CHAPTER 5

CURRENT AND FUTURE INTERACTIONS BETWEEN NATURE AND SOCIETY

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CURRENT AND FUTURE INTERACTIONS BETWEEN NATURE AND SOCIETY

EXECUTIVE SUMMARY

A: INTERACTIVE ANALYSIS OF HUMAN-NATURE RELATIONSHIP

Future scenarios of Biodiversity and Ecosystem Services (BES) and implications to human well-being in the Asia-Pacific region need to account for the unique regional characteristics and national policymaking practices within the subregions (*well established*). The Asia-Pacific region is unique among regions, owing primarily to its high natural and cultural diversity, but also to the fast rates of social, economic and political changes, human population growth and the threats to both biodiversity and human well-being from natural disasters, especially climate driven extreme events {5.2, 5.2.1, 5.2.2, 5.2.3}. Improving our understanding of the rapidly changing influence of drivers across the multiple dimensions of biodiversity and nature's contributions to people (NCP) is a key urgency to provide better decision-making support tools to policymakers in an increasingly uncertain future {5.1.1, 5.1.3, 5.1.4}. This is challenging because from the policy perspective since both BES and human well-being can be spatially defined by political boundaries such as countries or regional cooperation platforms {5.2.2, 5.2.3}. However, the actual and natural interactions of BES and human well-being processes may not necessarily be confined to such political definitions {5.1.4} **(Box 5.3)**.

The future scenario of biodiversity being likely to depend more on underlying drivers than direct drivers such as climate change, further scenarios and models for Asia-Pacific region need to align more closely with the commonly used dimensions and scales (e.g. subregional or national) by policymakers in the Asia-Pacific region (*established but incomplete*) {5.2.1, 5.2.2, 5.2.3}. A small group of scenarios and models have limitations to address necessary and relevant scales and themes of BES so a variety of tools and approaches are required to understand plausible future of biodiversity in the Asia-Pacific region {5.3.2 and 5.3.3}. In assessing the best available scenarios and models, notwithstanding the shortcomings, the confidence gained from the critical evaluations of factors and pressures across multiple dimension of BES need to be considered {5.2.3} **(Table 5.2)**. Identifying and focusing upon key underlying drivers and themes needs to be given more emphasis {5.2.1. 5.2.2, 5.2.3}. For example, the majority of models and scenarios exploring BES trends focus on climate change (e.g. **Figure 5.11**, **Figure 5.14**, **Box 5.5**). However, a key driver cutting across different types of ecosystems contributing to the threats is found to be forest and pasture land conversion to agriculture to feed increasing population, accommodate urbanization and meet increasing demand for natural resources in the Asia-Pacific (*established but incomplete*) {5.2.1} **(Figure 5.8, Box 5.2)**.

With rapid expansion of population, increasing standard of living, expanding hydro-power sector and expansion of plantation crops in the Asia-Pacific region, future food, water and ecological security will face a severe challenge in some of the subregions unless effective policy and governance reforms in BES management are introduced (*established but incomplete*). The Asia-Pacific region especially, the South and Western Asia subregions are particularly water scarce with limited surface water supply and over-reliance on groundwater leading to salinity-related problems {5.2.2., 5.3.2.1; **Table 5.2**}. All the major rivers in the Asia-Pacific region are anticipated to suffer declines in water flow under different climate change scenarios, affecting freshwater availability and water quality {5.2.2; **Box 5.3**}. The combined and synergistic impacts of drivers will lead the impact on all habitats, at least in the near future, with varied extent across the subregions {5.3.3}. Because of increasing demand for urban and agriculture land, aquaculture, and tourism infrastructure mangrove habitats remain particularly susceptible to future changes and are prone to local extinction {5.2.3}. Available scenarios for NCP from mangroves and coral alone anticipate losses worth billions of dollars per year, due to sea-level rise and costal land encroachment {5.2.3}. Coral reefs are projected to experience increasing frequency of bleaching, death, disease, and degradation, mostly due to ocean warming and acidification attributed to climate change. Even under conservative scenarios with global mean temperature increase of 2°C by the end of the century, about 90 per cent of corals are expected to suffer severe degradation by 2050 (*established but incomplete*). {5.2.3; **Figure 5.13**; **Box 5.5**}.

There is variation in the coverage, distribution and relative influence of different drivers on the human-

nature interactions across the Asia-Pacific region (*established but incomplete*) {5.3.2.1} (Figure 5.17). Most studies on influence of drivers focus on social and economic drivers, but lack integration of ecological drivers, such as the invasive alien species or new breeds of species, which underpin existing research gaps {5.1.3, 5.2.1}. In Oceania and North-East Asia, economic and policy drivers are somewhat less integrated, in South and South-East Asia, economic drivers, particularly changing lifestyles and consumption patterns, expansion of biofuels, and governance reforms were found to have strong influence {5.3.2.2, 5.3.3.3}. Similarly, climate change-related drivers such as sea level rise and rise in sea surface temperature have been relatively well captured in Oceania including Pacific islands compared to other subregions, in part because of the well-known climate vulnerability of small islands and low lying coastal areas in the Pacific {5.2.3}. However, most studies significantly focus on social and economic drivers, but lack incorporation of ecological drivers, such as possible introduction of invasive species or new crop or animal breeds, which underpin existing research gaps {5.2.1, 5.2.2, 5.2.3}. Scenario archetypes depicting plausible futures under Business As Usual conditions, which are predominantly influenced by Market Forces, or scenarios with increased focus on national-level securities, all present narratives that show declines in both BES and human well-being across the Asia-Pacific region {5.2.1, 5.2.2, 5.2.3}.

B: SCENARIOS AND MODELS AS DECISION SUPPORT TOOLS

From available scenarios and models projecting future human-nature interactions in the Asia-Pacific region, there is a clear indication of substantial future declines that will impact human well-being or good quality of life (*established but incomplete*) {5.2 and 5.3}. Assessment of projections from 63 recent publications on human-nature interactions in the Asia-Pacific region clearly indicate decreasing trends over time (regardless of spatio-temporal scales), except for mitigation and adaptive/anticipative scenarios {5.3.2}. Despite an overall increase in forest and protected area coverage {4.1.2.1, 4.2.5} (Table 4.1), the flow of ecosystem goods and services from most of the ecosystems in the Asia-Pacific region is projected to decline although in some subregions (e.g. North-East Asia) the production trend shown an increase {5.2.1, 5.2.2}. For example, since the increased demand for forest products, especially timber will be catered by both planted and natural forests mostly outside the countries of consumption; overall, natural forest area loss is likely to reach 75 per cent by 2100, with up to 42 per cent of forest biodiversity lost {5.2.1.1}. Afforestation and reforestation efforts are increasing in the region and may lead to lower rates of forest area decline, but the biodiversity decline is expected to continue with potential loss of ecosystem function leading to negative impacts on human well-being {5.2.1.1}. Increasing demands for biofuel, palm oil and agriculture products due to expanding urban population is likely to intensify competition for land, especially in South and South-East Asia (*established but incomplete*) (5.2.1). Based on single quantitative estimates available, Business-As-Usual scenarios suggest BES declines valued at up to $5 trillion per year across the Asia-Pacific region, which under scenarios depicting policy for futures with positive and sustainable options for nature conservation, can be drastically reduced *(unresolved)* {5.2.1.2}.

It is difficult to ascertain the exact magnitude of change and future trends of nature's contribution to people in the entire Asia-Pacific region as the studies of interactions between BES and human well-being and good quality of life are typically carried out at national and local levels indicating the need for systematic regional assessment (*well established*) {5.2, 5.3}. The existing scientific literature outlining future trends in BES for the entire Asia-Pacific region or its subregions are predominantly climate-centric, providing long-term projections of 2050 and beyond (*well established*) {5.3.3, 5.4}. Scenario exercises that focus on a specific component of biodiversity and/or ecosystem services for the entire region are extremely limited {5.3.4}. Based on the limited evidence available, it is difficult to indicate likely changes with significant confidence as well as to synthesize the information into one set of plausible futures for the entire Asia-Pacific region, since the studies are spatially based, and utilize dissimilar models, data, and assumptions {5.2.1, 5.2.2, 5.2.3}. For example, scientific studies showing better community participation in ecosystem management, coupled with systematic incorporation of traditional and indigenous knowledge into natural resource management plans and policies pointing toward better future for BES, are available from some subregions only {5.2.2, 5.2.3}. Similarly, only a handful of studies actually deployed multi-stakeholder-based scenario development, therefore these components are assessed as *inconclusive* {5.2.2, 5.2.3}.

C: FUTURE OF BIODIVERSITY AND HUMAN WELL-BEING IN THE ASIA-PACIFIC

The most significant drivers influencing biodiversity and ecosystem futures are economic, demographic, and anthropogenic climate change, thus scenarios that are based on application of new technology and management improvements that reduce their impacts are likely to improve the future of BES in the Asia-Pacific region (*inconclusive*) {5.3.3, 5.4.3}. Among the results of the assessed scenarios, biodiversity loss would be lowest under the 'Global Technology' scenario in North-East Asia and Oceania, under the 'Consumption change' scenario in South-East Asia, and under the 'Decentralized Solution' scenario in Western Asia and

South Asia {5.3.2} **(Figure 5.15)**. In order to reduce the impact of climate change on biodiversity in Western Asia and Oceania, and crop production in South-East Asia, North-East Asia, and South Asia {**Figure 5.16**, left side}, appropriate technological and management interventions are likely to yield positive results {4.2.4, 5.1.2}. In terms of plausible future land use, all subregions would expect increases in natural areas under the three alternative pathways, compared to the 'Baseline' scenario {5.3.2}. The greatest increases in natural area are anticipated under the 'Consumption Change' scenario in Western Asia and South-East Asia, under the 'Global Technology' scenario in North-East Asia and Oceania, and the 'Decentralized Solution' scenario in South Asia {5.2.1, 5.3.2, **Figure 5.10**}. A decrease in natural area, in comparison with Business-As-Usual, is expected only in North-East Asia under the 'Consumption Change' pathway {5.2.1, 5.3.2, **Figures 5.1**, **5.10**, right side}.

Despite declines predicted in both BES and human well-being in the Asia-Pacific region, scenarios under new policy reforms and behaviour change and their effective implementation that encapsulate sustainability and on-going protection of nature indicate either slowing down of declines in BES, or even improvements in some subregions (*established but incomplete*) {5.2, 5.3.2, 5.3.3}. Scenario exercises that focus on a specific component of biodiversity and/or ecosystem services for the entire region being rare, hence, based on the available literature evidence; it is difficult to indicate likely changes with significant confidence {5.2.3, 5.3}. It is difficult to synthesize this information into one set of plausible futures for the entire Asia-Pacific region, since the studies are not only spatially separated, but also utilize dissimilar models, data, and assumptions {5.3.4.1}. However, critical evaluation of alternative scenarios in the Asia-Pacific can help its population prepare for both climatic and non-climatic hazards and disasters and/or modify the course of events towards reduced negative impacts of expected future declines in NCP {5.3.4}. Nevertheless, scientific studies from the Asia-Pacific region suggest better community participation in ecosystem management, as a systematic incorporation of traditional and indigenous knowledge into natural resource management policies, which could be one of the pathways for sustainable futures {5.3, **Box 5.6**}.

Technological advances and progress in economic development ignoring consideration of biodiversity and ecosystem conservation is less likely to lead to improved human well-being and good quality of life (*well established*). Ample evidence exists in the region that the countries have managed to increase the GDP at the expense of natural capital in the Asia-Pacific region {5.1.3, **Figures 5.4, 5.5, 5.6**}. Economic development is derived from diverse components of human, physical, social, economic and natural capitals in which the ecosystem services contribute significantly to enhance the good quality of life of the people {5.1.3}. However, in most of the Asia-Pacific countries as indicators of human well-being and good quality of life are predominantly of economic nature with significant negative implications on regions biodiversity and ecosystem services {5.1.4, **Box 5.1**}. This is because nature's contribution to people most often are not reflected with the purely economic indicators based accounting system since it undervalues the contribution of ecosystem services {5.2.1}. As a result, countries which are unsustainably exploiting their natural capital are most likely to face decline in future well-being and good quality of life in the long run (*established but incomplete*) {**Figure 5.7**, 5.1.3, 5.3.4}

5.1 INTRODUCTION

This chapter aims to provide a comprehensive assessment of the available scenarios on current and future interactions between biodiversity and ecosystems services (BES) and human well-being within the Asia-Pacific region. In particular, this chapter evaluates the trends and trajectories of available scenarios for BES and human well-being interactions within the Asia-Pacific region. This goal is approached from two directions: In Section 5.2 we draw on published literature from the Asia-Pacific region, examining plausible futures within terrestrial, marine and freshwater ecotypes. In section 5.3, we assess the current evidence from a suite of sources that have employed scenario and modelling approaches at various spatial and temporal scales. However, it also important to emphasise the variability of BES and human well-being interactions among member countries in the Asia-Pacific region, even among the developed nations (c.f. Chapter 2). In section 5.4 we examine the limited number of supranational scenarios developed across the Asia-Pacific region and subregions. We also take a 'global to local' approach by applying *well established* and accepted global scenarios to the Asia-Pacific region to highlight plausible futures across the region and subregions. Our final section (5.5) sketches key themes leading to policy options to be explored in Chapter 6 and encapsulated in the Summary for Policymakers (SPM).

5.1.1 The context for Scenarios and Models in the Asia-Pacific region

The Asia-Pacific region is characterized by a remarkable heterogeneity of resources, societies and socio-cultural contexts, and is spread over four of the world's major bio-geographical realms (Australian, Indo-Malayan, Oceanian, and Palearctic), including several archipelagic countries across the Indian and the Pacific Ocean. From the remote Pacific islands to Deserts of Western Asia, the region serves as a habitat for numbers of globally important endemic species, both terrestrial and marine, and has contributed to the well-being of the different ethnic and socio-cultural groups through provision of a range of valuable ecosystem services. This further translates to high bio-cultural diversity that exist under different political and social contexts, all of which have profound implications for the future of the region. Chapters 2, 3, and 4 have laid out the status, trends, changes, and reasons for changes to the biodiversity and ecosystem services in the region across various ecosystem types and subregions. By assessing and exploring scenarios and models, this chapter seeks to build on these trends to articulate plausible futures relating to biodiversity, ecosystem services and human well-being (notionally to 2050).

Important findings from the preceding chapters of this assessment offer context to the benefits of using scenarios across broad themes pertinent to human well-being.

Food production and food security: Food security has been identified across all chapters as an important concern in the region. Whilst estimates indicate overall improvement in food security (2.2.4), this is not uniform across the subregions and even within countries in a subregion (4.2) owing to problems of poverty and insufficient access with consequent high rates of malnourishment in certain areas within the Asia-Pacific region (2.4). Being a basic need, increasing food supply for both domestic and export markets has been a priority for many national governments in the region, and thus policies are geared towards this direction. These range from positive policies promoting sustainable agriculture (6.2; 6.5), to perverse incentives for chemical inputs use and agricultural intensification (4.2). Market based instruments such as certification schemes for sustainably produced, organic, and local foods are gaining popularity (4.2).

