during last 30 years (Takehisa Yamakita *et al.*, 2011). Associated with these habitats are the dugong populations in the Southern Great Barrier Reef, which have to very lowest levels in the last 50 years (in the year 2011) along with other species (Department of the Environment and Energy, 2016).

3.2.3.4 Kelp forests and other algal communities

Kelp forests are distributed from temperate to arctic zones and are commercially important especially in north East Asia, both as edible Kelp and fish habitat. Although local sustainable management are on-going in northern pacific side of East Asia (Hokkaido Japan), decreasing trend was recorded from 2080 km^2 in 1978 ha to 1250 km^2 in 2007 in Japan. North east Asia, especially west pacific side of Japan and urban areas of Australia exhibit drastic decrease in Kelp forests (FRA Japan, 2009; Wernberg *et al.*, 2011). In addition, the distribution of Kelp forest is expanding northward, probably due to global warming (Wernberg *et al.*, 2011). Other algal beds are also reported from temperate to tropical areas and most of them are important both culturally as well as commercially (Japar Sidik *et al.*, 2012; Kawaguchi & Hayashizaki, 2011). In Australia a recent assessment of giant kelp forests was done in South-East part. These are reported to be suffering from increased sea temperatures and it is projected that in future the kelp forests will become increasingly concentrated away from equator in any remaining suitable habitats (Department of the Environment and Energy, 2016).

3.2.3.5 Coral and other reefs

Coral reefs are the most diverse coastal ecosystems on earth and of disproportionate ecological, economic and food security importance to the Asia-Pacific region which has an inordinate proportion of the world's healthy coral reefs (Chapter 1). The death of reef-forming corals undermines resilience of coastal communities, and can lead to the collapse of important coastal ecosystems. According to a recent assessment (Huang & Roy, 2015) one third of reef-building corals in the region are threatened, with serious evolutionary consequences. Coral diversity is highest in the Asia-Pacific region, with unique genetic diversity (D. Huang & Roy, 2015). Loss of habitat quality, heavy damage to entire reefs are major threats in the region (Bellwood *et al.*, 2004; Bruno & Selig, 2007; Côté *et al.*, 2005; De'ath *et al.*, 2012; UNISDR/UNDP, 2012; Wilkinson, 2008). In the case of El Niño event in 1998, 16 per cent of the world's coral reefs and 50 per cent of those in the Indian Ocean were destroyed (UNISDR/UNDP, 2012). Increase in sea temperature and ocean acidification have been projected as major drivers of change along coastal environments which may lead to decline in coral reefs (Burke *et al.*, 2011; Chin *et al.*, 2011). In the north western Pacific, distribution of reef-building coral species is expanding toward poleward (Hiroya Yamano *et al.*, 2011). Species associated with corals also expand their distribution with expansion of distribution of their host corals (H. Yamano *et al.*, 2012). However, ocean acidification (OA) may limits its poleward expansion as the cold water regions are strongly affected by OA (Yara *et al.*, 2012).

In the Philippines, patterns of coral reef fish disappearances revealed as much as 88 per cent decline in catch per unit effort since the 1950s for large reef fishes like bumphead parrotfish, humbhead wrasse and giant grouper. Aside from being significant target fish, these fishes are ecologically important. For example, Bumphead parrotfish is very important species to keep coral reefs healthy. While this study is at the country level, but the reef fish species covered are widely distributed within the Indo-Pacific region (Lavides *et al.*, 2016). Increasing outbreaks of crown of thorns starfish, a native predator that has boom bust cycles linked to environmental pollution from farm lined estuaries affected The Great Barrier Reef (Wooldridge & Brodie, 2015). Coral bleaching events are also increasingly devastating to the northern two thirds of the reef over the last few years where coral-algae associations are disrupted by high sea temperature (Ainsworth *et al.*, 2016). Prior to recent bleaching in Australia, there has been an increase of coral reef area which is attributed to establishment of several protected areas (Waycott *et al.*, 2009). Habitats and communities in the Great Barrier Reef ranged from poor to worsening at the end of 2015, although some species like green turtle populations improved (Department of the Environment and Energy, 2016).

Among the most serious emerging threats to coral reefs are coral diseases, which have devastated coral populations throughout the Caribbean since the 1980s and accompanied the mass coral bleaching there in 2005 and 2006 (Wilkinson, 2008). Over 90 per cent of the main reef forming corals in the Caribbean have now died due to coral disease with the severity of disease outbreaks commonly correlated with corals stressed by bleaching (Wilkinson, 2008). Coral diseases are also being observed more frequently on Indo-Pacific reefs in heretofore unrecorded places such the Great Barrier Reef, areas of Marovo Lagoon in the Solomon Islands and the Northwestern Hawaiian Islands. The outbreaks seem to be related to bacterial infections and other introduced disease organisms, increasing pollution, human disturbance and increasing sea temperature, all of which have put reef-forming corals at serious risk.

Several studies have demonstrated that mussels play an important role in building the reefs and ecosystem functioning in reef areas (Dittmann, 1990; Markert *et al.*, 2009; Norling & Kautsky, 2008). Reefs themselves are important foraging grounds for avian species (Caldow *et al.*, 2003; Nehls *et al.*, 1997), blue mussel (*Mytilus edulis*), and Pacific oysters (*Crassostrea gigas*) which are sensitive to changes in habitat conditions (J. L. Gutiérrez *et al.*, 2003; Kochmann *et al.*, 2008; Kröncke, 1996). At a regional scale effects of climate change and other drivers have not been assessed. The black mussel (*Mytilus crassitesta*) is also an important bivalve species actively cultured in Korea with a highest annual production of 69,375 MT in 1980. However, from 1981 to 1987 the output had been gradually decreasing and only 29,813 MT was produced in 1987 (FAO, 2015b). Highest diversity of species among mussel beds have been reported along western part of Pacific Ocean (Kochmann *et al.*, 2008). Though the decline of black mussel, an increase in population of green mussel has been reported from temperate region of Japanese Pacific water (Ohgaki *et al.*, 2011).

Oysters play important role in regulating the food chain and nutrient cycling in coastal areas (Schulte *et al.*, 2009). They have supported civilizations for millennia, from Romans to California railroad workers (MacKenzie *et al.*, 1997). Oyster reefs have experienced the largest global loss of any marine habitat type, and are expected to decrease by 85 per cent compared to their historic extent (Beck *et al.*, 2011). Harmful fishing techniques affected the oysters negatively (Pollack *et al.*, 2012) besides overharvesting, water pollution, invasions of commercial hybrids, and other factors (L. A. Brown *et al.*, 2014). Extensive cultivation of oysters is considered one of the drivers that may affect the biodiversity and nature's contribution to people in these areas and reported in at least 60 countries (Ruesink *et al.*, 2005). Despite being highly important locally, introduced oyster only contributed 6 per cent of the world’s annual oyster harvest which is approximately 3.3 million tons (Ruesink *et al.*, 2005). Some commercial oyster farms have been affected by introduced pathogens such as *Bonamia ostreae* (New South Wales and Tasmania in Australia, and New Zealand), but native oysters are less affected (Whittington *et al.*, 2016).

3.2.3.6 Aquaculture and other artificial substrata

About ninety per cent of world Aquaculture production is from the Asia-Pacific region (Funge-Smith *et al.*, 2012) and the top 10 countries of the world in aquaculture production belongs to this region (Lymer *et al.*, 2010). The major targeted aquaculture species belongs to the fin fishes (fresh water species: 60 per cent; Marine species: 32 per cent and Brackish water species: 8 per cent of total production) accounts about 49 per cent of the total aquaculture production ; molluscs about 19 per cent; crustaceans about 7 per cent, echinoderms (Sea cucumbers) in trace and Aquatic plants about 22 per cent by production of total aquaculture in this regions. The species used for aquaculture are very limited in comparison to the available species in the region. The major stake of marine and brackish water aquaculture is from China, Indonesia, Philippines, Japan, Viet Nam, Republic of Korea and Bangladesh in this region. The marine and brackish water aquaculture in this region is intensive and the production from the Brackish water and marine sector is growing in rate of 3 per cent per annum and all together the Aquaculture growth in this region is about 6.7 per cent, whereas, some countries like India, Indonesia, Vietnam, Myanmar the production growth rate is about 9-24 per cent. The major challenges for Aquaculture in the management of Biodiversity of the subregions due to introduction of Invasive/Alien species for profitable over production, improper management of Bio-security measures, diseases etc.

In addition, increasing urbanization in coastal area and resultant modification of habitats (e.g., shift from soft sediment to hard benthos) is likely to change the biodiversity and nature's contribution to people in the area.

3.2.4 Marine

In this assessment, marine area means the area both in the euphotic and aphotic zones. It is however very difficult to separate status and trends of biodiversity and ecosystem service in the coastal and marine areas. Therefore, in this assessment, the distinction is not rigid.

3.2.4.1 Pelagic (euphotic)

The primary production and the total biomass supported by it in the pelagic ecosystem (<200m depth in euphotic zone) are not uniform in the marine area. It is mostly regulated by the supply of nutrients. In the marine areas, upwelling and vertical mixing play the most important role as a supplying mechanism of nutrients to the pelagic area, and the status has been continuously monitored using satellite for decades. The status of pelagic ecosystem is influenced largely by the large scale status change of ocean, e.g. El Niño, La Niña, Indian Dipole, decadal oscillation and “regime shift” (Litzow *et al.*, 2014). Recently, primary production of marine area measured by Chlorophyll *a* concentration abundance is decreasing is various parts of marine area such as Indian Ocean and Western Pacific (Boyce *et al.*, 2010).

Species composition of marine pelagic animals has changed dramatically in the North and South western pacific areas. This change is characterized by increase of gelatinous zooplankton such as jelly fishes and planktonic tunicates (Lilley *et al.*, 2011). Typical events has been observed in the north western Pacific region, where big blooms of huge Nomura's Jellyfish were observed and it impacted fisheries activity (A. J. Richardson & Gibbons, 2008; Uye, 2014). Harmful Algal blooms are also warned issues in highly populated area especially in a bay (Anderson *et al.*, 2012).

3.2.4.2 Pelagic (aphotic) and benthic

The aphotic zone includes the areas which are more than 200m deep in the ocean, including the ocean shelf and slope, abyssal zone (sea floor), trench, and trough. There are significant information gaps regarding status and trends of marine biodiversity and ecosystems in the Asia-Pacific region (Webb *et al.*, 2010). Figure 3.8 shows the number of records and completeness of information existing in the Ocean Biogeography Information System (OBIS) regarding marine biodiversity (http://www.iobis.org). In the Asia-Pacific region, areas in the western Pacific are comparatively well surveyed, but the knowledge of biodiversity remains below 50 per cent in most areas of the Indian Ocean. Nevertheless, it is obvious that tropical to temperate western Pacific areas and the eastern Indian Ocean area are hotspots of marine biodiversity (Tittensor *et al.*, 2010).

It has been known that biodiversity and body structure of benthic animals has a specific pattern (known as mid-slope diversity hypothesis) with depth in the marine environment (Levin *et al.*, 2001; Rex & Etter, 1998). This pattern has well been known in the Atlantic but same pattern has been known from Western Pacific (Shirayama & Kojima, 1994) and Indian Ocean area too (Raman *et al.*, 2015). Sediment grain size, productivity and water flow is hypothesized cause of this pattern. Submarine canyons are typically incident in the continental slope. Increase in geographical heterogeneity and their effect to the current and other material flow are considered to increase diversity and productivity (Levin & Sibuet, 2012). Terrestrial input of organic materials also affects this area however artificial debris also accumulated. The Asia-Pacific region is characterized by the highest species richness of brittle stars in the world. It is the frequently dominant species of muddy plains and also present in hard substrates. Among depth gradient bathyal zones, the highest number of brittle star species are observed in the Asia-Pacific region (Thuy *et al.*, 2012). In the case of the southern hemisphere, the distribution of brittle stars are separated into latitudinal clusters. Dispersal limitation was also an important factor to differentiate species (O'Hara *et al.*, 2011).

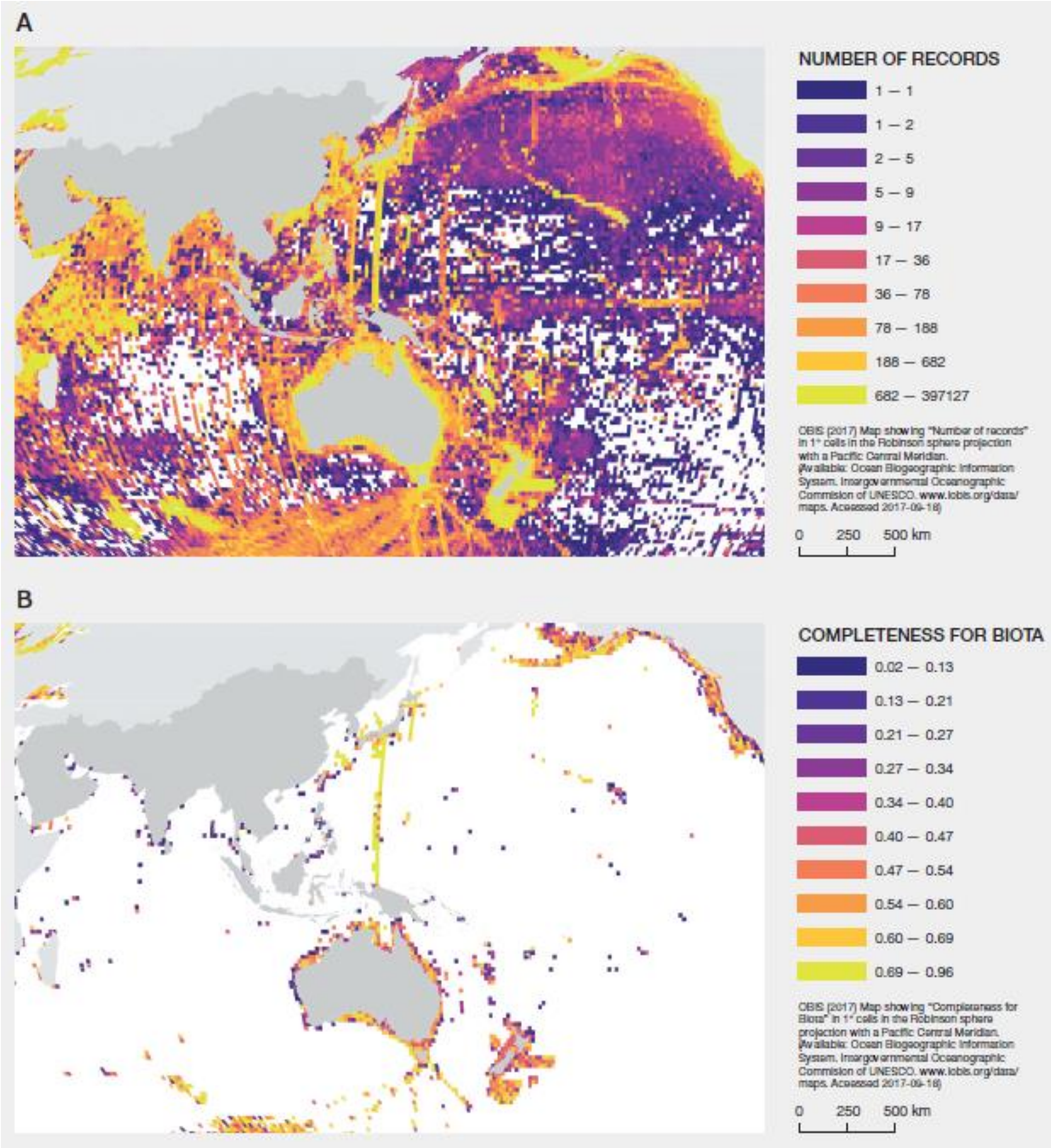

Figure 3.8 Number of records (A) and completeness of data (B) in the coastal and marine biomes of the Asia-Pacific region in the Ocean Biogeography Information System (OBIS). Good records exist in Oceania and some parts of North-East Asia, but data in the remaining subregions are incomplete. Source: OBIS (2017a, 2017b).