Nonetheless, given the growth of population, urbanization, and changes in lifestyles of populations, especially those who had traditional lifestyles, the demand for food is increasing (4.2). Food crops are being increasingly cultivated as monocultures (3.2; 4.4), in conditions not naturally feasible for their cultivation (3.2). Crops are often used for purposes other than 'food' (e.g., industrial and biofuel use, and as animal feed) and produced using intensive agricultural techniques that use excessive chemical fertilizers and pesticides (3.2). This has resulted in loss of agro-biodiversity (3.2.1), ecosystem degradation (3.2.1) declines in soil fertility (3.2.1.5), large scale conversions of bio-diversity rich forest and fertile land (3.2) and the spread of invasive alien species (3.4, 4.1.4). Additionally, incidence of pollution of water and soils have increased (3.2.2) impacting human, plant and animal health (3.2, 4.1.3). In the case of the fisheries sector, over-exploitation of fish resources in response to rising market demand is facilitated by large trawlers that do not discriminate between species (3.2.4, 4.1, 4.4.5). The increase in the demand for meat in the region, has led to large scale forest land conversion for pasturelands, ranches with negative implications for biodiversity (3.2). Such changes also have made the region more vulnerable to extreme events and climate change as both the adaptive capacities and natural mitigation options are reduced (3.2, 4.4). Increased trade and globalization have facilitated quicker and larger movement of food products and have contributed to higher production at environmental costs (4.2.2). In some cases, it has been noticed that this has led some countries to under-utilize their resources (such as forestry resources) as they source cheaper options from other countries (4.2.2).

Health security: While not directly expressed, it is captured in aspects of access to clean air, water, ecosystem functioning, regulation of pests and vectors of diseases. Key themes considered across all chapters deal with high levels of air (4.1.3), water (4.1.3), and soil (4.1.3) pollution across the subregions. Influential factors included increasingly built up areas in urban centres with limited vegetation, and chemical run off in soil and water. Loss of natural ecosystems or their degradation also enables the spread of disease causing vectors and pests (4.1), in addition to threats to human life due to increasing vulnerability to extreme events. The uses of traditional medicine as well as medicinal plant diversity and abundance have also reduced, due to commercialization of products that is not always commensurate with sustainable regeneration capacities (2.3, 2.4). Technological solutions to ameliorate these impacts are available and are often successful where deployed (4.2.4).

Water security: Freshwater is required for consumption, irrigation, and energy-generation purposes. Trends indicate large scale water stress in different subregions in the Asia-Pacific region arising from over exploitation of water resources and high pollution from agricultural, fishery and other industrial activities (2.4, 3.2). Efforts at managing water resources have resulted in some innovative mechanisms of transboundary co-operation between countries and co-management between different stakeholders in an ecosystem (2.3).

Energy security: Given the large population and extensive urbanization in the region, the demand for energy is also high. This is met heavily through coal, firewood, oil and biofuels (2.4, 4.1). The region is the highest consumer and supplier of coal and (4.1), with resultant loss of species through deforestation, land clearing, and mining activities (4.1). Emphasis on producing cleaner coal and clean energy is increasing across the region (4.1, 4.2) and is likely to be a key driver of future change.

Income and Livelihoods: Rising commoditization of food and biofuels resources, and increasing availability of lifestyle products enabled by globalization have had both positive and negative impacts to biodiversity (4.2). On the one hand, tropical deforestation has seen unprecedented levels in the last decade due to activities like oil palm plantations and on the other end (3.2), commercialization has enabled a revitalization of local livelihoods and economies by creating niche markets for local products, and local ecosystems through activities like for instance, ecotourism (4.2.2).

Equity and Justice: Large scale transformations of traditionally occupied and managed ecosystems for various development purposes have had negative impacts on the livelihoods of local communities (2.2). These impacts have resulted in migration to urban centres and consequent unemployment, inadequate access to basic necessities of life, and the loss of sense of place and culture (2.3, 4.2).

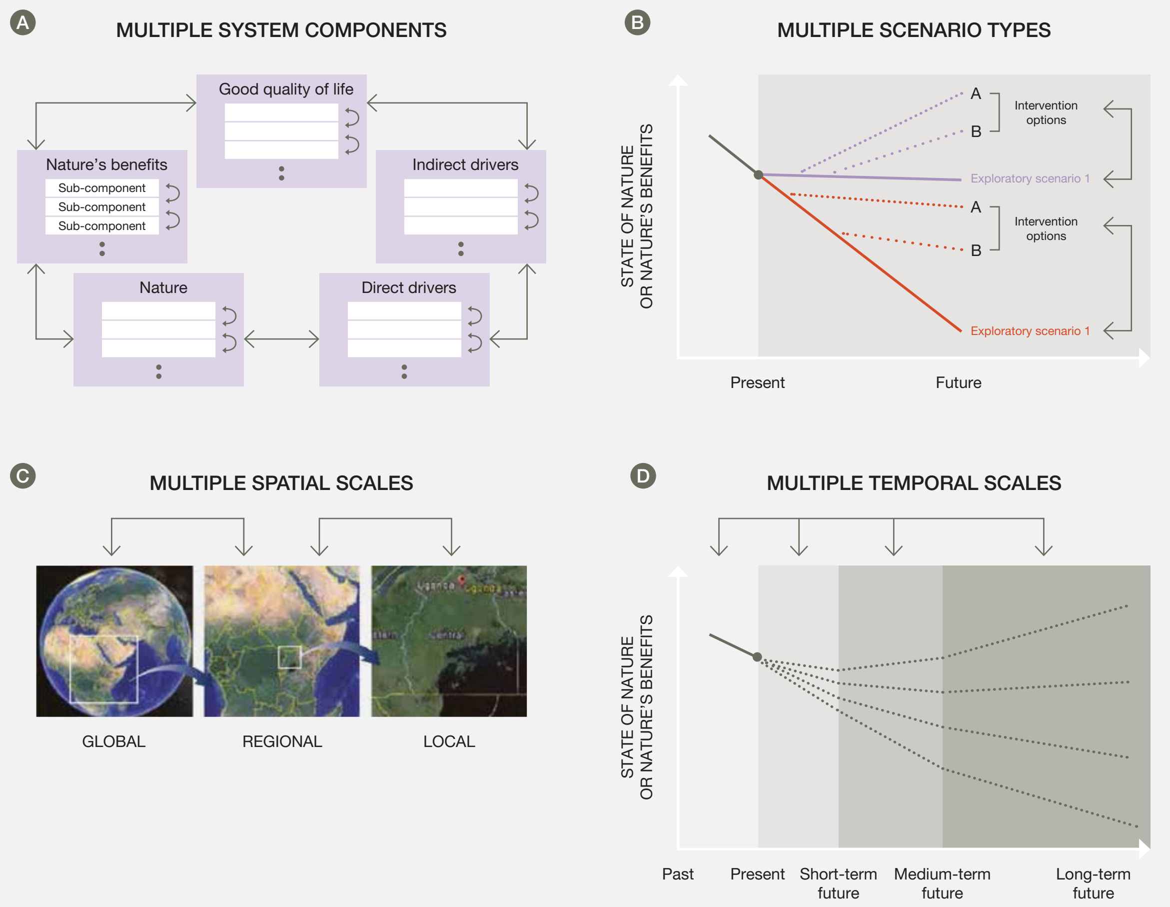
Policies focusing on changing existing production patterns and the management of ecosystems have exacerbated the problems, particularly in rural and nomadic communities (3.2), including exposure and sensitivity to extreme events, such as natural disasters (2.4).

Specific policies relating to rewarding local knowledge, practices on conservation are being developed, such as laws on equitable sharing of benefits from using resources and related knowledge from communities; or co-management of forests, watersheds and landscapes or coastal areas. Where these are implemented cooperatively between local communities, governments and private sector, they have been found to be mutually beneficial (2.3.2, 2.3.7, 2.5, 3.4.6). Similarly, policy support for niche markets also enable sustaining cultural practices and better address the needs of the poor (4.2). The combination of these factors in the Asia-Pacific and subregions lead to potentially divergent and unique future options. Despite the general appreciation of the major challenges faced by the Asia-Pacific region above and in **Chapter 1**, there is a lack of systematic or synthesized scenarios and modelling assessment of interactions between BES and human well-being in its widest sense for the region. Therefore, this chapter evaluates and presents an assessment of available scenarios of current and future interactions of BES and human well-being in the Asia-Pacific region, in particular, following the integrated assessment approaches of the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES).

5.1.2 IPBES framework: Integrated assessments of multiple components of interactions between Biodiversity and Ecosystem Services and Human Well-being across multiple spatial and temporal scales

The assessment of current and future interactions between BES and human well-being in the Asia-Pacific region follows the integrated conceptual framework of IPBES (see Chapter 1). In particular, it takes into consideration the multiple components of BES and human well-being relationships such as the multiple direct and indirect drivers (see Chapter 4 for detailed assessment and discussion of drivers) impacting BES (see Chapter 3 for detailed assessment of BES status and trends in the Asia-Pacific region), and thereby subsequently impacting human well-being and good quality of life (see Chapter 2 for detailed assessment of nature's benefits to people in the Asia-Pacific region). The multiple components of BES and human well-being, and their interactions can be expressed in terms of plausible scenario narratives for BES and human well-being at various spatial and temporal scales (**Figure 5.1**; IPBES Deliverable 3c.).

Figure 5 1 **Illustrations of multiple components A, scenarios B, and spatio-temporal scales of Biodiversity and Ecosystem Services and Human Well-Being. Source: IPBES (2016).**



5.1.3 Current understanding of interactions between Biodiversity and Ecosystem Services and Human Well-being in the Asia-Pacific region and its gaps

One of the main characteristics of the Asia-Pacific region is its great diversity – from natural ecosystems, socio-cultural and political systems, and status of economic development – thus integrated assessment of BES and human well-being interactions within this region can be very challenging, especially without coordinated effort or shared database and methodologies. Up to 65 per cent of countries in the Asia-Pacific region could be considered as 'developing', and as few as 20 per cent considered as 'developed' according to economic measures (UNESCAP, 2016). However, all are dependent on BES for their well-being, be it through provision of clean water or soil function for agriculture and food security. For example, a significant proportion of the Asia-Pacific region population is reliant on solid biofuel, especially within lower income countries (**Figure 5.2**). The concept of well-being has already been discussed in the earlier chapters but it can manifest in the form of service provision impacting other forms of capital (see **Box 5.1**).

However, the countries comprising the Asia-Pacific region also share many regional characteristics, such as (1) the degradation of many BES due to rapid deforestation and conversion of land to agricultural (**Figure 5.3**), industrial and urban areas, (2) the high population and population growth rates in many countries (3) the high biodiversity within the region (from genetic resources to ecosystems), (4) the exposure and vulnerability of many countries to natural calamities and disasters; (5) the depletion of coastal marine ecosystems within the Asia-Pacific region and the continuous overcapacity in fishing sectors of the region (**Figure 5.4**); (6) the intensive eutrophication and modification of many aquatic and inland water ecosystems within the region to support energy production

Figure 5 2 **Proportional energy derived from solid biofuels from latest available data in 2010, including traditional energy sources (firewood) by country within the Asia-Pacific region.**

Colours indicate income levels, based on per capita GDP and circle sizes are proportional to population size. Source: Energy supply from primary solid biofuel and total energy supply is from the International Energy Agency data (2013) http://data.iea.org/. Data presented using Gapminder World software, a free vizualization from Gapminder.org, CC-By License.

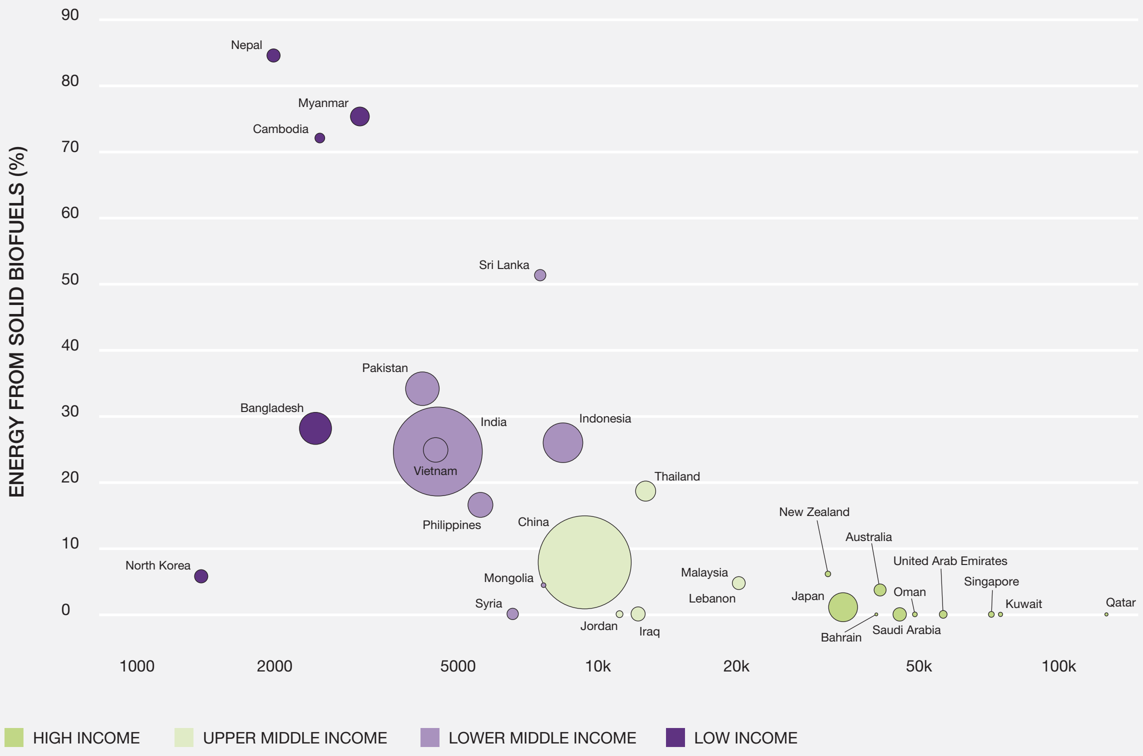


Figure 5 3 **Proportion of land (forest and others) converted in the Asia-Pacific region for pasture and cropland. Source: GEO-5 (UNEP, 2012).**