Good records exist in Oceania and some parts of North-East Asia, but data in the remaining subregions are incomplete. The abyssal zone is the most common habitat in bottom marine environments and the abundance and diversity of macro benthic organisms are very low in this area. However, research on meiofauna and microbial organisms has revealed their high endemism, diversity, and distribution (e.g. Shirayama, 1984). Trench areas have higher benthic biomass compared to abyssal zones (e.g. Itoh *et al*., 2011). Recently, pelagic ecosystems, especially for the microbial community, have also been found to have a vertical pattern (Nunoura *et al*., 2015). The biodiversity of deep pelagic zones in the world's oceans remains largely unknown despite the significant provision of a range of nature's contribution to people (O'Dor & Gallardo, 2005).

3.2.4.3 Shipwrecks, debris and other substrates

Shipwrecks accumulated at the ocean floors eventually serve as special 3D habitat for a number of marine species. These sites function as fish aggregators and thereby increase the local biodiversity. Such artificial habitats are prominent in southern oceans especially closer to Australia (Stieglitz, 2012). Likewise, other marine debris accumulated near shores and between islands especially at the junctions of oceanic currents and underwater valleys greatly influence the marine habitats (Lebreton *et al.*, 2012; McIlgorm *et al.*, 2011). Although such artificial habitats play positive role in marine environments, increase in inorganic substances and toxic plastic based pollutants is a major concern (Kako *et al.*, 2014). Massive pulses of labile organic matter to the deep-sea floor was due to falls of large whales. The interest in whale fall ecology began with the discovery of a chemoautotrophic assemblage on a whale skeleton in the North-East Pacific in 1989 (C. R. Smith, 1992). It has been observed that whale falls share 11 species with hydrothermal vents and 20 species with cold seeps, and thus may provide dispersal stepping stones for a subset of the vent and seep faunas (C. R. Smith & Baco, 2003).

3.2.4.4 Seamount and rise

Survey of seamounts was carried out extensively in the Asia-Pacific region during the project of Census of marine life (Stocks *et al.*, 2012). There are thousands of seamounts in the Asia-Pacific region and they are the focus of exploration for seabed minerals, especially polymetallic sulphides in the Southwest Pacific (S. D. Scott, 2007) and cobalt-rich crusts in the central Pacific Ocean (Hein, 2002). There are significant differences in the structural complexity of benthic habitats, species numbers and abundance, and the composition and structure of assemblages between fished and unfished seamounts off Australia and New Zealand (Koslow *et al.*, 2001). Especially information from South-East to Western Asia is very limited. Same situation occurred on the species identification. In some area, 30 per cent of species are newly recorded and most of them are expected to have any specialty to seamount habitat (de Forges *et al.*, 2000).

Higher production and diversity have been recorded in some seamounts compared to surrounding habitats (de Forges *et al.*, 2000). Lower rate of the overlap on the species composition was observed between different cramps of the seamount (Glover & Smith, 2003). Changes of the productivity of the seamounts can be evaluated by fishery survey. However, there is limited published information on seamounts except a few survey reports from Australia and New Zealand. Expansion of the oxygen minimum zone in the east tropical Pacific and Indian Oceans has also been recorded with limited information on biological response (Stramma *et al.*, 2010).

3.2.4.5 Chemosynthetic ecosystem

Chemosynthetic ecosystem is the generic term of the ecosystem based on bacteria which using the oxidation of Inorganic compound as a source of energy. Hydrothermal vents, cold seeps or gas hydrates are abundant in both Pacific and Indian oceans of the Asia-Pacific region. These ecosystems have been studied extensively under the Census of Marine Life project (German *et al.*, 2011). Chemosynthetic sites have also been recorded for each curie (Tokeshi, 2011). However, the number of the newly found chemosynthetic sites has been increasing. Research about temporal observation or geographical comparison on this habitat is rare in the Asia-Pacific region. By the geographical comparison, endemism of the chemosynthetic sites are high and it is decided in the local scale (Nakajima *et al.*, 2014). Similarity of the macro benthos community is distance dependent and might be affected by the chemical composition of the vent (Nakajima *et al.*, 2014). The effect of the chemical of the vent was especially true for smaller species (Urabe *et al.*, 2015). The characterization of deep-sea vent communities in Manus Basin (Bismarck Sea, Papua New Guinea) was made to test the hypothesis whether there was any difference in macrofaunal community structure between the sites using macrofaunal data sets from a proposed reference site (South Su) and a proposed mine site (Solwara 1) (Collins *et al.*, 2012).

By the global comparison, importance of the consideration of the geographical event (such as eruption from vent) is pointed as near future trend in some active vent site (Glover *et al.*, 2010). Researches related to the impact assessment for the drilling resources are also getting increase but not yet summarized as integrated way (M. R. Clark *et al.*, 2010).

3.2.4.6 Status and trends of Asia-Pacific fisheries

There are several hotspots of faunal diversity in the coastal and marine areas of the Asia-Pacific region. Such hotspots are mainly located in the tropical western Pacific and eastern Indian ocean[61] (T. Yamakita *et al.*, 2017). According to the distribution of potentially extinct species in the Asia-Pacific region, threats to the marine biodiversity is high in the coasts of South Asia and central Indian Ocean. Biodiversity and abundance of large predators, such as tuna species, is reported to have decreased constantly in the Asia-Pacific region over the past 50 years (R. A. Myers & Worm, 2003; Worm *et al.*, 2003). This trend is especially strong in the Indian ocean and the southern Pacific ocean around Australia and New Zealand. It is known to have resulted in increase of cawnose ray that consequently impacts the fisheries of shell fishes (R. A. Myers *et al.*, 2007). Diversity of predators such as sharks, tunas and turtles are reported to be highest between 20–30° N and S latitudes, where tropical and temperate species ranges overlap in the south-western Pacific Ocean (Worm *et al.*, 2003). Figure 3.9 shows the pattern of marine and coastal biodiversity and threats on it. It is noteworthy that biodiversity of coastal region is high in Oceania, South East Asia, North East Asia and Indian Ocean. On the other hand, threats on biodiversity is especially high in Oceania, South Asia and Central Indian Ocean.

In South-East Asia Humpbacked whale populations have increased recently in Australian waters (Department of the Environment and Energy, 2016). Another species of major conservation concern in the Asia-Pacific region is the Dugong which are found in tropical and sub-tropical waters of the Indo-Pacific region. Dugong occurs in more than 40 countries but many are developing countries that have limited capacity to contain impacts on dugongs within sustainable levels that lead to population declines and local extinction from a number of areas within their range (Helene Marsh *et al.*, 2011). Approximately 85,000 of the world's dugongs are found in the inshore waters of northern Australia (H Marsh & Lefebvre, 1994) and accounts for at least three quarters of the global population, perhaps more (Helene Marsh, 2002). The International Union for the Conservation of Nature (IUCN) rates their extinction risk as Vulnerable on a global scale based on an inferred or suspected reduction of 30-50 per cent over the last three generations (90 years; Lawler, *et al*., 2002). This classification describes a taxon that faces a moderate risk of extinction in the wild within 50 years (Marsh & Sobtzick, 2015). A regional assessment of the Dugong (Helene Marsh *et al.*, 2011) has concluded that the populations of Indian sub-continent (Andaman and Nicobar Islands) and East African populations fall under 'Endangered' category. Further, according to this assessment, populations of Palau and the Japan (Ryukyus) are said to be 'Critically Endangered' while those of Red Sea, Gulf of Aden, Arabians Gulf, archipelagic East and South East Asia, and Western Pacific Islands are 'Data Deficient'. According to more recent assessment, Dugong population of Australia is 'Near Threatened' (J. Woinarski *et al.*, 2014). Dugongs are vulnerable to two broad classes of threats viz., direct persecution by netting, traditional hunting or large-scale losses of seagrass, and those that decrease the calving rate by reducing feeding opportunities due to habitat degradation and boat traffic (Helene Marsh *et al.*, 2011). Globally dugongs are included in Appendix I of CITES (Helene Marsh & Sobtzick, 2015).

[61] http://www.iobis.org

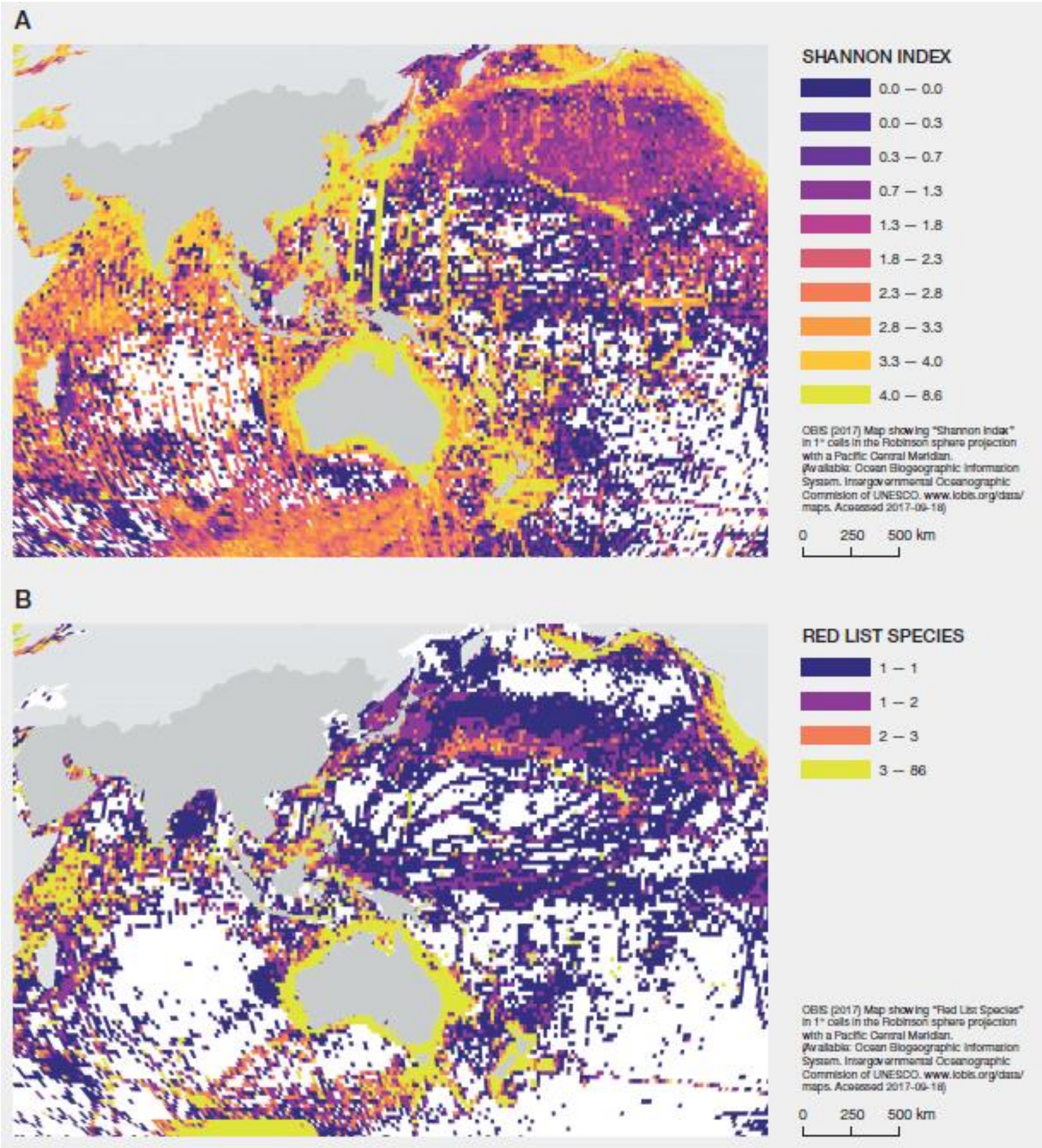

Figure 3.9 Distribution of marine and coastal biodiversity (A: Shannon Index) and threats to it (B: number of Red List species) in the Asia-Pacific region. Source: OBIS (2017d, 2017c)

To date, the Asia-Pacific region has been among the top producers of global fisheries (Funge-Smith *et al.*, 2012; Pauly & Zeller, 2017). However, detailed analyses of fisheries production in the region have shown severe declines in recent decades (Kronen *et al.*, 2010; McManus, 1997; Pauly, 1994; Pauly *et al.*, 2005; Pauly & Zeller, 2017; Russ & Alcala, 1998; Stobutzki *et al.*, 2006; Teh & Sumaila, 2007; R. Watson & Pauly, 2001). Evidence shows that the level of commercial fishing in the Asia-Pacific region has increased leading to steady declines in fish stocks (Anticamara *et al.*, 2011; Bell *et al.*, 2017; R. A. Watson *et al.*, 2013). Local extirpation of a few highly sought after species, such as Groupers (Epinephelinae) (about 20 species at risk of extinction and another 22 species near threatened) and Humphead wrasse (*Cheilinus undulatus*) has already been observed in the region (Chen & Ng, 2009; Sadovy de Mitcheson *et al.*, 2013; Y. Sadovy *et al.*, 2003; Yvonne Sadovy, 2005). Similarly, systematic assessments of fisheries and fish densities in some countries within the region have shown severely depleted status (Anticamara & Go, 2016; Funge-Smith *et al.*, 2012; Go *et al.*, 2015; Teh & Sumaila, 2007).

In addition to overfishing, the Asia-Pacific region has also experienced high levels of habitat degradation from destructive fishing (Bailey & Sumaila, 2015; Pauly *et al.*, 1989), crown-of-thorns starfish (*Acanthaster planci*) population explosions (Hutchings, 1986; Lane, 1996; Moran *et al.*, 1988), super-typhoons (Anticamara & Go, 2017; Gouezo *et al.*, 2015; Reyes *et al.*, 2015), sea-filling of land reclamation (Madin, 2015), pollution (Reopanichkul *et al.*, 2009; Todd *et al.*, 2010), and climate-change related coral bleaching and erosion events (Ainsworth *et al.*, 2016; De'ath *et al.*, 2009; Munday *et al.*, 2008). Based on these continuing threats and trends it is projected that at the current level of extraction, most, if not all, of the exploitable fish stocks in the region could be lost by 2048 (Renton, 2008; R. A. Watson *et al.*, 2013; Worm, 2016; Worm *et al.*, 2006; Worm & Branch, 2012; Zeller *et al.*, 2015). Although, the plausibility of losing commercial fisheries by 2048 is widely debated (Branch, 2008; Hilborn, 2007, 2010), the overall scenario of fisheries in the Asia-Pacific region, especially in the South East Asia and South Asia subregions is bleak due to cumulative effects of (a) illegal, unreported, and unregulated fishery; (b) use of big nets and trawlers, (c) damming of rivers, (d) use of explosives such as dynamites, (e) climate change induced ocean warming and acidification, and (f) coastal pollution .(Saito *et al.*, 2016; Teh *et al.*, 2017; Toba *et al.*, 2016; Yonezaki *et al.*, 2015). It should also be considered that even after management interventions are put in place, recovery of depleted stocks may take a significant period of time. (J. B. C. Jackson *et al.*, 2001; Roberts, 2007) .

Although some progress has been made, there is an urgent need to improve the effectiveness of fisheries management, coastal habitat recovery, and reduction of fishing effort in the Asia-Pacific region, in order to prevent further fisheries decline and the loss of many fisheries stocks. Furthermore, there is a need to conduct systematic and region-wide assessments of fisheries stocks and coastal habitat in the region to aid conservation, management and restoration.

3.2.5 Biocultural diversity

3.2.5.1 General

Biocultural diversity is defined in context here as "the total variety exhibited by the world's natural and cultural systems, explicitly considers the idea that culture and nature are mutually constituting" (Díaz *et al.*, 2015) and incorporates ethno-biodiversity. It captures three elements: i) diversity of life including human cultures and languages; ii) the existing links between biodiversity and cultural diversity; and iii) the coevolution of biodiversity and bio-cultural diversity over time. A global map of bio-cultural diversity (Loh & Harmon, 2014) shows that it is focussed in the tropical areas with a number of hotspots in the Asia-Pacific region, particularly SE Asia. Bio-cultural diversity is assessed globally using the Global Index of Bio-cultural Diversity (Loh & Harmon, 2005).

This assessment of the status and trends of bio-cultural diversity across the Asia-Pacific region tries to assess:

- language diversity, diversity of philosophical, spiritual and/or religious perceptions of biodiversity and nature's contribution to people and the degree to which indigenous and non-indigenous peoples are still culturally and spiritually linked to nature;
- the importance of indigenous local knowledge (ILK) in the region for understanding and contributing or able to contribute to improved management of biodiversity and nature's contribution to people;
- the value of nature to the peoples of the region in the context of exploitation, sustainable and unsustainable use and as some other source of livelihood or basis for human well-being not already considered, and;

- trends in the relationship between cultural and scientific approaches to biodiversity conservation and the connections across different knowledge systems

3.2.5.2 Linguistic diversity

Of the eleven largest language families (Loh & Harmon, 2014), the Asia-Pacific region includes the following language families: Afro-Asiatic, Indo-European, Altaic, Sino-Tibetan, Austro-Asiatic, Austronesian, Trans-New Guinean, and Australian. Using Index of Linguistic Diversity (Harmon & Loh, 2010; Loh & Harmon, 2014) described the status of the languages in each of these language families. The percentages of languages in each of these families that are extinct or critically endangered / endangered respectively, are 11 per cent and 9 per cent in the Afro-Asiatic family, 2 per cent and 2 per cent in the Indo-European family, 0 per cent and 18 per cent in the Altaic family, 0 per cent and 4 per cent in the Sino-Tibetan family, 0 per cent and 11 per cent in the Austro-Asiatic family, 2 per cent and 11 per cent in the Austronesian family, 2 per cent and 22 per cent in the Trans-New Guinean family, and 33 per cent and 59 per cent in the Australian family. Loh & Harmon (2014) concluded that linguistic diversity and biodiversity are equally threatened, both showing about 30 per cent decline since 1970. Within the Asia-Pacific region, declines in linguistic diversity have been catastrophic in the Australian and Trans- New Guinean families, resulting from language shift away from small indigenous languages towards larger, national or regional languages. Loh & Harmon (2014) stated "Australia and the island of New Guinea deserve particularly close attention: Australia because its indigenous languages are the most highly threatened in the world, and New Guinea because it is the most linguistically diverse place on Earth. Most of the 1,000 or so languages of New Guinea are threatened, but their decline is not as rapid as in Australia where more than 90 per cent are threatened with extinction". Linguists predicted that 50–90 per cent of the world's languages will disappear by the end of this century (Gorenflo *et al.*, 2012). Gorenflo *et al.* (2012) also showed that two countries of high biodiversity, Indonesia and Papua New Guinea, account for 70 per cent of all languages in the Asia-Pacific region. This allows parallel strategies to be developed in these subregions targeting conservation of both indigenous languages and biological diversity.

3.2.5.3 Biocultural diversity

In their global biocultural diversity assessment, Loh & Harmon (2005) ranked country level biocultural diversity indices by country area and population size. Based on these assessments, these authors ranked the following countries of the Asia-Pacific region as most vulnerable top 2 countries globally for biocultural diversity are in order of declining diversity: By area - Indonesia, Papua New Guinea, Malaysia, Brunei, India, Philippines, Vietnam, Lao PDR and Solomon Islands and By-population – Papua New Guinea, Indonesia, Brunei, Solomon Islands, Australia, Lao PDR and Malaysia. Biocultural approach to conservation provides a humanistic approach for conservation through appreciation of biocultural diversity and heritage, social-ecological systems theory, and different models of people-centred conservation (Chapter 2). It also provides effective and culturally sensitive conservation outcomes and assists in recognising the impacts of eroding biocultural as well as biological diversity (Berkes, 2007; Garnett *et al.*, 2007; McCarter & Gavin, 2015). The Australian Institute of Aborigines and Torres Strait Islander Studies (AIATSIS) produced a map for the whole of Australia to show the language, cultural, trade boundaries and relationship of these groups (AIATSIS, 1996). Ens *et al.* (2015) showed how indigenous biocultural knowledge has informed research and management of biodiversity, fire, threatened species, invasive species, aquatic ecosystems and climate change. The inclusion of culture is one of the ways to enhance the role of indigenous people, knowledge and land into national conservation priorities. Areas that are bioculturally and biologically rich which are facing exceptional threats would be appropriate to be targeted for conservation (N. Myers *et al.*, 2000) or extremely remote areas such as islands (Chander *et al.*, 2014; Girardi *et al.*, 2015).

Like other parts of South-East Asia, the Hawaiian Islands exhibit immense biocultural significance of native ecosystems and species. The same ecological richness of the Hawaiian ecoregion that create the unique Hawaiian biota shaped indigenous Hawaiian culture into one that formed an intimate, familial relationship with their ecosystems and species. The strong sense of familial reciprocal connection created a sustainable human-nature system that stood for a millennium, independent from the rest of the world, with a remarkably small human ecological footprint[62] (15 per cent of the land area displaced with human infrastructure and agriculture) that provided for 100 per cent of the needs of a thriving Polynesian civilization (Kirch, 2011; Ladefoged *et al.*, 2009). The benefits of nature to native Hawaiian society ran the gamut from food, medicine, shelter, tools for agriculture, and all other trappings of material culture, and extended into intellectual, ethical and spiritual well-being. These contributions of nature to people cannot be adequately expressed in terms of monetary or service economics. They were the basis of a human-nature relationship that is a model for sustainability, and ultimately is needed for humanity's survival in a finite planetary biosphere (Gon, 2014).

3.2.5.4 Indigenous and local knowledge

Aichi target 18 aims to ensure that traditional knowledge (TK), innovations and practices of Indigenous local communities (ILCs) are respected, protected and encouraged. Several indicators, including ILC's tenure right to land, traditional occupations, ILC-based management, and linguistic diversity, were suggested for consideration to measure the target (CBD/COP/DEC/XIII/28). These indicators on ILC, however, could give indirect information of status and trends in ILK. Moreover, these indicators could not be widely applied to global, regional, or national assessments for data deficiency except for the linguistic diversity.

Direct measurement of TK is a challenging task. For example, the VITEK (the Vitality Index of Traditional Environmental Knowledge) directly access the retention or loss of TK along successive generations within a given local community. The VITEK, however, has been applied to limited number of cases. The results of the pilot studies indicated 30 per cent decline between the eldest to the youngest cohorts. Women in the community have been able to retain more TK across generations than men have (UNEP-WCMC, 2016b). VITEK approach is recommended to estimate changes in TK of ILC.

3.2.5.5 Status and trends in biocapacity[63]

Overexploitation and unsustainable use of natural resources for economic benefits are major factors degrading habitats in low-income countries. In the Asia-Pacific region, the per capita ecological footprint in 2008 was 1.6 gha which exceeds the per capita biocapacity by 0.8 gha. In addition, the biocapacity per person in 2008 had decreased to only two thirds of that available in 1961 (WWF & ADB, 2012). The average biocapacity per person will decline as populations grow rapidly in the Asia-Pacific region.

Socio-economic growth at some point does improve the attitude of people and implementation measures towards conservation. However, it also increases demands for natural resources and environment for production. Mongolia entered into market economy with democracy since 1992, and the herds were privatized. The new way of pasturage for cashmere production gradually prevailed in Mongolia, however, it looks to be unsustainable for its impact to vegetation loss and land degradation than that of sheep herd has.

[62] Ecological footprint has a variety of definitions, but is defined by the Global Footprint Network the as "a measure of how much area of biologically productive land and water an individual, population or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices. The ecological footprint indicator used in this report is based on the Global Footprint Network unless otherwise specified.

[63] The definition that follows is for the purpose of this assessment only: "Biocapacity" has a variety of definitions, but is defined by the Global Footprint Network the as "the ecosystems' capacity to produce biological materials used by people and to absorb waste material generated by humans, under current management schemes and extraction technologies". The 'biocapacity' indicator used in this report is based on the Global Footprint Network unless otherwise specified.

Slash-and-burn or swidden agriculture is a traditional farming style in many ethnic communities settled in mountainous area. Under the condition of small population, it has not destroyed local vegetation and has less impact on biodiversity (Oh & Kang, 2013; van Vliet *et al.*, 2012). With population increase and socio-economic development, however, slash-and-burn is gradually replaced by ordinal agriculture. Although the transformation of slash-and-burn into more intensive land uses improve household incomes, it often leads to permanent deforestation, biodiversity loss, increased weed pressure, declines in soil fertility, and accelerated soil erosion (van Vliet *et al.*, 2012).

3.2.5.6 Cultural and scientific approaches

Both cultural and bio-scientific approaches are needed to implement biodiversity conservation. For example, recognition of ILC's contribution and role to conserve nature is very important to resolve the existing scientific and technical gaps for the implementation of Aichi target 11. The target 11 for protected area is 17 per cent for terrestrial and inland waters and 10 per cent for marine areas. Protected area coverage in the Asia-Pacific region has been increased steadily to 13.3 per cent of terrestrial and inland waters and 15.3 per cent marine and coastal areas (IUCN & UNEP-WCMC, 2014). Especially, trends in marine protected area showed sharp increase since 2005, largely due to increases in the South Pacific. It is partly due to the locally managed marine areas (LMMAs) in the South Pacific which shows community-based management based on cultural and bio-scientific approaches.

Various types of Community Conserved Areas (CCAs) are prevalent in the region. Study from South Asia has revealed that the tradition of CCAs, which are managed and guided by traditional knowledge, belief systems and local customary laws, have contributed significantly for conservation and livelihoods promotion (S. Bhatt *et al.*, 2012). Religious beliefs worshiping the sacred lands, animals or trees are very popular and traditional way of nature protection in ethnic people of the Asia-Pacific region. For instance, the 25 ethnic groups settled in Yunnan are worshiping the sacred mountain and sacred tree and they all have the idea of protecting the forest and nature (Oh & Kang, 2013). Sacred natural sites are also distributed throughout the state of Uttarakhand in northern India (Negi, 2010). The value of sacredness in conservation and maintenance of bio-physical diversity in the landscape surrounding Mt. Kailash, and that spans in adjacent areas of three countries -China, India and Nepal, has been recognized for promotion of transboundary cooperation through "Kailash Sacred Landscape Conservation and Development Initiative" (Rawal *et al.*, 2012).

The amount of information within traditional knowledge is also matter of interest. These information, however, are largely unknown to developing or underdeveloped countries. In the Asia-Pacific region, China, India, and New Zealand are the countries to have records of TK of ILC. The Traditional Knowledge Digital Library (Traditional Knowledge Digital Library) database of India is well-known for its exceptional amount of information for preservation of traditional knowledge, prevention of its misappropriation, and creating its linkages with modern science. India, as mandated under the Biological Diversity Act, is also in the process of developing legally accepted documentation of the local knowledge as PBRs (People's Biodiversity Registers), and has registered 1901 PBRs in 14 states (Ministry of Environment and Forests Government of India., 2014).

The Apatani tribe in Arunachal Pradesh, North-East India make a unique case study wherein cultural diversity is a very effective method for protecting both natural resources and the cultural integrity and survival. This ethnic tribe is known for their unique eco-cultural traditions that has strongly influenced the sustainable use of natural resources and livelihood of these ethnic tribes in an otherwise remote, and environmentally fragile landscape in the region. The unique 'Wet-Rice Cultivation' system which combines rice, millet and fish cultivation in the form of 'sedentary agriculture' is a classic example of indigenous knowledge system which is not only highly productive but also energy efficient (Barua & Slowik, 2009).