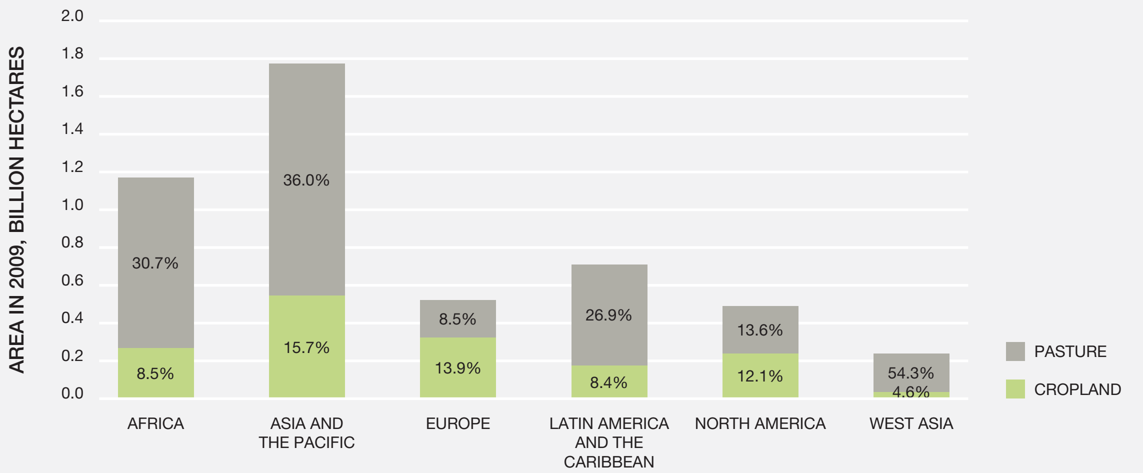


Figure 5 3

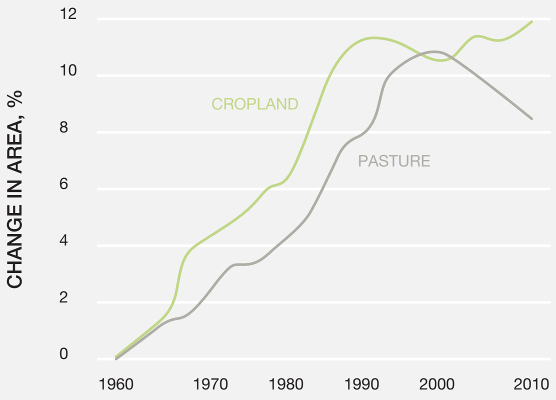
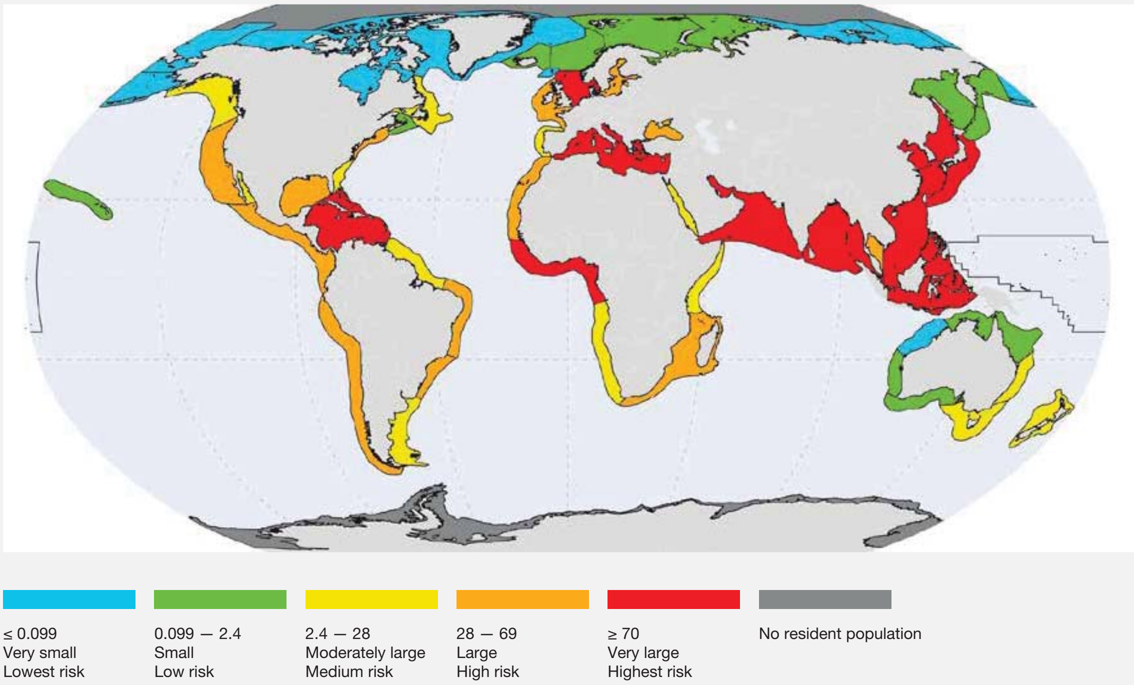


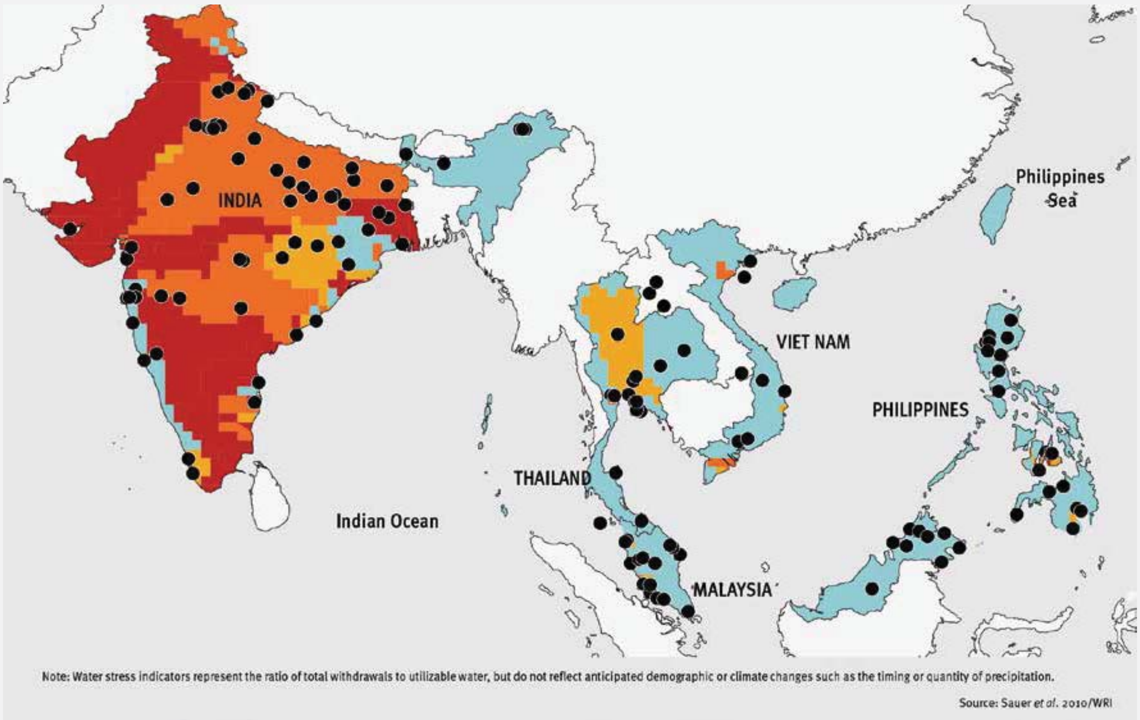
Figure 5 4 **Populations along global coastal areas and the risk to the ecosystem (overcapacity or over-exploitation) with high values in the Asia-Pacific region. Source: IOC-UNESCO & UNEP (2016).**



(hydrothermal energy), irrigation of agricultural lands, and heavy pollution of many aquatic ecosystems within the region coming from industries, urban sewage, and agricultural run-off **(Figure 5.5)**.

These disturbances to ecosystems, coupled with the growing demand for more resources to sustain the need for large and rapidly growing population within the region, pose a threat for calamitous collapse of BES productivity within the region. Hence, there emerges a need for this assessment to help guide policies aimed at recovering and maintaining the sustainability of BES and human well-being interactions of desired present and future BES and human well-being interactions within the region. Integrated scenario and modelling analysis of BES and human well-being interactions have been shown to be useful in providing guidance for policies that could provide clear pathways and options for sustainability (IPBES, 2016).

Figure 5 5 **Thermal and hydro power plants in the Asia-Pacific Region, and the stress on aquatic ecosystems in the region. Source: GEO-5 (UNEP, 2012).**



WATER STRESS

SCARCE
STRESSED
MODERATE AVAILABILITY
ABUNDANCE
● PASTURE

5.1.4 Further considerations for an integrated assessment of scenarios of interactions between Biodiversity and Ecosystem Services and Human Well-being within the Asia-Pacific region

Given the vast diversity within the Asia-Pacific region, conducting an integrated regional assessment of scenarios for BES and human well-being interactions would require careful consideration in terms of relevance to policymaking conventions within the region. This is challenging because from the policy perspective BES and human well-being can be spatially defined by political boundaries such as countries or regional cooperation platforms, such as The Association of Southeast Asian Nations (ASEAN) or The South Asian Association for Regional Cooperation (SAARC). However, the actual and natural interactions of BES and human well-being processes may not necessarily be confined to such political definitions (e.g. connectivity among migrating species both on land and sea or the flow of freshwater and associated biodiversity across national boundaries). Thus, the assessment must seek to provide insights for BES and human well-being interactions that are relevant to national context and regional, or appropriate spatial context, when applicable or necessary. Similarly, temporal scales must be provided to reflect the appropriate interactions between BES and human well-being that would require long time (e.g. forest or coral reef restoration) vs. those that operate at relative shorter temporal scales (e.g. seasonal agricultural production or seasonal tourism activities).

Despite a general increase in awareness of these issues in recent years, the current state of BES (and subsequent human well-being) in the Asia-Pacific region has vastly deteriorated from the previous decade (established in chapter 3), while future projections are no exception either (UNEP-WCMC, 2016) (see section 3.4). As per the GBO-4 assessment report, the state of biodiversity in the Asia-Pacific region will continue to decline at least until 2020 (CBD, 2014).

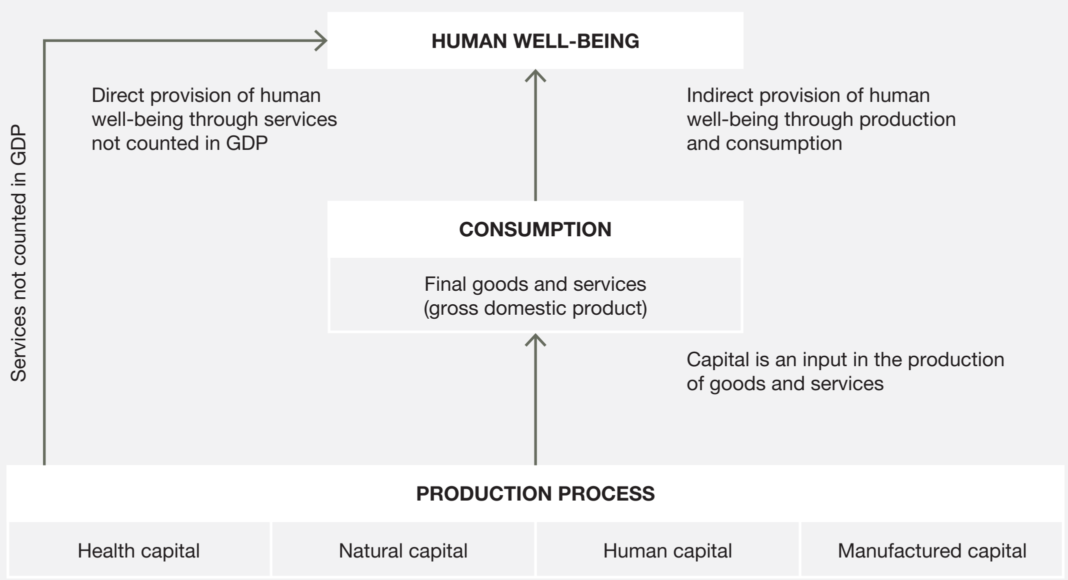
Box 5 1 What constitutes Well-being?

The Millennium ecosystem assessment defined human well-being to be derived from five components: basic materials, health, security, good social relations, and freedom of choice and actions, where freedom of choice and actions is expected to emerge from the other components of well-being. The Millennium Ecosystem Assessment highlighted the important contribution of ecosystem services to the human well-being. Ample evidence exists at the micro-level in different countries highlighting the dependence of communities on different ecosystems for their livelihoods, providing a source of income, employment, and economic safety-net among other things.

At the national level, countries often rely in Gross Domestic Product as a measure of well-being (a reflection of the capacity of the country to produce goods and services) and improving the quality of life (as measured by the Human Development Index). However, more emphasis on GDP as a measure of well-being would have significant negative impacts on ecosystem services. Ecosystem services can decline but the GDP can go up. Gundimeda and Atkinson (2014) notes that Natural capital (ecosystems) provides multiplicity of intermediate and final goods which are often invisible and thus are not measured by the national income indicators like the GDP. Some of the reasons include: (1) the contribution of natural capital as an input into the production process; (2) the broader values that the society places on these assets; 3) the benefits provided by ecosystems go beyond the production boundaries of the system of national accounts, which measure GDP; (4) failure to account for the impact of human activities on natural capital. There has been considerable advancement in practical assessment for this natural wealth (ONS, 2014; United Nations, 2012; UNU-IHDP & UNEP, 2012; World Bank, 2011)

Increased emphasis on expanding the economic opportunities has come at the expense of ecosystem health, biodiversity, air quality, and human resiliency. There are also other dimensions, other than GDP, which impact the well-being like the educational opportunities, health, natural landscapes and ecosystems, social networks, among others (see **Figure 5.6**). Thus, the concept of inclusive wealth takes into account all these dimensions of wealth. Inclusive wealth is defined as the Present Discounted Value of all capital assets, where the stocks are valued in terms of their shadow prices (Arrow *et al.*, 2012), and through the changes in shadow prices, the society can get real signals on the impact of loss of ecosystem services. The shadow prices contain information on the impact of the future scarcities.

Figure 5 6 **Relationships between produced capital, consumption, and human well-being. Source: UNESCO/UNU-IHDP and UNEP (2014).**



It is often seen that the economies of countries that are exploiting their natural capital grow rapidly. Raudsepp-Hearne *et al.* (2010) break this paradox by arguing that the critical dimensions of human well-being have not been adequately captured. With the increase in production per capita, and important provisioning services, human well-being would increase regardless of the decline in other services. Due to the technology and social innovation, human well-being appears to be less dependent on ecosystem services. In addition, due to the time lag between ecosystem service degradation and the negative impacts on human well-being, these negative impacts may take some time before being felt to a measurable extent.

5.2 OBSERVED AND PROJECTED IMPACTS ON BIODIVERSITY AND ECOSYSTEM SERVICES IN THE ASIA-PACIFIC REGION

Human well-being and sustainable futures are linked to the steady flow of goods and services from nature (c.f. Chapter 1 and 2). Building from Chapter 3 (Status, trends, and future dynamics of biodiversity and ecosystems underpinning nature's contributions to people) and Chapter 4, here we highlight key features of observed and projected impacts in nature-society interaction, particularly portraying plausible future states under the existing Business-As-Usual (non-interventionist) scenarios and the links to the human well-being. The projections of such interactions highlight the future risks of changes in various drivers on the ecosystems and enable proactive policies to mitigate the impacts. In this section we explore the impact of various drivers on different ecosystems and its consequent impact on well-being in the Asia-Pacific region based on the synthesis of literature.

However, given the diverse demographic and structural variation across the region, and the multiplicity of the approaches used, it is difficult to synthesize and single-out the observed trends and projected impacts with specific reference to the entire region or any of the subregions. The available scientific evidence of an observed and future trend in nature-society interaction from the region (or at the subregion) are particularly scanty, and only handful number of studies considered the entire region (or subregions) as their projection scale, thus adding complexity to project plausible future of nature-society interactions in the Asia-Pacific region.