At the same time, rural forestry as part of their community natural resource management to maintain several natural resource plantations like bamboo forest, pine plantations and mixed broad-leaved forest not only signifies a traditional institutional arrangement but also a value system that has strong socio-cultural interconnections with the landscape in which they are placed.

Recent new discoveries of lesser known taxa (e.g. discovery of Apatani Glory moth and range extension of Bhutan Glory butterfly) clearly signifies the fact that wild biodiversity is also well conserved in landscapes where livelihood systems are sustainable. The Apatani cultural landscape is currently recognized as GIAHS (Globally Important Ingenious Agricultural Heritage Systems) for the conservation of multi-species (including cultivars), complex agroecosystems maintained by traditional societies (Koohafkan & Cruz, 2011; Ramakrishnan, 2004) and is also tentatively listed on the UNESCO World Heritage site list.

Community based natural resource management as found amongst the Apatanis could significantly contribute towards the integration of ‘Traditional Ecological Knowledge’ into biodiversity conservation and this could prove to be a very useful tool in conserving and managing an otherwise environmentally fragile tropical landscape in developing tropics while at the same time focusing on the sustainable livelihoods of these traditional developing societies. Among the various cultural approaches, the village forest managements have been widely accepted throughout the Asia-Pacific region. Japanese term for socio-ecological production in landscapes is Satoyama (Fukamachi *et al.*, 2001; Takeuchi *et al.*, 2003, 2016). The Satoyama Initiative was established in 2009 as a global program to protect traditional landscapes and lifestyles in rural areas. The International Partnership for the Satoyama Intitiative (IPSI), launched in 2010 at the CBD COP10, holds many conferences, events, other activities and collects case studies of work. Box 3.3 provides more information on sacred natural sites which link culture with nature and thereby promote biodiversity conservation.

Box 3.3 Sacred natural sites

Sacred natural sites are the natural areas that receive protection because of religious beliefs or cultural practices of the local communities (Dudley *et al.*, 2010). In the Asia-Pacific region they include freshwater habitats of various types (Gupta *et al.*, 2016; R. P. B. Singh & Rana, 2016), single trees (Caughlin *et al.*, 2012), forest patches of various sizes (Allendorf *et al.*, 2014; L. Hu *et al.*, 2011; Ormsby & Bhagwat, 2010; L. Zeng & Reuse, 2016), or entire landscape, including sacred valleys and mountains (Shen *et al.*, 2015). They occur in most, if not all, countries in the Asia-Pacific region and form part of the culture of numerous different ethnic groups. Well-documented examples include the sacred forest groves in India (Ormsby & Bhagwat, 2010), the Dai holy hills of Xishuangbanna in southwest China (Zeng & Reuse, 2016), the fengshui woods of southern China (L. Hu *et al.*, 2011), the Shinto shrine forests of Japan (Omura 2004; Rots, 2015), and the sacred mountains of Tibet (Shen *et al.*, 2015). It has been estimated that there are >100,000 sacred groves in India (Ormsby & Bhagwat, 2010) and that more than 25 per cent of the Tibetan plateau falls under sacred land (Shen *et al.*, 2015).

Although local people may benefit from resources provided by these sites, such as the availability of medicinal plants, this is not usually the main motivation for their protection and, in most cases, direct exploitation is rather restricted (Ma *et al.*, 2015; Ormsby & Bhagwat, 2010; Shen *et al.*, 2015). As a result, sacred sites often preserve not only plants but also animals that has disappeared from the surrounding landscape (Brandt *et al.*, 2013; Dudley *et al.*, 2010; Gao *et al.*, 2013; Junsongduang *et al.*, 2014; Ormsby & Bhagwat, 2010; Shen *et al.*, 2015). This is particularly the case where sacred forests are the only forest left in a human-dominated landscape (L. Hu *et al.*, 2011; Ormsby & Bhagwat, 2010). Although often assumed to be remnants of earliest continuous forest cover, there is limited evidence for this and at least some sacred groves and fengshui woods were apparently established in deforested areas (Ge *et al.*, 2015).

Sacred natural sites may be the earliest form of habitat protection, but most are not part of formal protected area systems. As a consequence, their continued protection depends on the continuation of local beliefs and local control over their fates (Allendorf *et al.*, 2014; Ormsby & Bhagwat, 2010). Recent threats include loss of customary rights, encroachment by cash crops, demand for timber and other forest resources, social and religious change, generational change, cultural assimilation, immigration, and urbanization (Allendorf *et al.*, 2014; Ormsby & Bhagwat, 2010). Many sacred forests and other sacred sites in the Asia-Pacific region have been lost or badly degraded in recent decades (Ormsby & Bhagwat, 2010; L. Zeng & Reuse, 2016), but others are still respected and protected (Shen *et al.*, 2015; Verschuuren, 2016), suggesting that they will continue to have a role in the future.

Contributor: Richard Corlett

3.2.6 Protected area coverage

Protected area coverage is documented in Protected Planet (www.protectedplanet.net), an online platform maintained by United Nations Environment World Conservation Monitoring Centre (UNEP-WCMC) and IUCN. As shown in Figure 3.10a, 3.10b the Asia-Pacific region as a whole has 14.6 per cent of its area under Protected Area (PA) coverage, with slightly less under terrestrial protected areas (13.3 per cent) than under marine protected areas (15.3 per cent). However, there are noticeable subregional variations in total protected area coverage, terrestrial protected area coverage and marine protected area coverage.

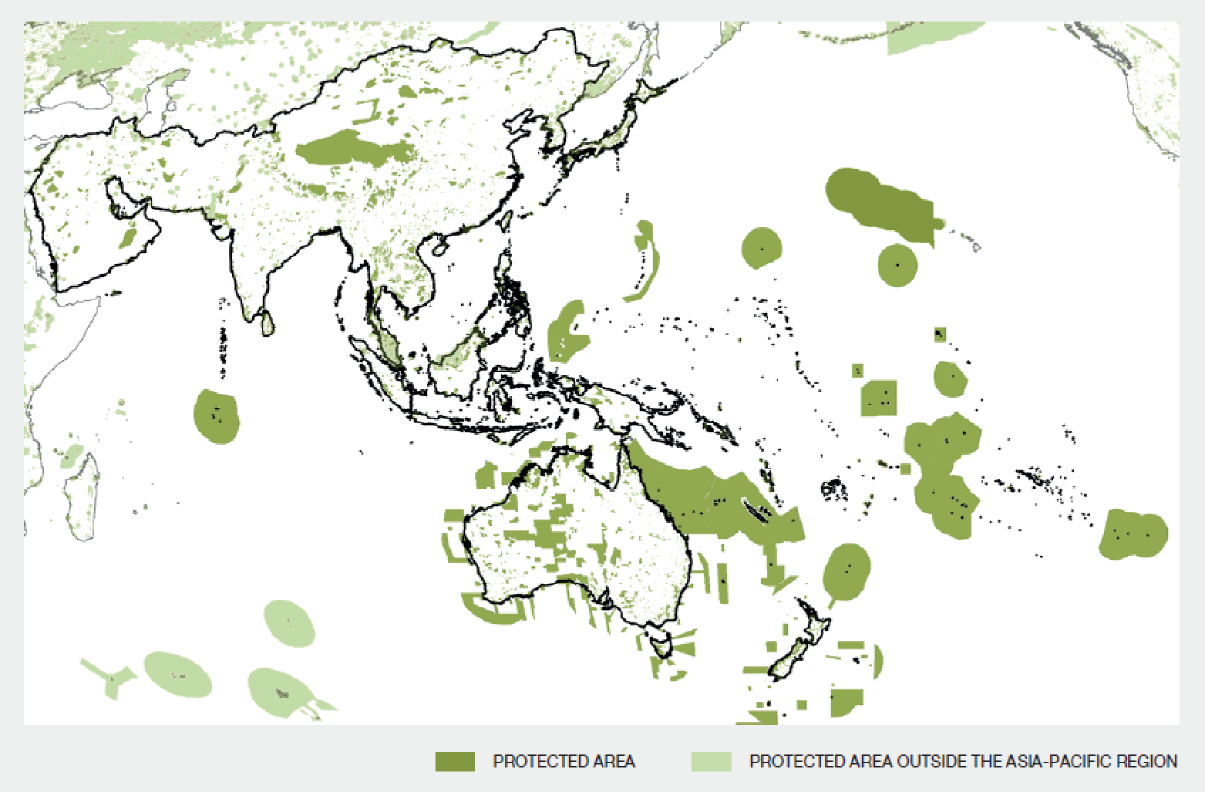

Figure 3.10 A. Protected area coverage in the Asia-Pacific region. Source: UNEP-WCMC & IUCN (2018).

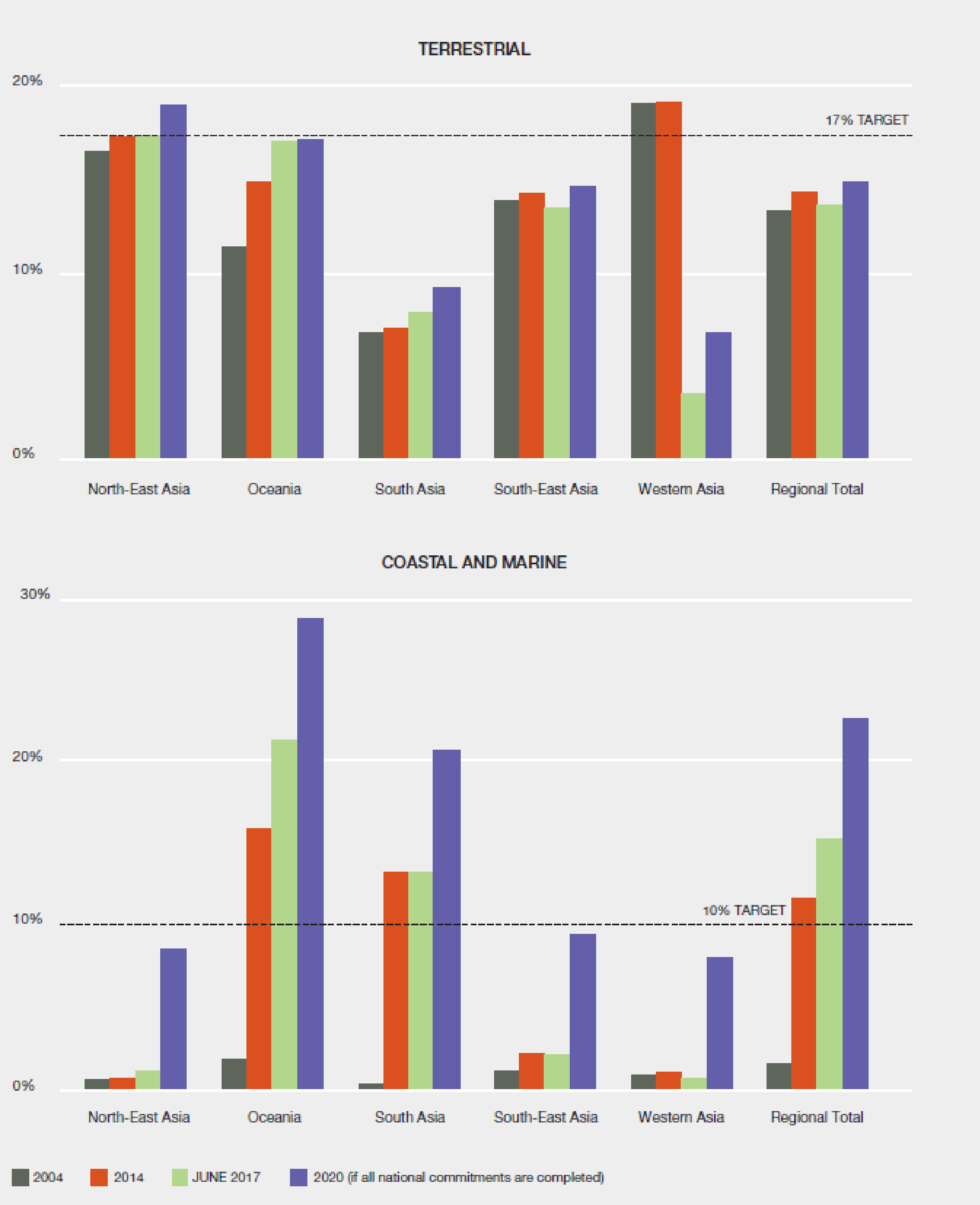

Figure 3.10 B. Proportion (%) of terrestrial and marine protected area coverage in the Asia-Pacific region and subregions.
Note: The large shift in the Western Asia data between 2014 and June 2017 is due to the correction of protected area coverage data in the World Database on Protected Areas. Data source: World Database on Protected Areas in 2004, 2014 and June 2017 (UNEP-WCMC & IUCN, 2017).

Oceania has the greatest protected area coverage in the region with 18 per cent total protected area coverage, followed by 13 per cent in Western Asia, and 11 per cent in North-East Asia. South-East Asia has only 5 per cent of its total area protected (terrestrial and marine areas combined). The protected area systems of North-East Asia and Western Asia are overwhelmingly dominated by terrestrial areas (17 per cent and 18 per cent respectively), while the Oceania and South Asia subregions have greater marine protected area coverage (18 per cent and 13 per cent respectively) than terrestrial protected area coverage. The high marine protected area coverage in South Asia is largely driven by the 640,000 km^2 British Indian Ocean Territory marine protected area (De Santo *et al.*, 2011; Sheppard *et al.*, 2012).

Much of the region's 13 per cent marine protected area coverage can be attributed to the large area dedicated to marine protected areas in Oceania (Australia, New Zealand and other Pacific countries). Once Oceania is excluded, the total marine protected area coverage for Asia is only 4 per cent, although this is a significant increase from the 1.4 per cent cited earlier in the *Asia Protected Planet Report* (Juffe-Bignoli *et al.*, 2014). As for wetlands registered as Ramsar sites (https://rsis.ramsar.org/), 319 and 80 sites are located in Asia and Oceania, respectively, contributing to sustainable management of wetlands, although its effectiveness is often lower in urban wetlands (Hettiarachchi *et al.*, 2015).

3.2.6.1 Regional and subregional trends

While absolute protected area coverage provides important context, protected area coverage of Key Biodiversity Areas (KBAs) are more appropriate indicators for safeguarding nature (BirdLife International, 2017b; Butchart *et al.*, 2012). These are globally important sites that are large enough or sufficiently interconnected to support viable populations of the species for which they are important (Bibby, 1998). KBAs include Important Bird and Biodiversity Areas (IBAs) identified by BirdLife International using data on birds, and Alliance for Zero Extinction (AZE) sites holding the last remaining population of one or more Critically Endangered or Endangered species (Ricketts *et al.*, 2005), among other important sites identified for different taxonomic, ecological and thematic subsets of biodiversity. Since the 1980s, the Asia-Pacific region has seen a rapid increase in the proportion of Alliance for Zero Extinction (AZE) sites under protection. The region has also experienced a steady - but less marked increase - in the proportion of Important Bird Areas (IBA) under protected area coverage. Approximately 25 per cent of AZE sites are completely covered by protected areas region-wide, as opposed to 18 per cent in the case of IBAs (Figure 3.11). This makes an interesting comparison to the global pattern, in which 28 per cent of IBAs are completely covered by protected areas, compared to only 22 per cent of AZE sites (Butchart *et al.*, 2012); it may be driven by the low protected area coverage of IBAs in South, South-East, and Western Asia.

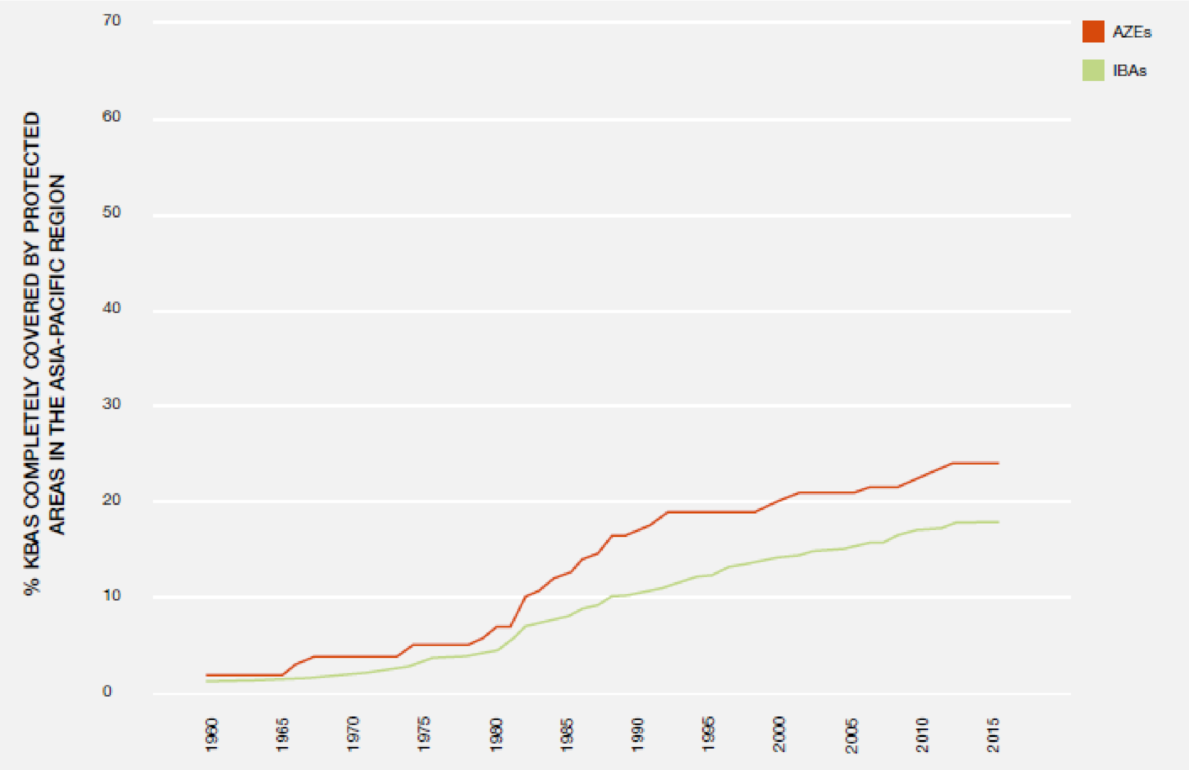

Figure 3.11 Growth in the proportion of Key Biodiversity Areas completely covered by protected areas in the Asia-Pacifi c region..
Data for two types of key biodiversity areas (KBAs) are shown here: Alliance for Zero Extinctions sites (AZEs) and Important Bird and Biodiversity Areas (IBAs). Data source: UNEP-WCMC & IUCN (2015) and World Database on Key Biodiversity Areas (www.keybiodiversityareas.org).

Taking a closer look at the protected area coverage of IBAs at the subregional level, it is apparent that North-East Asia and Oceania have a substantially higher proportion of their IBAs under protection (>25 per cent) than the other three subregions (10-12 per cent) (Figure 3.12). The growth pattern over time is also different among the subregions. Oceania experienced particularly rapid growth over the last decade, with its IBAs under protected area coverage rising from 16 per cent in 2000 to 27 per cent in 2015. In contrast, the most rapid growth in the coverage of IBAs in North-East Asia started in the 1980s, with 12 per cent of the subregion's IBAs being added to the protected area estate between 1981-1990. However, this growth levelled off in the 1990s, with only 4 per cent of the subregion's IBAs gaining protected area coverage between 1991-2000, and fewer than 3 per cent between 2001-2015. In Western Asia, the peak growth period occurred during the 1990s, with a particularly significant expansion occurring in the space of just two years (1994-1996), when coverage rose from 3 per cent to 9 per cent. The other regions (South Asia and South-East Asia) have maintained a modest but steady expansion over time, but have not experienced much growth in the last decade.

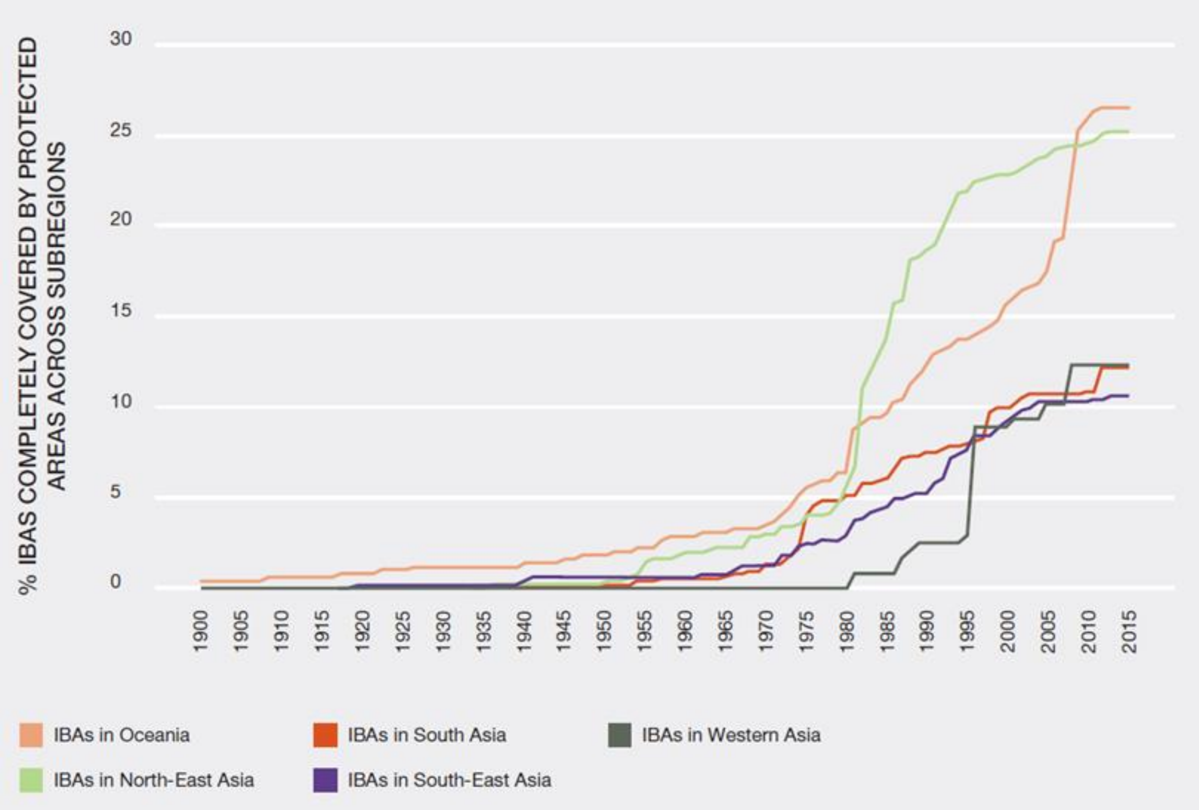

Figure 3.12 Growth in the proportion of Important Bird and Biodiversity Areas (IBAs) completely covered by protected areas in the Asia-Pacific subregions. Data source: UNEP-WCMC & IUCN (2015) and World Database on Key Biodiversity Areas (www.keybiodiversityareas.org).

Similar variations among subregions are also observed in the protected area coverage of AZEs (Figure 3.13), with North-East Asia (37 per cent) having more than double of the percentage of AZEs under protection than South-East Asia (15 per cent). Notably, the peak growth in North-East Asia occurred between 1980 and 1993, similar to the protected area coverage of IBA in this subregion. This growth may be in part contributed by the growth in protected area coverage during the same period in China, because the main objective for protected area establishment is the conservation of threatened species and natural ecosystems (Wu *et al.*, 2011; Zong *et al.*, 2007).

In summary, although there has been a significant increase in the coverage of IBAs and AZEs over the last several decades, the overall proportion of KBAs completely covered by protected areas in the Asia-Pacific region remains alarmingly low (25 per cent or less). This suggests that the region is not on track to protect areas of particular importance for biodiversity, as called for under Aichi Target 11.

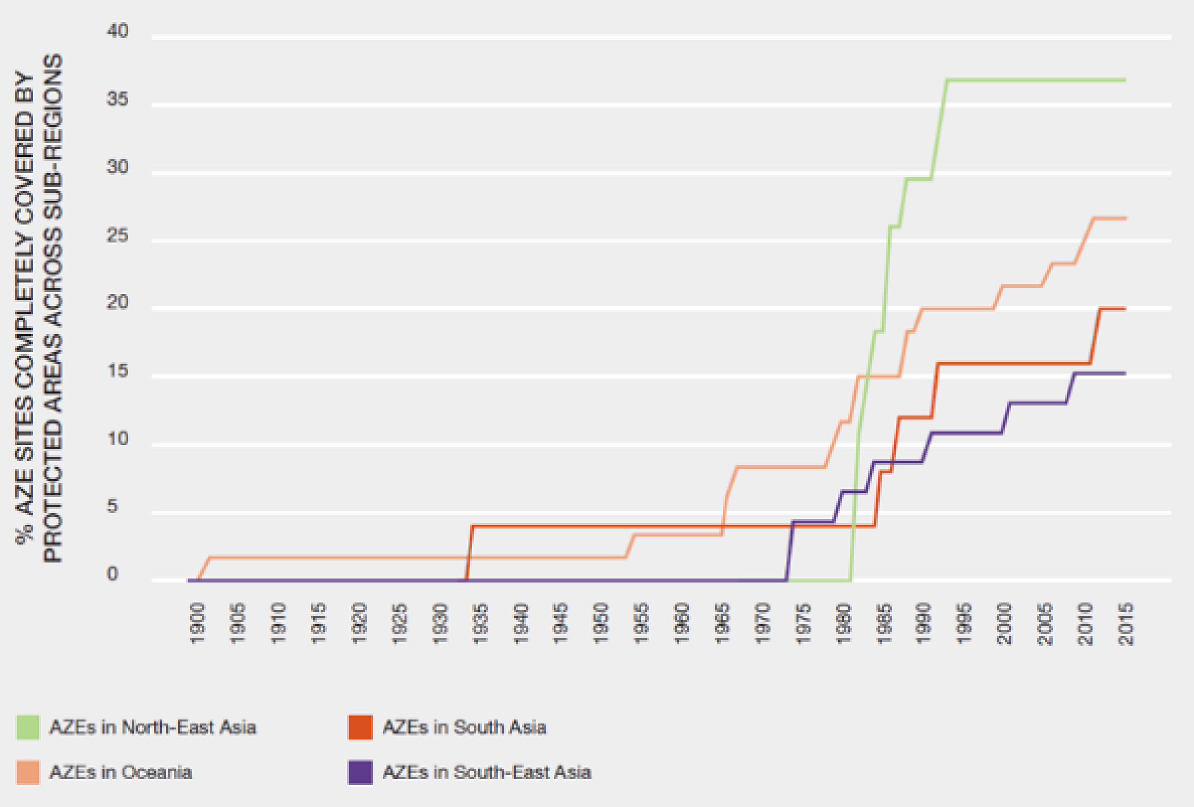

Figure 3.13 Growth in the proportion of Alliance for Zero Extinction (AZE) sites completely covered by protected areas in the Asia-Pacific subregions. Source: UNEP-WCMC & IUCN (2015) and World Database on Key Biodiversity Areas (www.keybiodiversityareas.org).

3.2.6.2 Species extinction risks

The IUCN Red List of Threatened Species (www.iucnredlist.org) documents species extinction risk. Overall, a very high proportion of the species found in the Asia-Pacific region is endemic, so the best estimate of extinction risk prevalence for endemics (25 per cent threatened) is only slightly higher than that for all species (21 per cent threatened) (Figure 3.14); these estimates assume that Data Deficient species (16 per cent of occurring species, and 19 per cent of endemic species) are threatened in the same proportion as non- Data Deficient species. The extinction risk for species occurring in the subregions is relatively similar (16-19 per cent threatened), except for Western Asia (11 per cent threatened). The extinction risk for species occurring in the Asia-Pacific region ranges from 18 per cent (if no DD species are threatened) to 34 per cent (if all DD species are threatened), and between 20 per cent to 39 per cent for endemic species.

Among endemics, the highest extinction risk is found in South Asia (best estimate of 46 per cent threatened) and North-East Asia (36 per cent threatened). However, the extinction risk for endemic species at the subregional level could be as high as 49 per cent threatened (South-East Asia) and 59 per cent threatened (South Asia and North-East Asia), if all endemic DD species are threatened. The lowest extinction risk occurs in Oceania and Western Asia (22 and 23 per cent threatened respectively), even though Oceania has the largest numbers of species actually extinct (73 extinct species in Oceania out of 106 extinct species for the region as a whole).

South-East Asia has the largest number of threatened species (1,182, including CR, EN and VU), and threatened endemic species (748). This is the result of high biodiversity (number of species occurring and assessed, 7,409), high endemism (3,069) and the highest extinction risk in the Asia-Pacific region (nearly 19 per cent threatened). The number of threatened species in South-East Asia is double that in South Asia and six times the figure for Western Asia. Similarly, the absolute number of threatened endemic species in South-East Asia is more than double that of South Asia, even though the latter has the highest percentage extinction risk for endemic species in the Asia-Pacific region. The extinction risk in South Asia is much more prevalent for endemic species (46 per cent threatened, compared to the overall risk for all species of 17 per cent threatened).