These complexities in synthesizing the available scientific evidence on the projected impacts on future biodiversity and well-being arise from the following reasons: (1) Majority of the publications did not have future projections of nature-society interactions, nor used comparable scenarios or models, and thus are of very limited use in the context of the IPBES integrated assessment framework; (2) The scientific literature that met the criteria had very limited information in terms of the spatio-temporal scales, scenarios used, models employed or nature's contribution to people or society; (3) Nature's contribution to people has been captured through diverse indicators (e.g. area changes, species richness, and species abundance)[1] and the studies also varied in terms of the number and nature of well-being indicators (in line with the MEA), limiting the comparisons on a common ground; (4) The spatial coverage of the studies differed from sub-national (local), national, subregional (sub-sections of the Asia-Pacific region) and global studies with subregional components; (5) The temporal scale of the nature-society interactions also varied, with ambiguity in the time-period of projections; (6) the nature of models used for projections often differed[2] and (7) as the plausible future depends on the scenarios considered (see section 5.3), the scientific studies used different set of local scenarios (see Appendix 2 for illustration of a set of studies); (8) the studies were taxonomically limited as only very few species were considered and they form very small percentage of the actual diversity. Moreover, existing scientific literature outlining future trends in BES for the entire Asia-Pacific region or its subregions are predominantly climate-centric, providing long-term projections of 2050 and beyond. The ecosystem services are dynamic and are influenced by social, ecological, and climatic systems and non-climatic factors and constraints (Bennett *et al.,* 2015). For instance, while globally, climate change may cause 10-15 per cent reduction of mangrove habitats in distant future, the imminent threat for the next 25 years comes from urban development, aquaculture, mining and overexploitation, with insignificant impacts from 'alteration of hydrology' or 'global warming' (Alongi, 2002, 2008). At the same time, mangrove future beyond 2025 will rest upon social, technological and ecological advances, and given the ongoing restoration efforts, the future might not be entirely bleak as often projected (Alongi, 2002).

Despite these ambiguities, it remains imperative to understand the future of BES in the Asia-Pacific region, as it provides a rough depiction of the likely state (or the baseline) of availability of key ecosystem services in the absence of any corrective policies (under the Business-As-Usual scenario). The section is designed to share the understanding of observed and projected impacts of BES in the Asia-Pacific region. By the term 'projected impacts,' we broadly refer to the IPCC's definition, which defines 'projection' as a model-based estimation of future (IPCC, 1995). The section is divided into three sub-sections, each catering to projected outcomes in nature-society interaction for terrestrial, freshwater, and coastal-marine ecosystems.

1. For example, the contribution of aquatic ecosystems is captured through quantity and quality of water supply provision but had limited information on aquatic biodiversity indicators, for coastal-marine ecosystems, the commonly projected indicators of NCP were coral reefs, coral reef habitat and fisheries. For terrestrial ecosystems, the most commonly projected NBP indicators were agricultural food production, forest area or habitat, biodiversity, and carbon storage.

2. For example, for aquatic ecosystems, hydrological or ensemble models (e.g. climate projections models CMIP3 and CMIP5, or bioclimate models) were most commonly used, but were often specific to the study. For coastal-marine ecosystems, most studies used ensemble models (e.g. climate projections models CMIP3 and CMIP5, or bioclimate models). For terrestrial studies, most used various versions of land-use (e.g. CLUE-S) or forest production and dynamics models

5.2.1 Terrestrial Ecosystems

5.2.1.1 Forest ecosystems

Forests are significant pools of BES and offer a number of valued ecosystem services, therefore changes in forest cover are often considered as a proxy for the state of terrestrial BES. However, there is a rapid loss of tropical lowland forests, threatening biodiversity and ecosystems in the Asia-Pacific region (see section 3.3.1). During 2000-2013, forest cover in the Asia-Pacific region has roughly decreased by 6 per cent. Particularly, degradation of forest remains severe in South-East Asia **(Figure 5.7)** (Hansen *et al.,* 2013; UNEP-WCMC, 2016). Although historically, demand for timber resulted in the loss of forests, in recent years, human-induced land-use changes, predominantly, for agriculture, habitation (Fox *et al.,* 2012; Kubiszewski *et al.,* 2016; Lal, 2011), expansion of biofuel and oil palm cultivation have contributed to the bulk of the loss in the Asia-Pacific region (CBD, 2014).

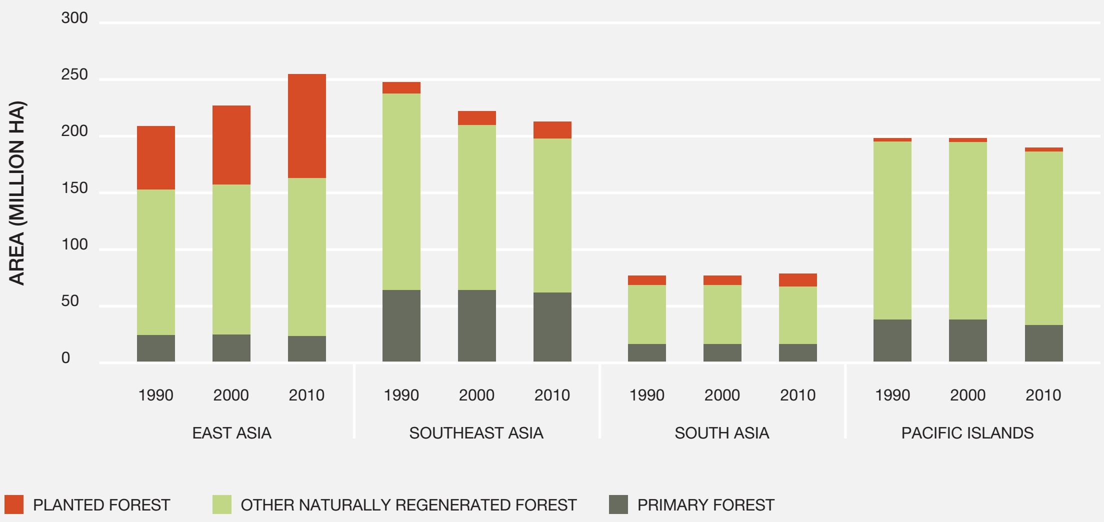
In general, further reduction of forested area, mostly in South and South-East Asia, are expected. Given the current trend, South-East Asia may lose the greatest extent of forest in future – i.e., nearly three-quarters of its original extent by the end of this century and 13 - 42 per cent of its original biodiversity (Sodhi *et al.,* 2004). Human intervention in forested areas, especially for biofuel expansion, will continue to dominate future conversion of forested areas, particularly in South-East Asia. For instance, a study by Raunikar *et al.* (2010) estimated annual growth rate of 1.04-1.94 per cent per year for biofuel sector in Asia (up to 2060). Some projections, nonetheless, also show that the loss of forest might slow down slightly by 2030, due to the expansion of planted forests and commercial forestry (d'Annunzio *et al.,* 2015; Rutten *et al.,* 2014). Although this might partially cater to an increasing wood-demand, especially from region's growing economies, this will not necessarily make sufficient positive impact in the future state of biodiversity (d'Annunzio *et al.,* 2015).

Significant species loss is, thus, expected in major biodiversity hotspots across the Asia-Pacific region (see **Box 5.2**). However, in the future, the region's protected areas, currently about 13.7 per cent of the total land area, will continue to possess much of the remaining biodiversity and, in general, will remain unaltered (CBD, 2014).

Among material contribution from forest ecosystems, wood-demand and production will increase across the region. However, much of the demand will be catered by planted forests. As **figure 5.8** suggests, share of planted forests are consistently rising in the Asia-Pacific region (FAO, 2010). Public and private investments in planted forests, particularly in South and East Asia, may lead to some improvement in forest cover as well as cater to about 83 and 96 per cent of future wood demand respectively (2050) (d'Annunzio *et al.,* 2015). In addition, international support for forestry schemes such as REDD/REDD-plus will also offer improvement in forest cover, particularly in the developing countries. Degraded grasslands and heavily degraded forests in the region may, thus, become economically lucrative for plantation development. In addition, abandoned farmland in East Asia would enable some degree of 'passive restoration'. As a consequence of this passive restoration, forest cover is likely to increase. For example d'Annunzio *et al.* (2015) estimated that forest cover in Asia is expected to increase marginally, from 593 million ha to 604 million ha by 2030. However, despite some projection in forest cover and timber production, there is a significant lack of future projections concerning Non-Timber Forest Products (NTFPs), which includes a broad range of commodities, including honey, wax, and medicine. These are equally important for the well-being for a vast section of communities, particularly in poverty reduction for forest-dependent communities. Moreover, loss of traditional species (mostly flowering plants) might lead to a reduction of traditional health benefits for the indigenous people and local communities (Millennium Ecosystem Assessment, 2005).

Figure 5 7 **Loss in global forest cover from 2000-2013. Source: Hansen *et al.* (2013).**

Figure 5 8 **Observed trend in forest category shows a growing inclination to planted forest, both by public and private sector, to meet industrial and commercial demand. Source: FAO (2010).**



Box 5 2 **Reconciling Oil Palm and Rubber cultivation with agriculture/forest conservation.**

Palm oil is the world's most important vegetable oil regarding production quantity. Indonesia, the world's largest palm oil producer, plans to double its production by 2020, which may have implications for other national priorities of rice production, forest and biodiversity protection, and carbon conservation. Koh *et al.* (2010) modeled the outcomes of alternative development plans and found that a *hybrid approach* wherein oil palm expansion targeted degraded and agricultural lands were most suited. This approach avoided any loss in forest or biodiversity and substantially ameliorated the impacts of oil-palm expansion on carbon stocks (limiting net loss to 191.6 million tons) and annual food production capacity (loss of 1.9 million tons). Similarly, strong international demand for natural rubber is driving the expansion of industrial-scale and smallholder monoculture plantations, with >2 million ha established during the last decade. Mainland South-East Asia and Southwest China represent the epicenter of rapid rubber expansion (Warren-Thomas *et al.,* 2015). Their study indicates that 4.3–8.5 million ha of additional rubber plantations are required to meet projected demand by 2024, threatening significant areas of Asian forest, including many protected areas with negative impacts on negatively impacts bird, bat and invertebrate biodiversity. However, rubber agroforests in some areas of South-East Asia support a subset of forest biodiversity in landscapes that are again degraded or retain little natural forest.

What are the implications of these changes to the Asia-Pacific region in terms of magnitudes? The resulting changes in forest ecosystem services for example can increase the income in these countries (e.g. oil palm and timber exports are a huge foreign exchange earner, which increase GDP) but decreases the value of the forest capital. The distribution of these impacts will be different across different strata of the society. A study by Gundimeda and Atkinson (2014) illustrated these trade-offs between the growth in income and changes in forest capital in different countries in the Asia-Pacific region classified by the income groups for the period 1990-2010. The study has illustrated the trade-offs between population growth, income growth and forest wealth **(Figure 5.9)**. **Table 5.1** shows the trade-offs in some countries of the Asia-Pacific region covered by each ecosystems and the changes in the unit values, of these ecosystems. The global GDP has also increased as well as the loss in ecosystem services. For instance, Costanza *et al.* (2014) showed that between 1997 and 2011, the global value of ecosystem services decreased by an estimated $20 trillion per year due to land use change, a loss approximating around one-third of the global GDP.

5.2.1.2 Agriculture and cultivated land

Agriculture and cultivated land are among the other important terrestrial ecosystems that have significant implication in human well-being for the Asia-Pacific region, particularly considering the rapid economic and population

Figure 5 9 **Trade-offs between economic growth (GDP) and forest wealth. Source: Gundimeda and Atkinson (2014).**

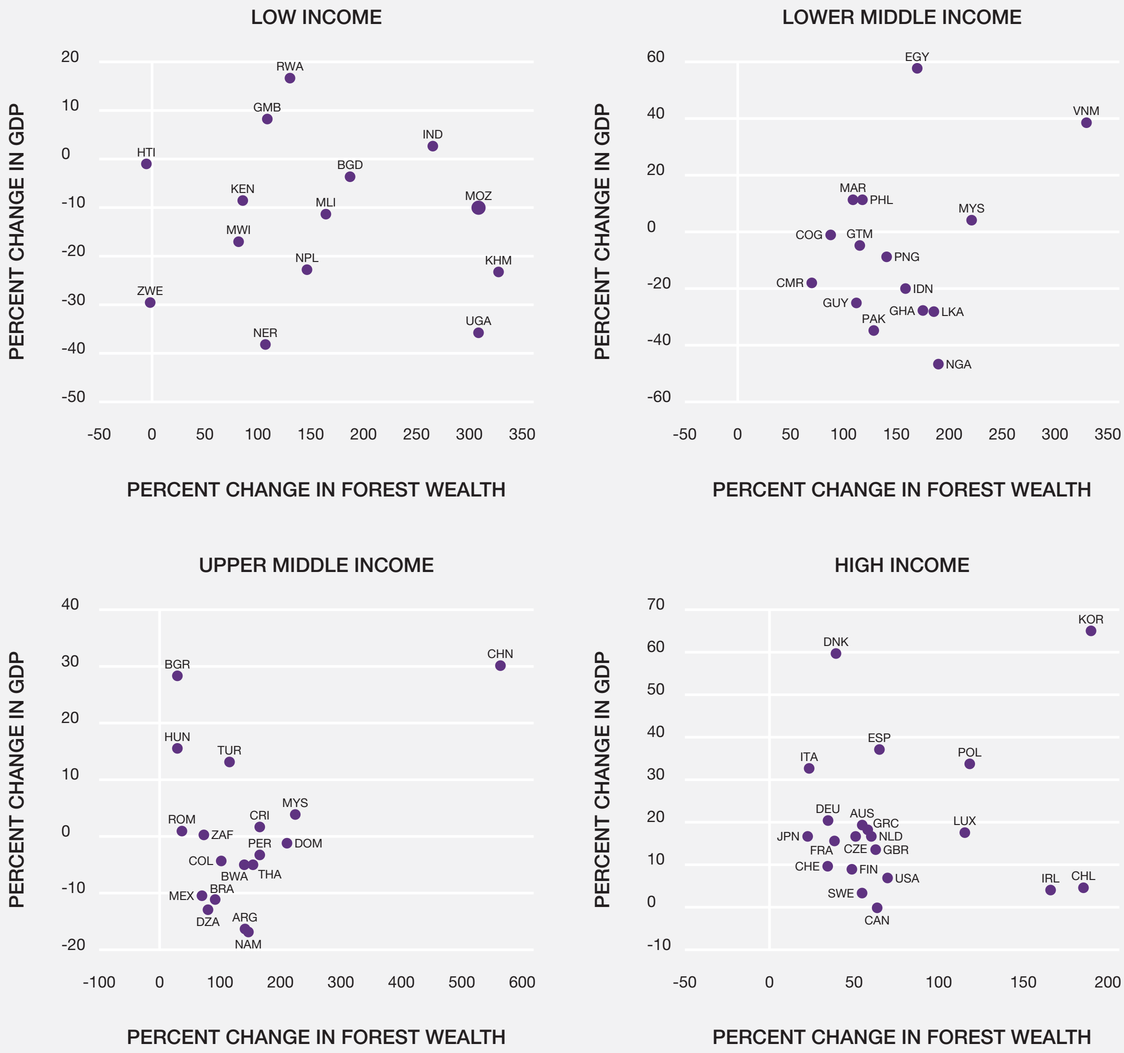


Table 5 1 **Changes in forest wealth and per capita forest wealth vis-a-vis GDP for some countries in the Asia-Pacific region. Source: Gundimeda and Atkinson (2014).**

	Changes in absolute forest wealth, 1990-2010	Per capita changes in forest wealth
Growth in GDP while investing in forest capital	China, India, Japan, Vietnam, Malaysia, Philippines	China, Vietnam, Japan
Growth in GDP while depleting forest capital	Indonesia, Myanmar, Thailand, PNG, Nepal, Pakistan, Bangladesh	Indonesia, Myanmar, Thailand, PNG, Nepal, Pakistan, Bangladesh, Malaysia, Philippines
Decline in GDP while declining forest capital	--	--
Decline in GDP while increasing forest capital	--	--

growth of the region. In general, there is a consensus that an increase in food demand from a wealthier population as well as changing consumption patterns (particularly increasing meat consumption) will expand cropland in the Asia-Pacific region, wherever it is still possible (UNEP, 2007) (also established in 3.2.1.5). For instance, the global availability of calories for consumption as food, i.e., calories per capita per day, will increase by 818 calories between 2000 and 2050. The steepest increases will be in Asia, followed by sub-Saharan Africa, and Latin America, and the number of children suffering from malnutrition will decrease significantly by 2050 (Hubert *et al.,* 2010). Nonetheless, increasing demands for biofuels and alternative use of cropland will intensify competition, especially in South and South-East Asia (Koh & Ghazoul, 2010) (*established but incomplete*). For example, Indonesia plans to double palm oil production by 2020. However, these may need the further diversion of forested areas or existing cultivated land, which may well compromise social goals of food security unless appropriate management is enforced (see **Box 5.2**). Technological improvement such as cultivation of high yielding varieties and improvement in the irrigated crop will contribute to enhanced food production system, however, may lead to rural unemployment in the agricultural sector (Rutten *et al.,* 2014). With growing middle-class, meat consumption is also projected to rise. For instance, Machovina *et al.* (2015) estimated that by 2050, meat demand will rise by the following percentages: India (1 per cent), Indonesia (5 per cent), and Malaysia (12 per cent). China (35 per cent), and Philippines (50 per cent), which will be met by further land conversation or importation.