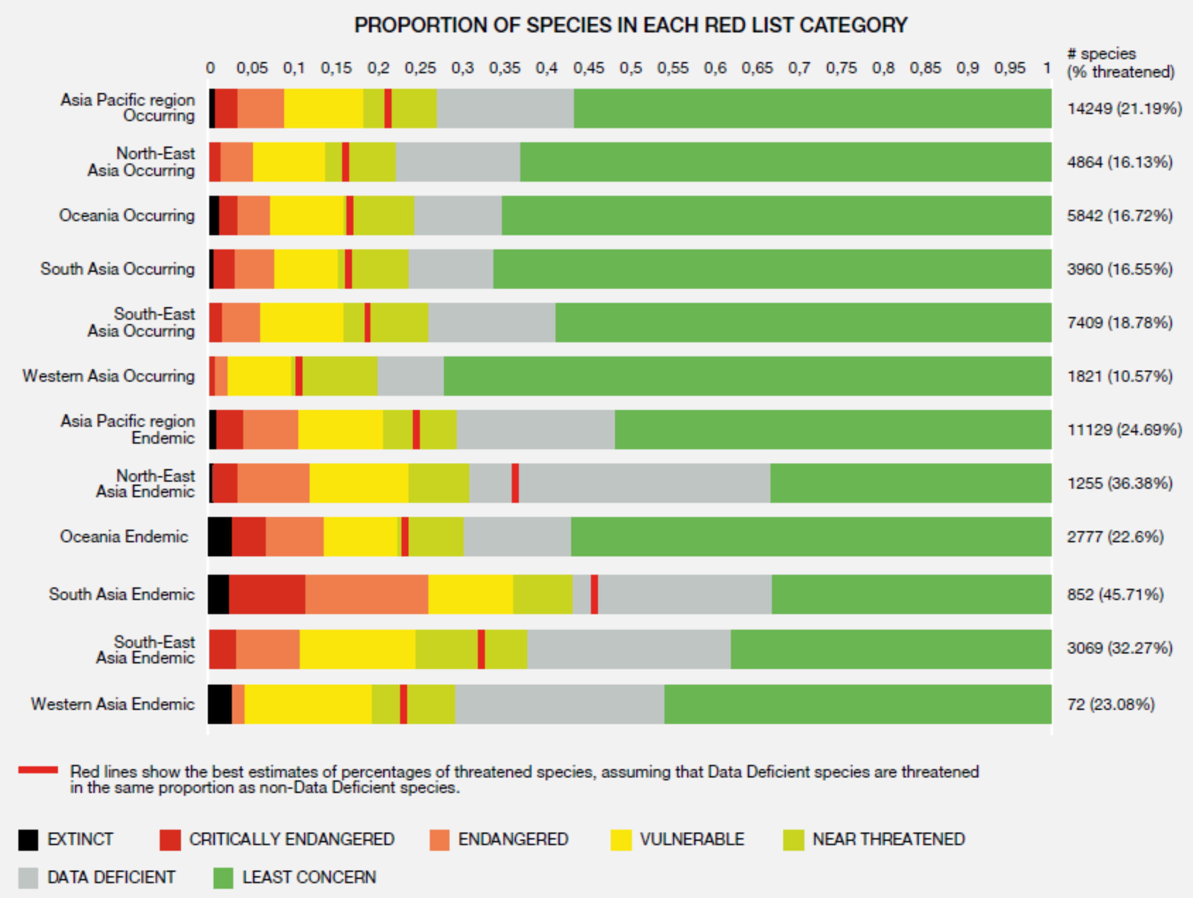

Figure 3.14 Overall extinction risk of species in the Asia-Pacific region. Source: IUCN Red List of Threatened Species (2017).

Figure 3.15 looks at Red List Indices, based on repeated assessments of extinction risk of all mammals, birds, amphibians, corals and cycads, weighted by species occurrence in the different subregions (Rodrigues *et al.*, 2014). The position on the y-axis indicates the aggregate extinction risk facing species in the region overall, while the slope represents how rapidly this extinction risk is changing. The Red List Indices show similar rates of decline across each of the subregions, with the fastest decline observed in South-East Asia, possibly driven by the recent conversion of the Sundaic lowlands to oil palm (Sodhi *et al.*, 2009).

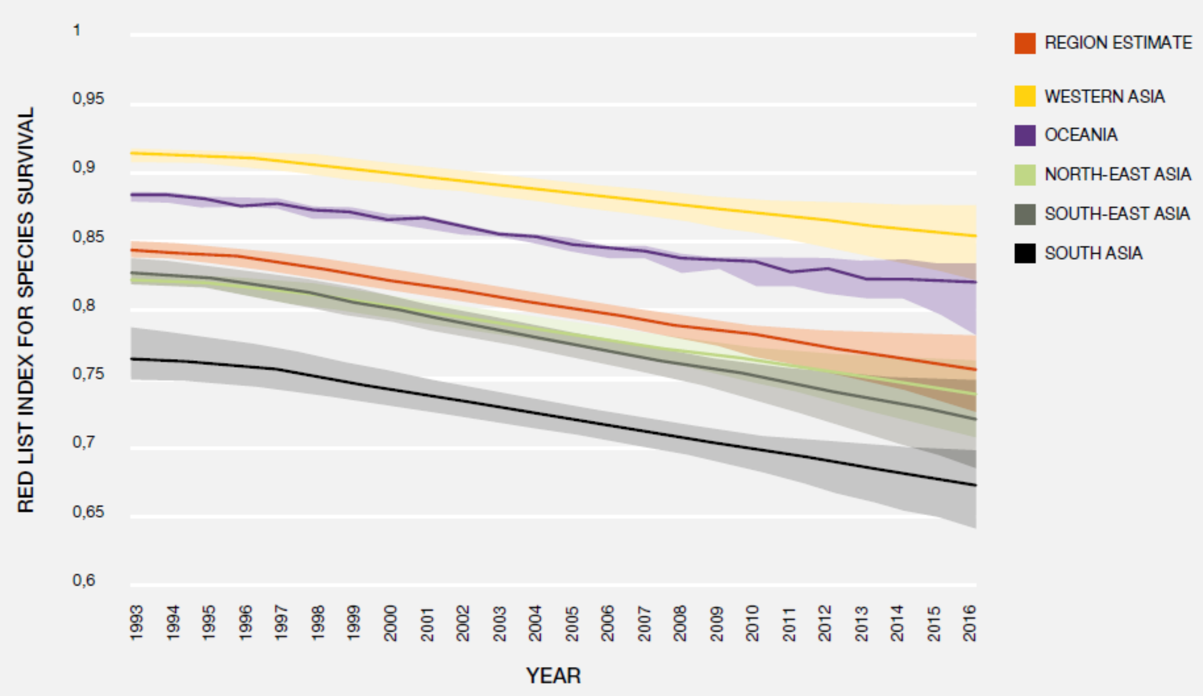

Figure 3.15 Red List Indices of species survival in the Asia-Pacific region, weighted by the fraction of each species' distribution occurring within each region/subregion in the Asia-Pacific region. Data from the IUCN Red List of Threatened Species (2017).

The foregoing analysis reveals that the Aichi Target 11 is achieved for coastal and marine areas in the Asia-Pacific region, but not for terrestrial and inland water. Other targets viz., Aichi Target 12 (by 2020, the extinction of known threatened species has been prevented); Aichi Target 14 (by 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained) and Aichi Target 15 (by 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable) have not been analysed comprehensively.

Because species differs in evolutionary history, there is increasing awareness for the importance of protecting "phylogenetic diversity" (Faith, 1992) and "Evolutionarily Distinct and Globally Endangered (EDGE)" species (Isaac *et al.*, 2007; Jetz *et al.*, 2014). Chapter 2 assessed the imperilled PD of the Asia-Pacific region as a portion of the estimated global imperilled PD for multiple taxonomic groups (cycads, amphibians, corals, mammals, birds and squamates). Over these major taxonomic groups, the estimated global per cent of phylogenetic diversity that is imperilled varies from less than 10 per cent (squamates) to more than 60 per cent (cycads) and for these six taxonomic groups, the fraction of global imperilled PD represented by species in the Asia-Pacific region is approximately 38 per cent (Chapter 2, Table 2.2). Pollock *et al.* (2017) calculated global and regional priorities for expanding protected areas to benefit the bird and mammal phylogenetic diversity. Among the four IPBES regions, the Asia-Pacific region has the greatest number of high priority areas for protection of mammal and bird PD (closely followed by the Americas). Mouillot *et al.* (2016) assessed current global protection of fish and corals phylogenetic diversity to be poor, and identified hotspot areas with the potential for conservation of poorly conserved PD for these taxonomic groups. These priority places span the global marine realm, but the Asia-Pacific region is significant in that nearly every 5 degree by 5 degree marine grid cell in this region offers opportunity for improving the conservation of both fish and coral PD.

3.2.6.3 Protected area management effectiveness

Protected Areas have been known to effectively aid in *in-situ* conservation of wild biodiversity through their management and conservation practices. Independent studies indicate that parks are an effective means to protect tropical biodiversity with majority of parks being successful at stopping land clearing, and to a lesser degree effective at mitigating logging, hunting, fire, and grazing (Bruner *et al.*, 2001). Because park effectiveness was associated with activities of guards, logging and clearing deterrent, demarcation of park border, and direct compensation to local communities, park's ability to protect tropical biodiversity is expected to increase with even modest increases in funding (Bruner *et al.*, 2001). Thus, the Management Effectiveness evaluation (MEE) can be employed as a tool to assess how well a protected area is being managed has evolved to meet the goals of protected area management as per IUCN- WCPA Guidelines and also aiding policymakers and practitioners (Leverington *et al.*, 2008). The main objectives of the MEE are for accountability by auditing (including reporting to Parliament) to improve management (adaptive management) for prioritization and resource allocation. The WCPA Framework assumes that good Protected Area management follows a process with six distinct phases or elements:

i. It begins with understanding the context of existing values and threats,
ii. Progress through planning and,
iii. Allocation of resources (inputs) and ,
iv. As a result of management actions (processes),
v. Eventually produces products and services (outputs),
vi. That result in impacts or outcomes.

India has more than 4.8 per cent of its total geographical area under the Protected Area network and has successfully adopted the MEE framework to come up with a systematic evaluation of the country's Protected Areas (Mathur *et al.,* 2011). The MEE-India assessment methodology is based on the IUCNWCPA Framework which is done at three levels: national, state and site level. It uses all the six Framework elements, each with a set of indicators . All criteria are scored on a four point scale with a numeric value (Very Good: 10; Good: 7.5; Fair: 5; Poor: 2.5) and subtotals for each element calculated. An overall management effectiveness score (in percentage) is assigned to each site and state with the results presented graphically. Expert committees comprising wildlife experts and scientists carry out the assessment to review management in each region of India and at the national level; the ultimate aim is to apply the management effectiveness evaluation framework on a regional basis. Some 10 per cent of the geographical area under Protected Area in the region has been randomly selected for review annually.

So far the MEE-India cycle has been successfully undertaken for Country's 40 Tiger Reserves (PA category accorded with highest protection as per law) and other National Parks and Wildlife Sanctuaries. These reports are available in a periodic manner with results available for the period 2005-06 and 2010-11 and 2014-15. The fourth cycle of MEE is currently ongoing.

3.3 Future trends in biodiversity and nature's contribution to people

Within the Asia-Pacific region, continued human population growth, increase in per capita consumption, conversion of natural ecosystems into intensive farming and crop monocultures, distortion of traditional agricultural systems, expansion of urban and industrial areas, overexploitation of wild plants and animals, pollution, and climate change will continue to adversely affect major ecosystems in the coming decades. Sensitive species and ecosystems will become increasingly confined to areas protected by law, by local communities, or by remoteness. Outside these areas, arable cropping has been extended to sites which were not entirely suitable for it, resulting in widespread soil degradation and erosion.

Future of biodiversity and nature's contribution to people in the Asia-Pacific region will depend on both inertia in the direct and indirect drivers and our proactive efforts for changing those drivers towards conservation and sustainable use of biodiversity. Therefore, to project future of biodiversity in the Asia-Pacific region, we need to consider both trends in drivers and possible options for conservation and sustainable use. One measure of biodiversity conservation status relates to the performance of Asia-Pacific countries to their Aichi target commitments, particularly Aichi target 11 for protected areas. Few countries in the Asia-Pacific region have had their performance assessed. According to the assessment of Australia's National Reserve System in 2011 (Taylor *et al.*, 2011) and 2016 (Taylor, 2017), Australia is less than halfway to achieving the target; only 36 of 85 Australian bioregions have reached the 2020 commitment of 17 per cent of total area protected and 1,691 Australian ecosystems and 121 species of national significance lack representation in the protected areas. This is in a back drop where 7 per cent of native plant species are rare endangered or vulnerable and the numbers of animals species per year being categorised as critically endangered has doubled over the last 10 years (Department of the Environment and Energy, n.d., 2016).

While detailed assessments on drivers are reported in Chapter 4, here we summarize future trends and possible impacts of key drivers on status and trends of biodiversity and nature's contribution to people in future.

3.3.1 Expected trends in forest cover

Rapid loss of tropical lowland forests is one of the most serious threats to biodiversity and nature's contribution to people in the Asia-Pacific region. This loss is most rapid in Indonesia (-0.68 M ha/yr) and Myanmar (-0.54 M ha/yr). However, forest cover is increasing in some tropical countries including Philippines and Vietnam. Imai *et al*. (2018) analyzed drivers contributing to the changes (losses and gains) of forest cover in SE Asian countries and found that major changes in forest cover took place between 1980s and 2000s. In 1980s, food and wood productions were considered major drivers of forest loss, but during 2000s food production had no significant effect on forest loss while wood production remains to be a major driver of forest loss. This was due to increase of investments to agricultural sector that improved productivity of good farms and decreased interests in expanding less productive farms. It was found that road density had significant negative impact on forest cover from 1990s to 2000s, suggesting that it led to rapid increase in logging and land use changes. However, increase in human population density during this period had no significant impact on overall forest cover which could be due to concentration of human populations in cities and increase of forest cover in rural areas. These findings agree with the forest transition hypothesis that predicts a national-scale shift from a shrinking to an expanding stage of forest area (Mather, 1992; Meyfroidt & Lambin, 2011), and a more general idea known as Environmental Kuznets Curve hypothesis (Figure 3.16) postulating that environmental pressure increases up to a certain level as income or GDP goes up but decreases after that (Dinda, 2004). Of course, this trajectory is not guaranteed uniformly across the Asia-Pacific region and forest loss may continue if we fail to control drivers promoting forest loss.

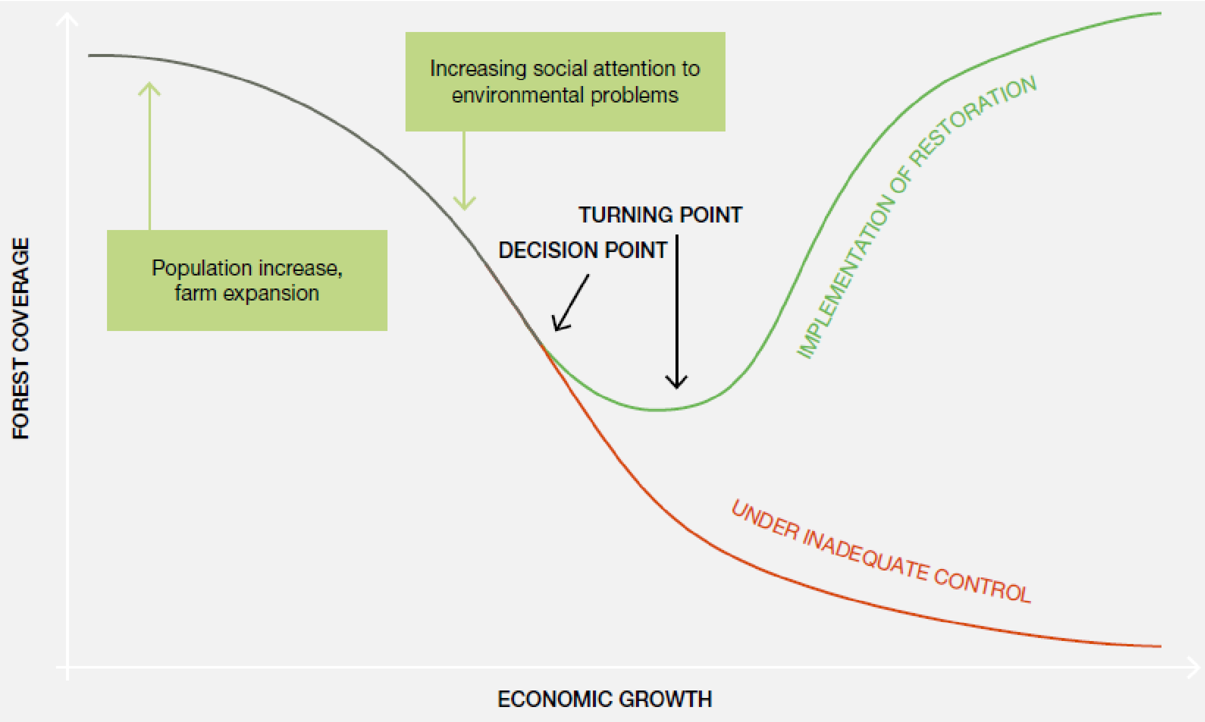

Figure 3.16 A scheme of forest transition under some key drivers. Based on Meyfroidt & Lambin (2011).

While the forest transition hypothesis and the Environmental Kuznets Curve hypothesis assume changes of drivers with a national-scale economic growth, our society is now tightly linked in a global market and international trades are imposing increasing levels of environmental pressure from one country to others. Thus, forest transition may not occur if incentives for land use change would continue under increasing demands of international trades. This may be the case of the expansion of oil palm plantation in SE Asia. There is an increasing demand for palm oil in a global market and hence tropical forests may continue to be converted to oil palm plantations. This expansion of the oil palm plantations is a major threat to not only terrestrial (Abood *et al.*, 2015; Edwards *et al.*, 2014) but also freshwater biodiversity (Konopik *et al.*, 2015).

Demand for timber in developed countries is another driver affecting land use change in tropical lowlands. Nishijima *et al.* (2016) examined the effects of timber extraction on bird extinction risks and showed that a few Asian countries including China, Japan and Korea are imposing dominant effects as large wood importers on the forests of Indonesia that is suffering large risks of species extinction as a major wood exporter. Future dynamics of tropical lowland forests in SE Asia will be affected by changing demands of such goods as palm oil and wood that provide strong incentives for land use change. Policy options for improving forest managements under those demands have been assessed in Chapter 6.

3.3.2 Land degradation and habitat loss

With increasing demands of infrastructure development, agricultural expansion and increased per capita consumption, it is projected that rate of land degradation in much of the Asia-Pacific region will increase in coming decades. Habitat fragmentation and loss in most of the ecosystems has taken the toll of a number of species. For example, a large number of obligate mammalian herbivores such as Eld's deer (*Cervus eldi eldi*), swamp deer (*Cervus duvauceli*), hog deer (*Cervus porcinus*), and a number of avifauna including threatened Great Indian Bustard (*Ardeotis nigriceps*), Lesser Florican (*Sypheotides indica*), Siberian crane (*Grus leucogeranus*) have declined at an alarming rate due to habitat degradation and loss (Dutta *et al.*, 2011, 2013).

Saving terrestrial fauna especially big mammals and other fauna such as Asian elephants, gaur, Sumatran rhinoceros, tiger, Orangutan, proboscis monkey, and hornbills that require large roaming areas can be achieved by protection as well as connecting large tracts of forests with wildlife corridors and through rehabilitation projects. Same goes for other wildlife species in other parts of the Asia-Pacific region. Conservation of long distance migratory species such as Siberian crane, Amur falcon, sea turtles, whales, dugongs and a number of water birds would require regional cooperation and enabling policies on part of all the countries in the region (Somveille *et al.*, 2013). Vegetation types are also estimated as declining in quality, the major causes being habitat fragmentation leading to unsustainable species populations (so called extinction debt). At least 22 per cent of major vegetation communities in Australia have >50 per cent of their remaining extent in fragments <1000 ha. Four communities have >25 per cent per cent of their remaining distribution in fragments <10 ha a proportion increases with each assessment for all coommunities (Department of the Environment and Energy, 2016).

Poor understanding due to data deficiency in certain cases, such as savannahs ecosystems, and conflicting policy environment (e.g. transhumance to sedentary pastoral practices in high altitude grazing lands) has contributed for increased vulnerability of these ecosystems to land-use changes thereby threatening biodiversity.

3.3.3 Pollution and excessive use of water

Freshwater biodiversity and nature's contribution to people are suffering disproportionately large risks under various pressures associated with economic developments including excessive use of water for industries, dam construction, and heavy use of fertilizers in agricultural fields in and around wetlands leading to rapid eutrophication. While water quality once much polluted has improved in some countries, following the trajectory suggested by the Environmental Kuznets Curve hypothesis (Dinda, 2004), losses of biodiversity by dam construction and wetland development are almost irreversible. In the Mekong basin, for example, many dams are being planned to construct and a model-based analysis projects show that dam construction will cause significant loss of fish diversity (Kano *et al.*, 2016) that will be irreversible. Governmental and inter-governmental efforts for avoiding such irreversible loss of biodiversity are highly desirable conforming with Aichi Biodiversity Targets 10 and 11.

3.3.4 Climate change and future of biodiversity and nature's contribution to people

Projected impacts of climate change on biodiversity and nature's contribution to people vary considerably across the Asia-Pacific region. IPCC (2014) predicts that certain ecosystems are likely to be affected more severely in coming decades due to climate change compared to others, e.g., alpine ecosystems, peatlands, coral reefs and mangroves. Rise in atmospheric temperature and increased length of dry season has several implications for the Asia-Pacific region including more forest fires, forest die back due to eruption of insect pests and fungal pathogens, other vector borne diseases, shrubbification of alpine habitats, reduced soil moisture and productivity and increase in IAS. Both climate change and increased frequency of extreme weather events could affect populations of restricted range species in terms of vigor, population size and viability, especially in case of reptiles and amphibians (Bickford *et al.*, 2010). Increased rate of glacial recession in the Greater Himalaya and Central Asia, degradation of permafrost will affect mountain hydrology and water discharge in much of the Hindu Kush Himalayan region and downstream areas. Increased hazards due to glacial lake outburst floods have been projected in some parts of the Hindu Kush Himalayas. This will have direct implications for alpine biodiversity elements, especially the endemics. Studies in parts of the Himalaya have predicted considerable loss of endemic plant species habitats. Also, trends of expansion of shrub lands at the cost of alpine meadows are evident both in Himalayan and Tibetan plateau. However, at the regional level there are inconsistencies and varying responses. This calls for standard and harmonized monitoring programme at regional scales and also long term ecological studies covering different eco-regions in the Asia-Pacific region (R. B. Harris, 2010).

Growing evidence from multiple pilot sites in Himalaya and Tibetan plateau has suggested that species are responding to increasing temperature with trends of range extension towards higher altitudes. While considering models of biome level shifts in Indian sub-continent, study reveals that tropical and sub-tropical grasslands, savannahs and shrublands are specifically vulnerable to shifts and predicting considerably large potential reduction in their size. A few studies have demonstrated that several species will shift their distributional range towards higher altitudes or latitudes due to global warming. Such shifts are already evident in case of certain coral species in Western Pacific and East China Sea, range extension of a predatory fish one of the s in the sea of eastern China and Western Pacific ocean, and of a few predatory fishes and sardines in the region (Hiroya Yamano *et al.*, 2011; Yara *et al.*, 2012). Wetzel *et al.* (2013) have projected that 15-62 per cent of islands in the Asia-Pacific region are likely to be totally inundated and up to 24 per cent will reduce to half or over one tenth of their present size in the event of 1-6 m rise in sea level. Further, these authors predict that species (especially listed under IUCN threat categories) in Pacific islands are much more (2-3 times) vulnerable as compared to those of Australasian and Indo-Malayan region and that rise in sea level due to global warming will increase the vulnerability of most islands in the Asia-Pacific region.

Cumulative effects of climate change and population growth are likely to threaten the food security in the Asia-Pacific region in the future. Increased temperature could reduce production of staple crops such as wheat (Nelson *et al.*, 2009). Agroforestry (AF) is considered important in the quest for a low-carbon future, and for designing a future society living in harmony with nature. Studies have indicated that many native plants along with monospecific crop fields are more environment friendly (Guillerme *et al.*, 2011). A few countries have adopted the policies on agroforestry (e.g., National Agroforestry Policy of India, 2014) as an adaptation strategy that links forestry, agriculture, environment and commerce (Mohan Kumar *et al.*, 2012).

3.3.5 Invasive alien species

Invasive alien species (IAS) are serious threats to biodiversity, the economy and human health. Invasive mosquito disease vectors, aggressive ants and venomous marine species such as jelly fish can have high impacts of human health (Nentwig *et al.*, 2016). A recent paper in *Nature* highlighted that the rate of exotic species establishment globally is increasing each year and does not appear to be slowing down (Seebens *et al.*, 2017). Increasing risks of invasive alien animals are also associated with increasing risks of emerging diseases.

Annual impacts of IAS in South-East Asia are estimated at a cost of $33.5 billion to the environment, human health, and agricultural production, among which the impacts of weeds, insects and pathogens are the highest, imposing a loss of $21.6 billion (Nghiem *et al.*, 2013). The number of IAS causing impacts in China agro-ecosystems has been growing at about 3 species a year since 1900, with a faster rate of increase in the last 15 years (Wan *et al.*, 2017a, 2017b). There are currently 618 IAS in China (45 per cent plants, 21 per cent insects, 8.3 per cent fish and range of other animals, fungi and microbes), 60 per cent in farmlands, 27 per cent in north western deserts and grasslands, 16 per cent in aquatic ecosystems (12 spp. of invasive fish and 6 weeds in inland waterways), 14 per cent in forests and at least 8 per cent in nature reserves (Wan *et al.*, 2017a, 2017b). Most were unintentionally introduced except for invasive plants. Urbanisation has promoted spread and human movement of native fish is also causing biodiversity decline. IAS are considered as one key biological threats to China's social development and ecological security. There are economic (US$17 B p.a.), social (impacts on economic viability in poor farming areas) environmental (biodiversity through degradation in multiple ecosystems) and human health impacts (plant and ant sting allergies affecting 14.5M people) (Wan *et al.*, 2017a, 2017b). IAS abundance is highest at lower altitudes and in the sub-tropical south-east and coastal regions and lowest in the north-west of the country. Eighty IAS species are actively monitored and a few key agricultural pests actively contained.

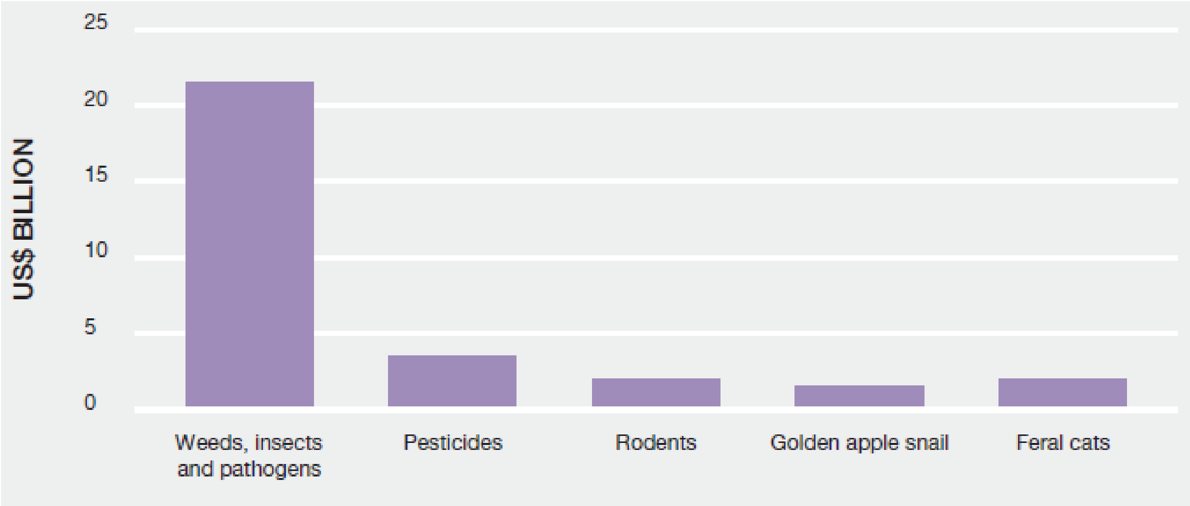

Fig. 3.17 Economic costs of invasive alien species in South-East Asia (estimated mean annual losses). Adapted from Nghiem *et al.* (2013).