Although the existing evidence is still incomplete, a growing number of studies highlight a poor outlook for the future state of agriculture in the Asia-Pacific region due to the possible negative consequences of climate change; particularly the semi-arid areas, which remain highly sensitive to climate change. In most cases, a gradual decline in crop production is projected under even the minimum possible climate impacts. For instance, Lal (2011) estimated that due to climate change, rain-fed rice and wheat cultivation will decrease in South Asia. In India, Soora *et al.* (2013) projected that climate change is likely to reduce irrigated rice yields by approximately 4 per cent in 2020 (2010–2039), approximately7 per cent in 2050 (2040–2069), and by approximately10 per cent in 2080 (2070–2099). However, climate change may also result in an increase of crop yield in some areas. For example, cereal production in North-East Asia may rise. IPCC's Fifth assessment report also suggested a likely northward shift of crop production which will benefit the temperate region, while crop production in the tropical region may suffer from a paucity of rain and heat stress unless proper management techniques are enforced (Hijioka *et al.,* 2014).

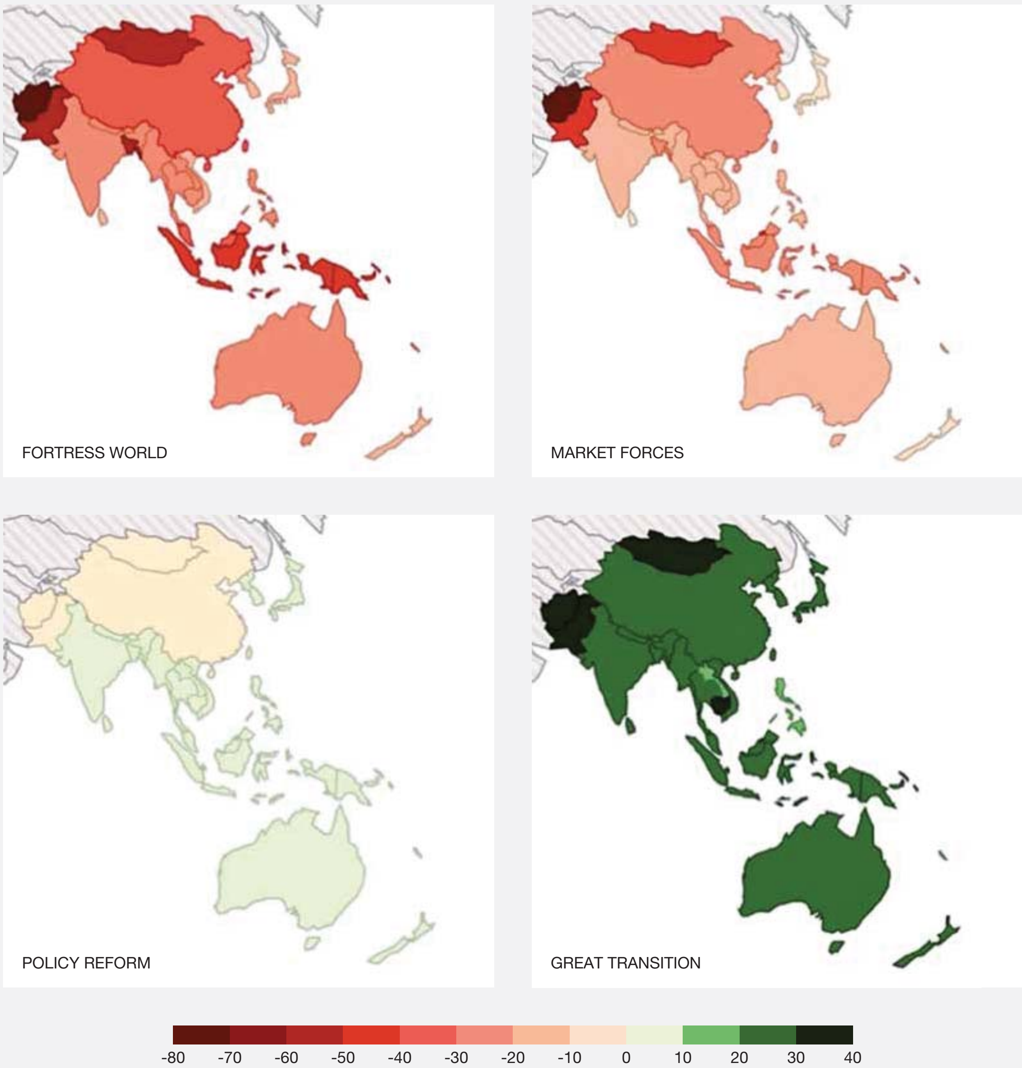
Future pathways studies on the importance of terrestrial ecosystems for human well-being are mostly qualitative and very few studies have quantified their impacts at the AP regional level. The only study which addressed the impact of changes in terrestrial ecosystems value is by Kubiszewski *et al.* (2016). They estimated the current value of benefits from ecosystem services for terrestrial ecosystems in 47 countries in the Asia-Pacific region at $US14 trillion/yr, most of which are non-marketed and not reflected in GDP **(Figure 5.10)**. The study calculated the changes in terrestrial ecosystem service value for the scenarios to the year 2050, under four archetypes: Market Forces, Fortress World, Policy Reform and Great Transition (see the next section for a more detailed description of archetypes). Change in value occurred due to two factors: (1) the change in area covered by each ecosystems, and (2) the changes in the unit values, which are dependent on the management policies of land and water. Under the Market Forces and the Fortress World scenarios, the ecosystem service value in the region continues to decline from $14 trillion/yr in 2011 to $11 and $9 trillion/yr in 2050 respectively. In the Policy Reform scenario, the value tends to remain at $14 trillion/yr and increased to $17 trillion/yr in the Great Transition scenario.

5.2.2 Freshwater Ecosystems

Although the Asia-Pacific region is home to 60 per cent of the world's population, it has access to only 36 per cent of its water resources, making the per capita water availability lowest compared to any other region (APWF, 2009). The freshwater ecosystems, consisting of rivers, streams, ponds, lakes and inland wetlands (Ramsar Convention Secretariat, 2012), are rich in biodiversity and ecosystem services (see section 3.2.2.), and at the same time, form an indispensable component of current and future human well-being in the Asia-Pacific region. Chapter 3 (section 3.2.2) provided a detailed assessment of observed changes in the freshwater biodiversity and concluded a sharply declining trend of freshwater biodiversity, owing to numerous anthropogenic disturbances, including the disappearance of wetlands throughout the region. This section focuses on water availability and their implications for the human well-being.

Contribution from the freshwater systems is pivotal for sustaining life and to support other activities, including agriculture, fisheries, and industry. Services from freshwater ecosystems are also seen as an integral component of a larger Water-Energy-Food nexus that remains critical for achieving several Sustainable Development Goal (SDG) targets in the Asia-Pacific region. With rapid expansion of population, increasing standard of living and expanding hydro-power sector in the Asia-Pacific region, future availability of fresh water, both in acceptable quality and quantity, remains a significant challenge for the region (*established*).

Figure 5 10 **Per cent change from the 2011 base map of ecosystem service value for each country under each of the four scenarios. Source: Kubiszewski *et al*. (2016).**

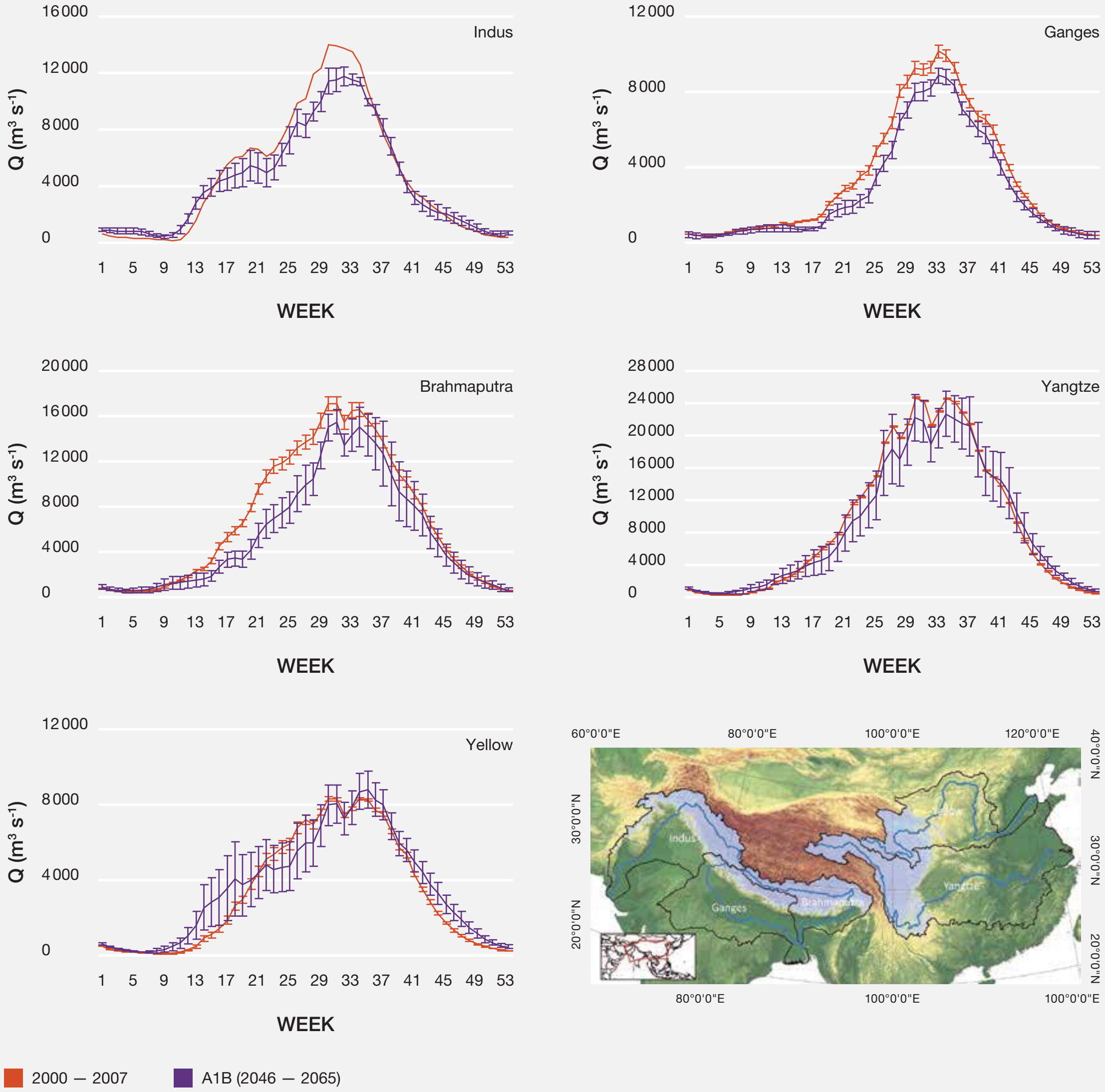


The current distribution of freshwater availability varies extensively within the Asia-Pacific region and differs widely among the subregions, as well as substantial seasonal variations. The Western Asia and the Pacific low islands are particularly water scarce with limited surface water sources and over-reliance on groundwater. However, in the tropical region of South and South-East Asia, monsoon plays a pivotal role for replenishing the freshwater systems, especially the large river systems of the region. The mighty rivers of Asia, namely the Indus, Ganges, Brahmaputra, Yangtze, and Yellow Rivers, with sources in the high mountains and Qinghai-Tibetan Plateau, serve as the primary sources of water and supports over a billion of the population living in their highly productive river-basins. However, there is a consensus that due to intense agricultural activity and massive water withdrawal, demand for water outstrips the natural replenishment capacity. The observed trend in rainfall, despite extensive variation, remain mostly unaltered or *inconclusive* of any specific pattern. While in some cases, rainfall increased over the decades, some also registered downward trend. For instance, IPCC's fifth assessment report stated that, in South Asia, a frequent deficit monsoon has been prevalent in recent years, however, with an increase in extreme weather events (Hijioka *et al.,* 2014). Similar consequences are also observed in Western Asia, with a non-significant downward trend in mean precipitation over the recent years. In general, Hijioka *et al.* (2014) pointed out that due to lack of historical observation in many parts of the region, it is difficult to draw any conclusive evidence of rainfall variability.

Water availability in the major Asian rivers, nonetheless, has been decreasing, often due to wide-spread diversion for irrigation purposes (Biemans *et al.,* 2011; Syvitski *et al.,* 2009). For instance, water-intensive crops, such as cotton are being produced in water-stressed regions or even water-scarce areas, sharply promoting diversion of fresh water from natural streams. The immediate ecological consequence of lack of freshwater reaching the ocean is a loss of sediment accumulation in large river deltas, damaging nutrient supply for aquatic ecosystems and potentially endangering faster submergence under the rising sea level (Syvitski *et al.,* 2009). In Indus delta, for example, 50 per cent decline in fish catch has been reported since 1993, while high salinity (because of reduction of freshwater flow) virtually turned previously diverse mangrove forest into a mono-specific mangrove forest (Memon, 2005). The future projections in perennial water flow in the big rivers basins within the Asia-Pacific region is most likely to decline, especially during the summer (Alam *et al.,* 2016; Elliott *et al.,* 2014; Immerzeel *et al.,* 2013) (see **Box 5.3**).

Box 5 3 Projected changes in water flow and supply across four major Asian river basins.

Figure 5 11 Simulated mean upstream discharge for the present (2000-2007) and projected future (2046-2065) under SRES A1B scenario, for the five major rivers of the Asia-Pacific region (Indus, Ganges, Brahmaputra, Yangtze, and Yellow rivers). Source: Immerzeel, Beeks & Bierkens (2010).



Box 5 3

The Indus, Ganges, Brahmaputra, Yangtze, and Yellow rivers are the significant sources of water for over 1.4 billion people in the Asia-Pacific region. Below is a set of figures showing the simulated mean upstream discharge for the present (2000-2007) and projected future (2046-2065) under SRES A1B scenario, for the five major rivers (see inset map). The model outputs show that all rivers are susceptible to flow reductions under climate change scenario, but the flow reductions are greater for Indus and Brahmaputra, threatening water and food security of over 60 million people dependent on those two rivers (Immerzeel *et al.,* 2010).

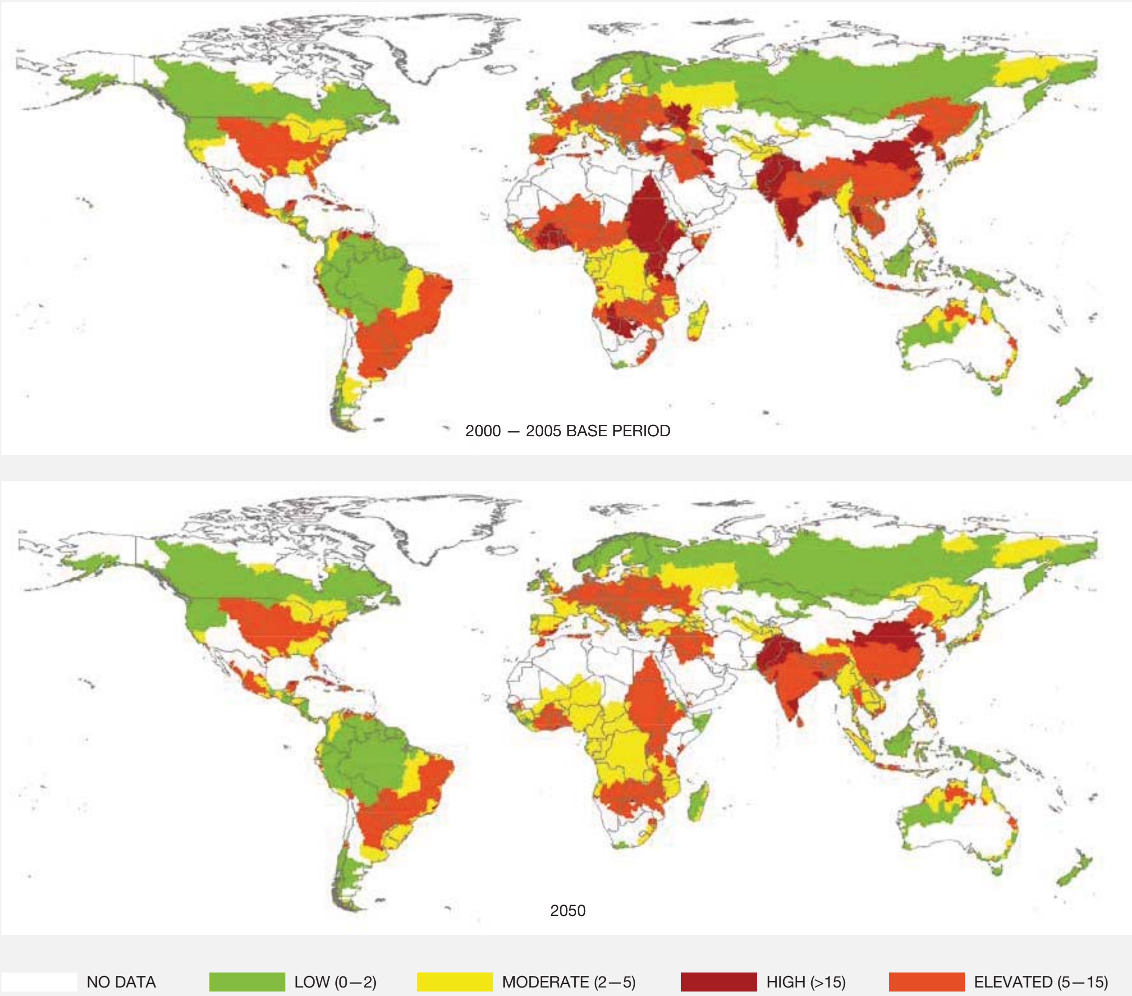
In addition, there are some trends suggesting shifts in monsoon regimes, rainfall or precipitations, and seasonality of dry and wet season, which may vary across subregions and countries (Hasson *et al.,* 2016; Trang *et al.,* 2017; Wang *et al.,* 2017). These climate change-related reductions and modifications of river flow and water supply will have large adverse consequences for the biodiversity, livelihood, food production, and water availability to the millions of people in the Asia-Pacific who are dependent on the major rivers for their water and food supply (Elliott *et al.,* 2014; Ferraro *et al.,* 2013; Hejazi *et al.,* 2014; Quinn *et al.,* 2013).

Future projections also suggest that construction of dams and blocking of tributaries would vastly reduce freshwater availability in downstream of major rivers, impacting biodiversity and nutrient transportation. Lack of freshwater flow may reduce further flora and fauna diversity, including mangroves and several freshwater fish species, particularly in the ecologically fragile delta areas, and indirectly impacting livelihood and security from natural disasters. For instance, a study by Ziv *et al.* (2012) modeled a potential catastrophic consequence of aquatic biodiversity and loss of commercially important fish species, if the planned dam constructions are executed across the Mekong River Basin - currently the most prominent inland fishery area of the world. Moreover, the quality of water would also deteriorate across the major river basins in Asia, particularly in South and South-East Asia, impacting freshwater biodiversity. A study conducted by CSIRO suggested that water quality in the major river basin would largely deteriorate unless strict management action is enforced **(Figure 5.12)**.

5.2.3 Coastal/Marine Ecosystems

Coastal/marine ecosystems, comprised of mangroves, coral reefs, seagrass beds and salt marshes, provide essential ecosystem services for vast section of the region's population living in the densely populated low lying coastal areas, including large river-deltas and several Small Island Developing States. The Asia-Pacific region, particularly, South-East Asia accounts for exceptional marine and coastal biodiversity and hosts nearly 32 per cent of the world's coral reefs (Wilkinson, 2008) and over 30 per cent of global mangroves (Hamilton & Casey, 2016). Several of the member states enjoy a relatively high share of mangroves, which include Indonesia (28.40 per cent), Malaysia (5.76 per cent), Papua New Guinea (5.12 per cent), and Myanmar (3 per cent) (Hamilton & Casey, 2016). The significant extent of mangroves is also found in South Asia and Oceania. On the other hand, the Coral Triangle in the western Pacific Ocean, which extends over the waters of Indonesia, Malaysia, the Philippines, Papua New Guinea, Timor Leste, and Solomon Islands, is a unique habitat for nearly 600 distinct species of reef-building corals that support more than 2000 species of reef fishes; while the Great Barrier Reef in Australia, stretching for over 2,300 kilometres, remain the world's largest reef system (Bohensky *et al.,* 2011; Wilkinson, 2008). However, over the years, the tropical coastline in the Asia-Pacific region underwent massive human-induced changes, with severe reported losses in mangroves, coral reefs, and a number of other important marine species. Spalding *et al.* (2010) reported that since 1980, South and South-East Asia had lost over 1.9 million ha of mangroves. Globally, mangroves are disappearing at an alarming rate of 1 to 2 per cent per year (Duke *et al.,* 2007), yet, the rate is particularly disturbing for South-East Asia. Hamilton & Casey (2016) reported that despite a growing awareness and recent slow-down in global mangrove deforestation, South-East Asia continues to lose mangrove with deforestation rates varying between 3.58 per cent and 8.08 per cent every year. Agricultural expansion into existing mangrove habitat accounted for the bulk of the mangrove loss in the Asia-Pacific region, particularly in South-East Asia, followed by an exponential rise in brackish water aquaculture. Approximately 75 per cent of the global commercial shrimps are produced in Asia, which is also known as an important economic activity for revenue generation, and is expected to rise in the near future. Globally, about 82 per cent of the reported loss of mangroves during 1975–2005 has been triggered by agricultural expansion (C. Giri *et al.,* 2008), and it continues to be an influential future driver. For instance, a study by Webb *et al.* (2014) projected that mangroves in the Ayeyarwady (Irrawaddy) Delta of Myanmar might disappear by 2030 with the current rate of agricultural expansion unless an optimum balance is achieved locally. However, countries like India and Bangladesh have been largely successful in maintaining a steady mangrove extent. For instance, a study by Giri *et al.* (2007) reported a negligible loss in the Sundarban mangroves, the largest contiguous mangrove forests stretching across India and

Figure 5 12 **Water quality risk indices for major river basins during base period (2000-2005) compared to 2050. Source: Veolia and IFPRI (2015, Fig. 3, p. 9).**



Bangladesh, since the late seventies. In both the countries, an extended network of protected areas, have played a significant role in mangrove conservation, despite tremendous population pressure in the vicinity.

The future of mangroves in the region, nonetheless, will be dominated by both climatic and non-climatic direct drivers. Of which, non-climatic drivers, such as human-induced land use changes, urbanization, agriculture and aquaculture expansion, will lead the primary changes for mangrove habitats, at least for the near and short-term future, although with varied extent across the subregions. Because of increasing demand for land, small island mangrove habitats remain particularly susceptible to future changes and are prone to local extinction. Climate change, on the other hand, may result in 10-15 per cent decline in mangrove habitats for long-term future (Alongi, 2008). Sea level rise could threaten mangroves especially in Bangladesh, New Zealand, Viet Nam, and China (see section 3.2.1). With rising sea-level, mangrove extent would probably decline first, and, subject to land availability, will migrate inwards. Some studies also suggest that rising temperature would result in poleward migration of mangroves, with anticipated changes in species composition (e.g. Gilman *et al.* (2008)). There is a strong consensus among the existing literature that loss of mangroves will lead to discontinuation of several primary benefits, such as shoreline stabilization, sediment accumulation, coastal protection, particularly for the low-lying coastal areas and thus, make communities more vulnerable to natural disasters and climate change (Gilman *et al.,* 2008). The projected monetary value of these foregone ecosystem services due to losses in mangrove area (2000-2050) in South East Asia has been given by Brander *et al.* (2012). Using the results of the IMAGE GLOBIO integrated assessment models for 1230 mangrove patches in South-East Asia (Brunei, Cambodia, Indonesia, Malaysia, Myanmar, Philippines, Thailand, and Vietnam), they produced aggregated values (losses) at the country level for foregone mangrove ecosystem services. The annual value of lost ecosystem services from mangroves in South-East Asia is estimated to be approximately $2.16 billion in 2050 (2007 prices), with a 95 per cent prediction interval of $1.58–2.76 billion. Assuming a linear time profile of these losses between 2000 and 2050, the present value of the stream of lost ecosystem services has been estimated between $17 billion - $40 billion expected to occur each year over the period 2010–2050.

Coral reefs also remain vulnerable to climate change and other environmental factors, predominantly from ocean warming, measured as rising sea surface temperature (SST) and ocean acidification. However, fishing and harbour activities, together with natural disasters such as cyclones and tsunamis have also played a key role in reef destruction in the past. Within the existing literature, there is a significant attribution of coral bleaching due to a rise in sea surface temperature, notably in 1998 and 2002, as well as during 2005, 2014 and 2016 (Donner *et al.,* 2005; Wilkinson, 2008). Although corals can recover from mild bleaching, the persistent rise in sea surface temperature continues to threaten coral reefs almost across the globe. For instance, a study by Yara *et al.* (2012) estimated that even with the best possible consequences, climate change would significantly reduce coral reefs in the Japan sea (see **Box 5.4**)

Based on an extensive assessment of published literature, Wilkinson (2008) provided the likely future for 40 years, and categorized coral reefs as follows: (1) Reefs 'effectively lost' [with 90 per cent of the corals lost and unlikely to recover soon] (2) Reefs at a critical stage with 50 to 90 per cent loss of corals and likely to become 'effectively lost' in next 10 to 20 years; (3) Reefs threatened with moderate signs of damage: 20–50 per cent loss of corals in 20–40 years, and (4) Reefs under no immediate threat of significant losses. In **Figure 5.13**, derived from Wilkinson's (2008) assessment, we summarize the current and future state of coral reef in the Asia-Pacific region. As such, the figure suggests that coral reefs in South and South-East Asia remain particularly in a perilous condition and unless appropriate management efforts are in place. This figure, however, does not fully account for the likely impact of climate change. However, it is estimated that 90 per cent of the existing reefs will experience the adverse impacts of the rise in sea surface temperature and ocean acidification by the end of the 21[st] century (Kwiatkowski *et al.,* 2015) (see **Box 5.5**), with other impacts of climate change on coral reefs anticipated by 2050 unless climate change mitigation strategies are effectively implemented (Frieler *et al.,* 2012; Hoegh-Guldberg *et al.,* 2007; Munday *et al.,* 2008; Pandolfi *et al.,* 2011; Reyes-Nivia *et al.,* 2013; Yara *et al.,* 2014).

Box 5 4 CASE STUDY: Future of corals around Japan under climate emission scenarios. From Yara *et al.* (2012).

CO_2 emissions causes ocean acidification, and along with global warming, it is an imminent issue for future status of calcifying organisms such as corals, because dissolved CO_2 reduces the saturation state of the carbonate mineral aragonite (Ωarag) in seawater (Hoegh-Guldberg *et al.,* 2007). Future coral habitats in the seas around Japan during this century were estimated based both on global warming and on ocean acidification, by using the results from the coupled global carbon cycle–climate model under the Intergovernmental Panel on Climate Change (IPCC) emission scenarios SRES A2 and B1 (Yara *et al.,* 2012, 2016). Under the business-as-usual emission scenario (SRES A2), coral habitats will be sandwiched and narrowed between the northern region, where Ω_{arag} decreases, and the southern region, where coral bleaching occurs. This resulted in disappearance of corals around Japan in the 2070s. Under the low-emission scenario SRES B1, however, the coral habitats will also shrink in the northern region due to the reduced Ω_{arag}, but to a lesser extent than under SRES A2, and in contrast to SRES A2, no bleaching will occur in the southern region. Therefore, coral habitats in the southern region are expected to be largely unaffected by ocean acidification or sea surface temperature warming under the low-emission scenario. Potential future coral habitats depend strongly on CO_2 emissions, and emphasize the importance of reducing CO_2 emissions to prevent negative impacts on coral habitats, which was also suggested for the world's corals and achieving the Paris Agreement is required (Magnan *et al.,* 2016).

Box 5 5 Delaying coral bleaching and degradation using mitigation technology (Kwiatkowski *et al.*, 2015).

Coral reefs from around the world, especially those in tropical latitudes, are projected to experience a high frequency of bleaching, death, diseases, and degradation, under the influence of climate change. Even under RCP2.6, that could achieve the increase of global mean temperature to 2°C, about 90 per cent of corals are expected to suffer severe degradation by 2050. However, analyses and simulations of geoengineering technology showed the potential to delay and ameliorate the effects of high Degree Heating Months (DHM>2) by 2035 and 2055, even under the medium emission and concentration pathway RCP4.5 – Figures A and C below, compared to Figures B and D (RCP 2.6).

Figure 5 13 Status of coral reefs in different coral habitats in the Asia-Pacific region. Data source: Wilkinson (2008).