Australia has the highest number of woody invaders (D. M. Richardson & Rejmánek, 2011) and invasive vertebrate IAS globally. The highest proportion of exotic flora in the region exists on oceanic islands and island states like New Zealand, but even in Australia 15 per cent of its recognised flora are now exotic (Department of the Environment and Energy, 2016). Australia, which has strong IAS import prevention legislation and regulation however, is showing no evidence that rates of naturalisation of exotic species are increasing (Caley *et al.*, 2016; Department of the Environment and Energy, 2016; Dodd *et al.*, 2015). Beyond such simple global trends and breakdowns for some specific groups there are few sources on information on biogeographic details on invasive species trends across the Asia-Pacific region. Where there are trends are in recognition of the negative impacts of IAS across the region as evidenced by growing international targets (e.g. CBD Aichi target 9) and national strategies for addressing these targets and starting to manage invasion progression and impacts across the region. An example of where more details do exist on status and trends of IAS is from the most recent Australian State of the Environment report (Department of the Environment and Energy, 2016), where such reports have been done roughly every five years since 1999.

IAS have been identified as a key threat to biodiversity generally and to threatened species in particular in Australian terrestrial and aquatic ecosystems, which are having very high impacts that are getting worse (Department of the Environment and Energy, 2016) . Specifically diseases, invasive animals and plants are all having high impacts and getting worse. Extensive grazing from exotic livestock (managed exotic species impacts) for agricultural production in Australia is also now a driver of biodiversity loss in plants and small mammals and ground active birds where grazing has been implicated in a few species extinctions. Where grazing has been removed such populations show a rapid increase (Department of the Environment and Energy, 2016) . The state and trends of IAS generally were considered poor to very poor with a deteriorating trend. Also the impact of IAS is the most frequently cited cause of listed species decline in Australia. All countries have insufficient data to assess the abundance and trends of most invasive animals although in countries like Australia which have reasonable data, distributions and abundances appear to be increasing. In marine environments quantitative information on trends is the most lacking, even though lists of assessed IAS get longer. Marine IAS impacts and trends therefore are highly uncertain except in a few individual species at well studied sites. In Australia widespread species include the New Zealand screw shell and the northern Pacific starfish (Department of the Environment and Energy, 2016) .

On Pacific islands IAS have been particularly impactful. The brown tree snake has caused the extinction of the endemic birds, fruit bats and geckos and the reduction of bird-dispersal and reproduction of new trees by as much as 60—90 per cent in Guam (CGAPS, 1996; Rodda & Fritts, 1993; H. S. Rogers *et al.*, 2017). French Polynesia, Rotuma, Hawaii and many other islands have experienced widespread extinction and drastic population declines of native birds, land snails and land crabs due to invasive avian malaria, rats, mongooses, cats, pigs, goats, ants, predatory land snails, flatworms and habitat degradation (G. Brodie *et al.*, 2014; Howarth, 1985). Increasing alien ant introductions have caused widespread biodiversity loss, human discomfort and increases in crop pests (Auina *et al.*, 2011; Fasi *et al.*, 2013; Jourdan, 1997; O'Dowd *et al.*, 2003; Vaqalo *et al.*, 2014). Critically important taro production in the region has been compromised by introduction of the taro leaf blight (*Phytophthora colocasiae*) and the taro beetle (*Papuana* spp.) (Aloalii *et al.*, 1992; Helen Tsatsia & Jackson, 2017). Abandonment of cultivation of the most important green vegetable and cash crop in Solomon Islands, hibiscus spinach (*Abelmoschus manihot*), resulted from the accidental introduction from PNG in the early 1980s of the aibkia beetle (*Nisotra basselae*) and the giant African snail (*Lissachatina fulica*) in 2007 (H. Tsatsia & Jackson, 2009). Introduced invasive insects and plant pathogens are threatening the existence of several culturally iconic and environmentally important trees in Hawaii, New Zealand, Fiji, Samoa, Nanumea Atoll, Tuvalu and other countries (e.g. Campbell, 2010; Thaman, 2011; Thaman & O'Brien, 2011).

Eight National Parks in Java have 67 invasive alien plant (IAP) species, two of which (*Chromolaena odorata* and *Lantana camara*) occurred in all. Histories of species introduction appeared as important as environmental factors (e,g, low canopy cover and altitude) in increasing IAS distribution and spread away from trails (e.g. *Acacia nilotica* in Baluran National Park (Padmanaba *et al.*, 2017)).

3.3.6 Natural resource governance

Overexploitation and unsustainable use of natural resources for economic benefits are major factors degrading habitats and common property resources in low-income countries. In the Asia-Pacific region, the per capita ecological footprint in 2008 was 1.6 gha which exceeds the per capita biocapacity by 0.8 gha. In addition, the bio-capacity per person in 2008 had decreased to only two thirds of that available in 1961 (WWF & ADB, 2012). The average biocapacity per person will decline as populations grow rapidly in the Asia-Pacific region. The report on Living Planet Index (LPI) shows a decline of 64 per cent in key populations of terrestrial and freshwater species over a period of nearly 4 decades (1970-2008) in the Asia-Pacific region as against global fall of LPI by 28 per cent during same period, suggesting serious degradation of these ecosystems in the region. Given the current rate of human population growth, expansion of urban industrial environments, transformation of agriculture in favour of HYV and cash crops and consumption pattern, transforming of forestry in favour of forest plantations, the biodiversity in the Asia-Pacific region are likely to be adversely affected in the coming decades. It is plausible that most of the biodiversity especially the ecosystem biodiversity in the next century may be confined to protected areas or in places where the local communities have taken the lead in local level conservation *in lieu* of economic incentives and equitable compensation. On the one hand, the unprecedented increase in human population of Asia has stressed the fragile ecosystems to their limits; and on the other, arable cropping has been extended to sites, which were not entirely suitable for it, resulting in soil degradation and erosion (Eswaran *et al.*, 2001).

In China and Vietnam, increase in forest area was caused by the mobilised reforestation policy/program such as Grain for Green project and Program 661(5million reforestation programme). That is quite unique feature of this region (Hyakumura *et al.*, 2007). The natural resource managers in most countries of the region have increasingly realized that community based co-management and strong leadership are the best ways to prevent depletion of bio-resources and degradation of ecosystems. Citing example from the fisheries sector, Guttierrez *et al.* (2011) have also demonstrated that co-management is the best strategy to achieve sustainable management of aquatic resources and securing rural livelihoods. Need for effective natural resource governance is needed at local, national and regional scales. In recent years transboundary cooperation has gained much significance in various parts of the Asia-Pacific region for achieving conservation goals and targets (Box 3.4).

Box 3.4 Improved transboundary cooperation for achieving conservation goals

Recognizing that environment and ecosystem boundaries transcend administrative and political boundaries, the concept of transboundary cooperation is being advocated increasingly to achieve conservation goals globally. Several initiatives in the Asia-Pacific region demonstrate growing interest in transboundary cooperation for protecting areas of high biodiversity values. Some of the initiatives include: (i) Cooperation among Cambodia, China, Lao PDR, Myanmar, Thailand, and Viet Nam in Greater Mekong Subregion (GMS), that fosters regional cooperation after long period of conflict in the area of poverty alleviation and ecological security; (ii) The Heart of Borneo (HoB) Initiative, led by Brunei, Indonesia and Malaysia governments, aims at conservation of biodiversity for the benefit of over 11 million people, including a million forest-dwelling indigenous communities, of Borneo; (iii) The Sulu-Sulawesi Seascape partnership for globally important Coral Triangle, across the waters of Indonesia, Malaysia and Philippines has helped enhancing local governments and community engagement in stewardship of marine areas leading to significant increase in no-take zone area and improved management of seascape’s marine resources; and (iv) Landscape level conservation by way of integrating conservation of endangered Snow Leopard with local and global economies is being focused under Global Snow Leopard & Ecosystem Protection Programme that engages with 12 range countries from Central Asia and Asia-Pacific region.

More recently, the International Center of Integrated Mountain Development (ICIMOD) has been facilitating transboundary conservation and development programme in the Hindu Kush Himalayan region with cooperation from its regional member countries,. Seven such potential landscapes, viz., Wakhan, Karakorum-Pamir, Kailash Sacred Landscape, Everest, Kangchenjunga, the Far Eastern Landscape and Cherrapunjee-Chittagong have been identified across west to east extent of the Hindu Kush Himalayas. Of these, Karakorum-Pamir, Kailash, Kangchenjunga and Far Eastern Landscape are in various stages of implementation by member countries through regional cooperation frameworks with a strong focus on developing knowledge base for informed management and policy decisions on landscape conservation and development. These initiatives are expected to enhance strong regional cooperation for economic development and environmental conservation and provide science based evidences to policy and practice forums at national and regional levels.

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3.4 Policy relevant messages

Biodiversity at the genetic, species, community and ecosystem levels is currently under threats almost everywhere in the Asia-Pacific region, and in many areas the situation is critical. Though, loss of biodiversity and nature's contribution to people are of global concerns, it is not necessarily of common concerns on the ground in many countries of the Asia-Pacific region. Hence, mainstreaming biodiversity conservation and utilisation in every aspect of sustainable development needs to be given high priority and should cascade from the highest level in the government to the local authorities and all stakeholders. This would empower the central, state/provincial and local governments as well all the stakeholders in equitable sharing of benefits and long term conservation of biodiversity.

Terrestrial, inland freshwater, coastal and marine ecosystems across the Asia-Pacific region are degraded and fragmented, compromising their ongoing viability and the provision of nature's contribution to people. Many species of flora and fauna are highly threatened and confined to isolated protected areas which face increasing anthropogenic pressures and conflicts. Currently 14 per cent of the land area of the Asia-Pacific region is in areas protected for the conservation of nature, which is equal to the global mean (T. M. Brooks *et al.*, 2016).

Food availability per capita has increased in the Asia-Pacific region over the last two decades. There are, however, many challenges that still confront this region such as population growth, rapid urbanization, new food demands by a rising middle class, and the effects of global climate change. Furthermore, the area of arable land available per capita in the region is very low (0.17 ha), implying the predominance of smallholder production systems. This has led to increasing land use intensification. At the same time, abandoned farmlands are increasing in countries such as Japan (10 per cent of agricultural lands) and Korea since the 1980s, which needs to be restored for providing nature's contribution to people. This region has the world's highest rates of mineral fertilizer use despite having limited cropland available to feed a large population. Agriculture development ('high inputs/high outputs' model of industrial agriculture) has resulted in the loss of crop genetic diversity such as land races which have been replaced by relatively few high yielding varieties (HYVs). The Asia-Pacific region has undergone a massive shift in land use patterns as croplands and have been converted into monocultures. Monoculture crops such as rubber, palm oil and cloves have replaced the swidden fields and have led to decline of agrobiodiversity. One such concern is the breakdown of traditional tree-rich agroforestry systems in the Pacific islands and elsewhere. However, there are indications that trees outside forests still abound in the Asia-Pacific region and play crucial economic, social, and environmental functions on local, national, and global scales. Significantly, the percentage of tree cover on agricultural lands has increased modestly in the recent past. For example, in South Asia, the area of >10 per cent tree cover increased by 6.7 per cent, along with East Asia (5 per cent), Oceania (3.2 per cent) and South-East Asia (2.7 per cent) between 2000 and 2010.

There has been a steady (up to 70 per cent) decline in the native varieties of plants and crop genetic resources in the Asia-Pacific region due to intensification of agriculture, widespread use of chemical fertilizers and a shift towards high yielding varieties. This trend will impinge on food security of indigenous people and affect local knowledge and practices. The assessment reveals that freshwater is a critical hotspot of biodiversity and nature's contribution to people and freshwater resources in the Asia-Pacific region is undergoing the most rapid rate of decline globally. Freshwater across the Asia-Pacific region are under heavy anthropogenic pressure due to excessive diversion of water, pollution, habitat degradation and loss. Biodiversity – including the abundance and distribution of freshwater taxa – has been affected by human activities. The Asia-Pacific region ranks high among the global hotspots of coastal and marine biodiversity. Biodiversity and nature's contribution to people in this region are highly threatened due to unsustainable commercial aquaculture, overfishing, and pollution, adversely affecting biodiversity and nature's contribution to people. Furthermore, with the push for organic agriculture and integrated farming systems in several parts of the region (e.g. India), the area under these land use practices is likely to increase in future. Yet, the proportional area of organic farming is still very low, for example, in Japan, it is <1 per cent and in India, it is about 3 per cent (certified organic production).

Steady increase in human population and rapid economic development of the Asia-Pacific region, has stressed the various ecosystems to their limits with some being critical. Despite the burgeoning anthropogenic pressures, the Asia-Pacific region continues to provide diverse biodiversity and ecosystem services to the human populations. It is likely that most of the biodiversity in the next few decades may be confined to protected areas or in places where the local communities have taken the lead in local level conservation in lieu of economic incentives and equitable compensation by the governments. Creating continuous awareness at all levels in society and capacity building of community based organizations for conservation are deemed important if the nature's benefits to mankind are to be sustained in the long run. Some countries have taken important steps forward by formulating their own national biodiversity policies but most lack proper mechanisms for implementation, monitoring, regular reviews and system of disincentives for not following wise and standard practices of conservation. Without adequate protection, remediation and proper policies, the current decline in biodiversity and nature's contribution to people on land, in freshwaters, and in the sea will threaten the quality of life of future generations in the Asia-Pacific region.

Creating continuous awareness at all levels in society and capacity building at local levels for conservation are deemed important if the nature's benefits to mankind are to be sustained in the long run. Some countries have taken important steps forward by formulating their own national biodiversity policies but most lack proper mechanisms for implementation, monitoring, regular reviews and system of disincentives for not following wise and standard practices of conservation. Both land sparing (high-yield farming combined with protecting natural habitats) and wildlife friendly farming can be effective for minimizing negative impacts of food production on biodiversity, given appropriate context (Miyashita, Tsutsui., *et al.*, 2014).

There has been a nearly 30 per cent decline in bio-cultural diversity in the Asia-Pacific region since the 1970s (well established). Decline of regional languages has been catastrophic in the indigenous Australian and Trans-New Guinean families, as a result of a shifting away from small indigenous languages towards larger, national or regional languages. Linguistic and biological diversity often coincide in the Asia-Pacific region and parallel strategies need to be developed for their conservation. The national governments need to give high priority to identify bio-culturally rich areas and develop strategies to document and mainstream the traditional knowledge and wise practices in the management of natural resources.

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