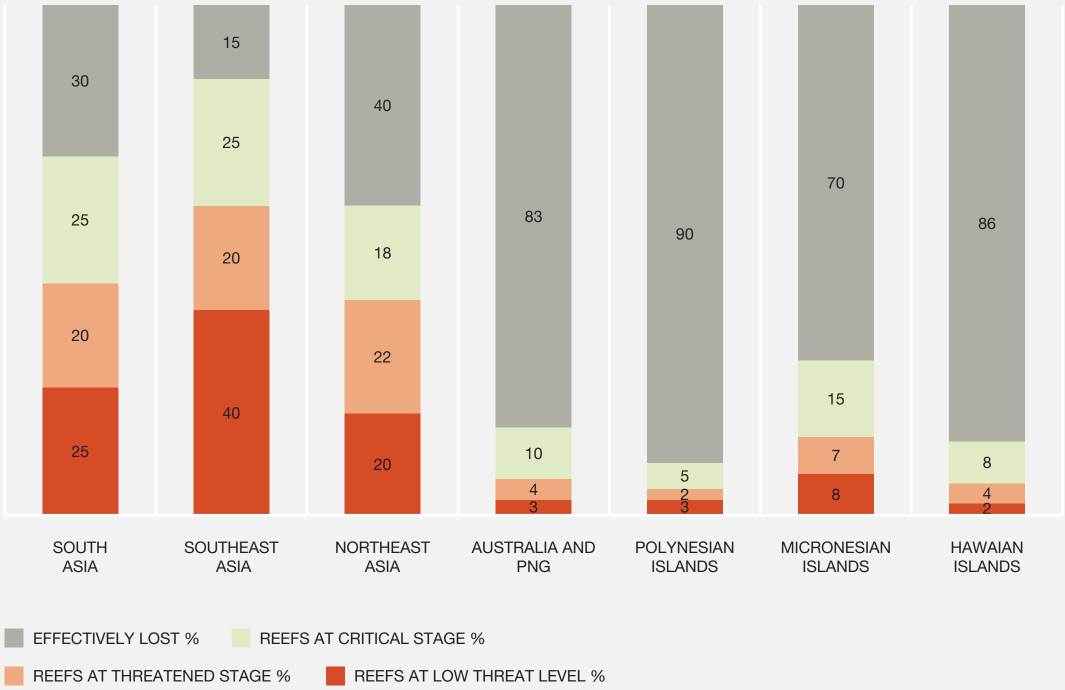
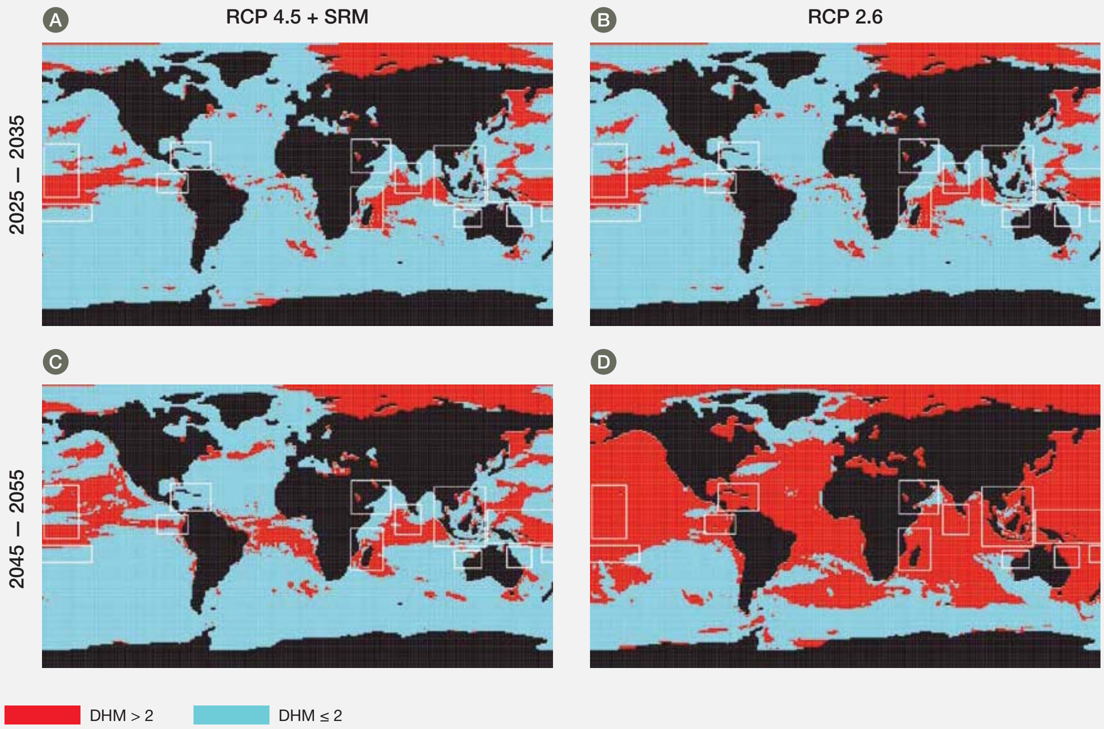


Figure 5 14 Degree Heating Months under RCP2.6 and RCP4.5 + solar radiation management. Source: Kwiatkowski *et al.* (2015).



In terms of the future trends in nature-society interactions that are dependent on coastal-marine ecosystems, a majority of the publications demonstrated that, most of the sensitive ecosystems (i.e., coral reefs, seagrass, mangroves, and their corresponding services such as fisheries) are adversely affected and will decline in productivity, albeit variably amongst subregions, also depending on latitudes (W. W. L. Cheung *et al.,* 2010; Gattuso *et al.,* 2015; Hoegh-Guldberg *et al.,* 2007; Lam *et al.,* 2016). However, the currently available literature that provides analyses of future pathways for Asia-Pacific fisheries and coastal habitats have been mostly limited to climate-related drivers (e.g., ocean warming and ocean acidification) (Gattuso *et al.,* 2015; Lam *et al.,* 2016) with no specific systematic and integrated assessments of plausible futures for Asia-Pacific fisheries. Global scale studies, which have included regional and subregional analyses, are in general agreement on the projected declines in the status of biodiversity and ecosystem services that many coastal-marine ecosystems provide across the Asia-Pacific region (Costello *et al.,* 2016; Worm, 2016; Worm *et al.,* 2009). Also, there is good evidence that such climate change-related declines are already taking effect (Blankespoor *et al.,* 2017; W. W. L. Cheung & Reygondeau, 2016; Kwiatkowski *et al.,* 2015; Schleussner *et al.,* 2016). Available evidence indicates that increased fisheries losses may occur to due to latitudinal shifts in species ranges, unless climate change mitigation is effectively implemented (W. W. L. Cheung *et al.,* 2010; W. W. L. Cheung & Reygondeau, 2016; Lam *et al.,* 2016). Of the limited national assessments carried out, indications also suggest future fisheries losses due to climate change (Bohensky *et al.,* 2011). Lam *et al.* (2016), using climate-living marine resources models, proposed that the global fisheries revenues could drop by 35 per cent by the 2050 under high CO_2 emission scenarios, with developing countries among the most severely affected. The numerous apparent drivers of fisheries decline and coastal habitat loss in the Asia-Pacific region (Section 3.2.4.6, Chapter 3, Chapter 4), indicate a plausible future where many of the fisheries and marine species in some regions of Asia-Pacific could decline considerably in the future under business-as-usual scenarios unless there is a substantial reduction in exploitation rates, perhaps as soon as 2048 (cf. Chapter 3; Chapter 4) (Costello *et al.,* 2016; Worm, 2016; Worm *et al.,* 2006, 2009). The heterogeneity of fisheries across the Asia-Pacific region and the variation in the rates of exploitation and effective implementation of policies suggest a mixture of approaches is required to avert collapse. Part of the reason for fishery decline in the Asia-Pacific region is due to acceleration in north-south redistribution of fisheries, where efforts to restore depleted fisheries in the developed world displaces fishery exploitation to the developing world, where there are weaker laws and enforcement capacity (FAO, 2016; Teh *et al.,* 2017; Worm *et al.,* 2009). A range of traditional approaches coupled with other regulatory approaches (such as strategic fishing closures, selective fishing gear, and ocean zoning) combined with economic incentives would therefore be required to prevent further depletion and steer fisheries towards a sustainable future (Costello *et al.,* 2012, 2016; FAO, 2016; Pascoe *et al.,* 2016; Worm, 2016; Worm *et al.,* 2009).

5.3 ASSESSMENT OF SCENARIOS AND PLAUSIBLE ALTERNATIVE FUTURES OF THE ASIA-PACIFIC REGION

The previous section 5.2 identified possible projected futures, broadly portraying the interactions between nature and society under the current trend or without any significant policy/management intervention (the Business-As-Usual scenario). However, these impacts indicate the likely changes in the future biodiversity and ecosystem services but is uncertain due to multitude social, political, economic and environmental factors and responses. In such cases, scenarios are useful to depict the plausible alternative futures based on integrating qualitative story lines and quantitative models, based on likely developmental pathways. This complicated scientific exercise is translated into simple and easily understandable language for the policymaker using various story lines about the future (which can be in qualitative or quantitative). However, as scientific studies do not assume a common scenario or story line, comparisons across the regions can be very difficult and in such situations, archetypes can be used to streamline the information into a set of common compatible scenarios. The methods of scenario building and assessing future changes of BES revolve around depicting plausible futures, and as such, the assumptions for alternative developmental pathways are principally governed by multitude of Social, Technological, Economic Environmental and Political (STEEP) factors (Hunt *et al.,* 2012).

There are several approaches to scenario building, at local, regional or at global scales. While global scale scenarios essentially rely on broad-based assumptions on future trajectories, subregional or local scenarios depict specific assumptions related to their spatial scales. Local scale scenarios are particularly important because they are often scaled-up as the basis of the global or regional scale scenarios and outline multiple factors and constraints that decide the course of future trajectories. Sometimes, these scenarios are developed involving various stakeholders, which could reveal some qualitative information on the validity of depicted future pathways and these can be coupled with quantitative scenarios and models to reveal options for the future (see **Box 5.6**).

Thus, attempts have been made by different studies to harmonize these various regional and global scenarios to facilitate common understanding (e.g. IPCC SRES scenarios, SSPs, Global Outlook scenarios, GEO3/GEO4 scenarios, and Millennium Ecosystem Assessment scenarios). However, it is unlikely that a single set of scenarios (or scenario family) can explain all conventional and unconventional uncertainties. Researchers or institutions mostly contemplate one set of discrete alternative futures based on their purpose-driven storylines, pre-selected drivers and accumulated experiences in future studies (Boschetti *et al.,* 2016). These storylines demarcate the area of precise interests within broad spectrum of uncertainties and thus, remain imperative to develop effective management and policy strategies.

This section attempts to explore the *plausible alternative futures* for the Asia-Pacific region, as represented in global, regional and subregional scenario exercises. In this section, we aim to understand the common threads and divergence of assumptions behind different scenarios, outlining the future socio-economic trajectories under multiple spatial and temporal scales as well as their implications for BES and human well-being.

5.3.1 Methodology for screening of scenario narratives

For this assessment, we apply a 'Global to Local' hierarchical screening approach to analyse and identify alternative futures for the region and harmonize them into a set of common agreements. Firstly, we scrutinize the assumptions behind scenarios for the Asia-Pacific region from three global assessment reports: The Global Environmental Outlook (GEO-3) (UNEP, 2002); Global Environmental Outlook (GEO-4) (UNEP, 2007); and the Millennium Ecosystem Assessment (2005), from which we identify specific considerations for the Asia-Pacific region, as well as future states of influential drivers (see section 5.3.2.1). This is followed by region-specific scenario depiction from downscaled, back-casted pathways that would essentially meet the key sustainability targets, including energy, climate, food and biodiversity with different sustainability measures such as technology and consumption change (section 5.3.2.2.). These pathways are adopted from PBL (2012, 2014), based on Alkemade *et al.* (2009), and provide subregion-specific, quantitative estimation of future status of BES and influential drivers using the GLOBIO model (http://www.globio.info/home). Lastly, we conducted a systematic literature search and review of regional and subregional scenario studies, incorporating appropriate peer-reviewed literature and important grey-literature sources (section 5.3.3). The review principally aims to explore scenario assumptions, often portrayed as qualitative storylines, to improve understanding of scenario typology and attributes, subregional characteristics, drivers and, their orientation to the Aichi Targets and Sustainable Development Goals.

Box 5 6 Role of Participatory Scenario building in delivering sustainable future.

An assessment of the participatory scenarios and models in the Asia-Pacific region demonstrates positive results for BES and human well-being where local people and other stakeholders have been involved in the decision-making process. Regional studies have indicated that incorporating local knowledge and scientific knowledge is essential to support local planning and inclusive decision-making to achieve long-term sustainability (Castella *et al.,* 2014; Nguyen *et al.,* 2013). It was further observed that adequate governance structures and institution that ensure community participation in the decision-making process, women's empowerment and leadership play an important role in assuring sustainable future. The role of participatory modelling and scenario building exercises remain also critical elucidating information that supports key sustainability issues. Models developed through participatory involvement with research are particularly useful in this regard and remain imperative to enhance participation, empower stakeholders through knowledge-sharing and increase local-legitimacy and policy salience (Castella *et al.,* 2014). For instance, using participatory models, Richards *et al.* (2017) demonstrated that providing people with a platform to share more information on ecosystem services should encourage them to consider a wider range of benefits that nature provides, and this in turn, may enable habitat management that better balances trade-offs between different services. Likewise, the application of the ADWIM (Asset Drivers Well-being Interaction Matrix) accounts for multiple stressors on multiple ecosystem goods and services and cross the conceptual boundary between ecosystem services modelling and adaptation planning (Skewes *et al.,* 2016).

Scenario reviews and discussions could provide a focus for public consultations on park and other management strategies. It has proved to be a useful method for participants to focus on adaptation actions for high priority impacts on important ecosystem goods and services and to learn and reflect about the current and likely future importance of EGS to livelihoods. However, economic benefits from BES are crucial to maintain and sustain local people's interest in conservation (Purushothaman *et al.,* 2013; Timothy, 1999). Despite their profound importance in local ecosystem management, current application of participatory scenario development and analysis are largely absent. In the Western Asia, for example, lack of efforts to address the socio-economic problems and a centralized control with limited public participation are identified as major weaknesses of the spontaneous participation of communities in decision-making process (Kolahi *et al.,* 2012). Developing long term collaboration at various spatial scales is important to develop a common understanding and goal for sustainable use of BES (Amatya *et al.,* 2010).

5.3.2 Assessment of scenarios from global and regional assessment reports

5.3.2.1 Implications of existing global assessments on the future of the Asia-Pacific region

Global assessments predominantly depict a set of exploratory scenarios (i.e., how the future might emerge) and outline broad-based assumptions on influential drivers.

The GEO-3 was among the first UNEP report to introduce scenarios to depict future uncertainties, utilizing four scenario archetypes and projecting changes up to 2032. These archetypes were derived from Global Scenario Group scenarios - a set of scenario narratives developed in 1995 by the Stockholm Environmental Institute (P. Raskin *et al.,* 2002). GEO-3 named four of its scenarios as *'Markets First', 'Policy First', 'Security First'* and *'Sustainability First'*, depending on the dominant drivers under which future emerges. For instance, in 'Markets First', market forces and free-trade dominate over social, political agendas and facilitates globalization with lesser consideration for environment. 'Policy First', on the other hand, outlines the emergence of appropriate policies, such as carbon taxes and investments in non-fossil-fuel energy sources, and in general, shows better consideration for environment. 'Security First' portrays a heavily fragmented world with high inequality as wealthier groups seek self-protection. Lastly, 'Sustainability First' relies on behavioural changes, supported by equitable values and institutions that drives environmental sustainability (UNEP, 2002). These pathways were retained in the later GEO-4, which were used for thematic modelling to depict the future status of BES (UNEP, 2007). GEO-4 provided specific and quantitative information of future for the Asia-Pacific region, up to 2050, although geographical boundaries differed slightly to this assessment. The future pathways of scenario analyses for the Asia-Pacific region under the four scenarios outlined in GEO-3 and GEO-4 reveal important distinctions and similarities between these plausible futures **(Table 5.2)**.

The Millennium Ecosystem Assessment (2005) adopted a different approach, introducing four scenario archetypes: *'Global Orchestration'; 'Order from Strength'; 'Techno-Garden'* and *'Adapting-Mosaic'*. The 'Global Orchestration' scenario portrayed globally-connected societies with strong focus on economic expansion and trade-liberalization. This pathway, on one hand, envisaged better health and education, reduced poverty and inequality, however it suggested that reactive management of ecosystems might lead to reduced protection. 'Order from Strength' represents a regionalized and fragmented world, concerned with security and self-protection and similar to the GEO 'security first' scenario. The fate of ecosystems is largely compromised under this pathway, as governments are primarily concerned with economic and military security. 'Techno-Garden', on the other hand, represents sustainable global societies through technical innovation and collaboration among nations. In this pathway, technology provides ultimate solution to major global problems and artificial ecosystem services successfully cater to the future demands. Alternatively, 'Adapting Mosaic' outlines local institutions, equipped with global knowledge, leading local-scale ecosystem management and restoration. However, in time they form regional networks, creating a mosaic, to counter global problems. MEA scenarios were segregated between three-time intervals, i.e. 2000-2015, 2015-2030 and 2030-2050, of which we considered here the last two. **Table 5.3** depicts key assumptions and their consequences for the Asia-Pacific region. Despite the Millennium Ecosystem Assessment (2005) providing some projections for Asia using these scenarios, due to cross-scale dissimilarities, it was not possible to synthesize precise regional projections under these scenarios.

5.3.2.2 Region-specific scenarios and future projections of Biodiversity in the Asia-Pacific region

The three global assessments (GBO3, GBO4 and MEA) were mostly exploratory, seeking to understand the plausible alternative futures for the Asia-Pacific region. However, they do not give an indication as to the possible future trajectories to achieving global sustainability targets. To address this, The PBL Netherlands Environmental Assessment Agency employed a back-casting approach to identify alternative development pathways that could meet the global sustainability targets by 2050 (PBL, 2012). Under the GLOBIO model, which considered five broad thematic drivers to depict biodiversity futures at global scale, namely: land use changes; atmospheric nitrogen deposition; infrastructure development; fragmentation; and climate change (Alkemade *et al.,* 2009). Using the same approach (PBL, 2012), plausible regional futures for the Asia-Pacific region up to 2050 were developed for this assessment. In line with the main report, a set of four scenarios were adopted; including a Baseline (BL) 'Business-As-Usual' scenario without any strong policy interventions and three alternative scenarios that would essentially fulfil global sustainability targets for energy, climate, food and biodiversity with different sustainability measures, such as technology and consumption change. Following PBL (2012), these alternative pathways were named: (1) Global Technology (GT), (2) Decentralized Solution (DS), and (3) Consumption Change (CC) **(Box 5.7)**.

Table 5 2 **Plausible alternative futures and their regional consequences under the GEO scenarios.**

<table>
<tr><th rowspan="2">Theme</th><th>Markets First</th><th>Policy First</th><th>Sustainability First</th><th>Security First</th></tr>
<tr><th>Free-market Liberalism</th><th>Decisive initiatives</th><th>Pluralism and New Values</th><th>Self-protection</th></tr>
<tr><td>Population (UNEP, 2007)</td><td colspan="2">Expected regional population is over 4.5 billion by end of 2050.</td><td>Population growth is lowest under this scenario, expected population is close to 4.5 billion by 2050.</td><td>Population growth is highest under this scenario. Expected population of the Asia-Pacific region exceeds 5 billion by end of 2050.</td></tr>
<tr><td>GDP (UNEP,2007)</td><td colspan="3">Highest increase in GDP, nearly five-fold increase in the entire region by 2050, with per-capita GDP increasing at a comparable rate.</td><td>Growth slows to about three-fold.</td></tr>
<tr><td>Freshwater (UNEP, 2002;2007)</td><td>In Asia, water withdrawals are expected to increase leading to an expansion of areas with severe water stress, especially in Western, South and South-East Asia. Salinity due to excessive irrigation may affect agriculture in Western and South Asia.</td><td>Water demand decreases or is unchanged due to ameliorative policy arrangements.</td><td>Water demand decreases or is unchanged because of technological innovation and cooperation.</td><td>Water withdrawals increase with severe water shortage, particularly in Western Asia. Salinity due to excessive irrigation will affect agriculture in Western and South Asia.</td></tr>
<tr><td>Air Quality (UNEP2002;2007)</td><td>Coal continues to be the major energy source (driven by price). With concomitant decline in air quality.</td><td>Emission standards, clean fuel, better urban planning, improve air quality. Sulphur dioxide concentrations may decline, although economic growth contributes Nitrogen oxides increases from vehicle emissions, particularly in South Asia.</td><td>Emission standards, clean fuel, better urban planning, improve air quality. Energy efficiency contributes to improving air quality.</td><td>Coal continues to be the major energy source, air quality worsens. Low energy efficiency increases air pollution, particularly levels of Sulphur dioxide and Nitrogen oxides.</td></tr>
<tr><td>Biodiversity / Natural Capital (UNEP 2002;2007)</td><td>Greatest loss is projected under this scenario. Increases in trade and free-markets adversely impact biodiversity, especially in South and South-East Asia.</td><td>Regional cooperation to reduce illegal extraction and establish more protected areas. However, economic improvement still drives loss of biodiversity. Overall terrestrial protected area might increase.</td><td>Better technology enables monitoring and management of biodiversity and ecosystems. An environmentally aware community facilitate conservation. Terrestrial protected area might increase.</td><td>Reduction in trade and greater control over resources limit exploitation, however, in areas with no control, BES suffer greater loss.</td></tr>
<tr><td>Agricultural Land (UNEP2002;2007)</td><td>Increase in food demand (nearly two-fold) will lead to agricultural land expansion, where still possible. Technological improvements and free-trade might meet food demands and partly halt agricultural land conversion at later stage.</td><td>The potential for agricultural land conversion is highest since governments prioritize increased food production.</td><td>Crop land will perversely increase to meet the sustainability targets, modern bio-crop cultivation may prevail, particularly in South-Asia and South-East Asia.</td><td>Low economic growth will restrict expansion of agricultural land.</td></tr>
<tr><td>Forested Land (UNEP2002;2007)</td><td>Deforestation will increase and forest cover will decline.</td><td colspan="2">Due to improved regulations (and restoration) for forest conservation, forest land is partly retained, although overall still decline in the Asia-Pacific region. Nevertheless, in Sustainability first, community based conservation, participatory management of forest resources, incentives mechanism may improve forest cover.</td><td>Key forest areas are preserved as protected areas, whereas outside protection, deforestation exacerbates.</td></tr>
</table>

Table 5 3 **Important scenario assumptions and their consequences for the Asia-Pacific region (Synthesis from Millennium Ecosystem Assessment).**

Year	Global Orchestration Globally connected world	Order from Strength Progressively compartmentalized	Adapting Mosaic Local institutions-based ecosystem management	Techno-Garden Artificial ecosystem services meet sustainability
2015-30	Technological developments, particularly in the field of agriculture, food production, and energy generation, became more rapid, leading to yield intensification. Increased wealth leads to dietary changes, meat consumption increases. Regional connectivity increases. As a result, environmental issues are prioritized.	Fundamental departure from trade-reforms. Increased conflict and global terrorism create barriers between nations. Local production suffers from risk, which might offer temporary environmental benefits. However, environmental issues deprioritized, as governments focus on economic and military security. 'Asian blocs' are created from dominant economic and military powers and some trade relationship established.	Despite trade barriers, improved communication technologies lead better information exchanges. The rate of biodiversity loss remains central to global political and scientific debate. Developing countries formulate adaptation policies. Civil societies spearhead local ecosystem management. Greater protection of ecosystems and reduced organized ecological crime.	Massive investment in agriculture, use of bio-technology and ecological engineering to trigger another green revolution. Evolution of New-Asian urbanism, with, for example green building materials, lower energy and water use, and urban agriculture. Aging and shrinking cities in developed countries. Reliability in ecological engineering increases private-sector involvement.
2030-50	Crop intensification due to increased irrigation (possibly leading to a fresh water crisis), better control of agricultural pests due to adoption of appropriate technologies. Growing unity within the Asia-Pacific region, regional unification and propagation of Asian culture. Many marine and coastal ecosystems may suffer from local extinction. As a result, coastal tourism might decrease in the region.	Lack of environmental awareness in developed wealthy countries due to limited international travel. Severe water crisis in some countries. Lack of capacity to develop cross-border agreements on water sharing, leads to widespread poverty and loss of ecosystems. Most governments recognize the problems, but too late to act.	More harmonized approach to integrate socioeconomic interests in ecological conservation. Further promotion of civil societies. Due to over fishing, fish catches decline to global low, meat consumption increases. Economic reform advocated, establishment of ecological networks.	Use of alternative fuels, such as solar power increases. Emergence of Biofuel economies in Asia and reduction of oil-wealth in Western Asia. Cheap, reliable eco-technologies will reduce income inequality between urban and rural areas. Innovation in auto-mobile technology and high level of fuel-efficiencies achieved, reducing pressure on natural resources.

Box 5 7 **Target seeking Scenarios depicting plausible futures (PBL, 2012).**

Global Technology (GT): This scenario portrays a future with a focus on large-scale technology such as intensive agricultural production, and international coordination (e.g. trade liberalisation). Along Global Technology pathways, international organizations, national governments and multinational corporations jointly lead provision of large-scale, global solutions to emerging problems, including climate change and biodiversity loss (Top-down approach). Particularly, the characteristic assumptions for Global Technology pathways can be summarized as (a) significant increase in crop yield and livestock productions (b) food markets become more global with trade liberalisation (c) expansion of protected areas and (d) gradual shift to clean and renewable energy.

Decentralized Solutions (DS): The Decentralized Solutions pathway offers a focus local energy production, agricultural production with more consideration on environment, and policy interventions that support equitable access to food. Under this pathway, national governments and regional initiatives lead the way (bottom-up). Consequently, biodiversity protection becomes more diverse emanating from a variety of local/regional initiatives. The other important considerations and assumptions are (a) larger emphasis on renewable energy as local/regional and (b) lack of improvement in agricultural yields due to slowing rates of technological development.

Consumption Change (CC): This pathway depicts an environmentally-aware society with a focus on changing people's consumption patterns, most notably by limiting per capita meat consumption, especially in wealthier countries. The important considerations under this scenario are (1) meat consumption across regions are harmonized and as a result meat-demand falls in developed countries, (2) about 50 per cent reduction in food-waste, (3) equitable access to food and better fuel efficiency in developing world.

5.3.2.2.1 Plausible alternative futures for Biodiversity and influential drivers in the Asia-Pacific region

Global biodiversity loss is often reported in relative terms, such as the Mean Species Abundance (MSA) of originally occurring species (Alkemade *et al.,* 2009; van Vuuren *et al.,* 2015). Predictive modelling under the Business-As-Usual scenario suggest that the Asia-Pacific region will continue to lose habitats and species at a similar pace with the global rate of extinction, with a loss of approximately 45 per cent of the original species abundance anticipated by 2050 (PBL, 2014) (also established in 5.2). However, analyses under the three alternative scenarios (i.e., Global Technology, Decentralized Solutions, Consumption Change), suggested that MSA declines can be partly constrained if alternative trajectories are enforced, with the greatest potential along the 'Decentralized Solutions' pathway (PBL, 2012, 2014). Subregional projections indicate dynamic variations in MSA declines, with some regions able to recover previous losses and others suffering increasing rates of decline **(Figure 5.15)**. Irreversible biodiversity loss in terms of MSA is anticipated in both South Asia and South-East Asia under all scenarios. In contrast, Western, North-East Asia and Oceania may register a slowing in MSA decline along alternative pathways. In Western Asia, the *'Decentralized Solutions'* and *'Consumption Changes'* scenarios may lead to significant improvements, while the *'Global Technology'* pathway may offer improvements for biodiversity in Oceania and North-East Asia.

- In the **global technology** scenario it is envisaged that large-scale technology will be developed (with resulting increases in crop yield and livestock production, expansion of global markets and trade liberalization) and global solutions will be found to emerging problems (through protected area expansion and a shift to clean and renewable energy, among others). Biodiversity loss would be lowest under this scenario in North-East Asia and Oceania.

- **Consumption change** entails an environmentally-aware society, changed consumption patterns, falling meat demand and food waste, equitable access to food and better fuel efficiency in developing countries, with lowest biodiversity loss in South-East Asia.

- **Decentralized solutions** involve local and/or regional initiatives for biodiversity protection, energy, agriculture production with environmental consideration, policy interventions that support equitable access to food and slow technological development. Biodiversity loss is lowest in Western Asia and South Asia under this scenario.

In terms of drivers, cropland and pasture expansion will continue to trigger highest losses of MSA under all scenarios. On average, crop and pasture expansion will result in 10- 25 per cent reduction of MSA in the region, but with significant subregional variation (**Figure 5.13** (PBL, 2012, 2014)). For instance, in South and South-East Asia, expansion of croplands will lead to 22-35 per cent predicted loss of MSA in 2050, especially under the 'Global Technology' pathway. The other subregions will have comparatively lesser impacts but may still suffer from average reductions of 3-10 per cent of MSA in 2050. The growing energy demands will also drive biofuel cultivation, which will peak in a 'Decentralised Solutions'. Under the Decentralized Solutions pathway, expansion of biofuels may facilitate enhanced regional bio-economies, driven by enhancement of rural areas. Although biofuel has strong potential to achieve energy security, mitigate some impacts of climate change, and reduce rural poverty (Yan & Lin, 2009); nonetheless, it will also increase conversion of natural areas to agricultural land in both South Asia and South-East Asia. Some countries in North-East Asia may also face negative consequences from abandoned agricultural land, especially along 'Global Technology' and 'Decentralized Solution' pathways. Among other important regional drivers, such as climate change, infrastructure development and nitrogen deposition, marginal subregional variation is anticipated. For instance, climate change would be a dominant pressure for species loss in Oceania (about 8 per cent of MSA by 2050) compared to South and South-East Asia (about 5-6 per cent of MSA by 2050), while, nitrogen deposition will have similar consequences across South, South-East, and North-East Asia.

In summary, biodiversity loss would be lowest under the 'Global Technology' scenario in North-East Asia and Oceania, under the 'Consumption change' scenario in South-East Asia, and under the 'Decentralized Solution' scenario in Western Asia and South Asia **(Figure 5.15)**. The most significant pressure driving biodiversity loss is climate change in Western Asia and Oceania, and crop production in South-East Asia, North-East Asia, and South Asia (**Figure 5.16**, left side). In terms of plausible future land use, all subregions would expect increases in natural areas under the three alternative pathways, compared to the 'Baseline' scenario. The greatest increases in natural area are anticipated under the 'Consumption Change' scenario in Western Asia and South-East Asia, under the 'Global Technology' scenario in North-East Asia and Oceania, and the 'Decentralized Solution' scenario in South Asia. A decrease in natural area, in comparison with Business-As-Usual, is expected only in North-East Asia under the 'Consumption Change' pathway (**Figure 5.14**, right side).

Figure 5 15 **Biodiversity loss in the Asia-Pacific region in terms of mean species abundance under different scenarios.**

Geographical boundaries differ slightly from IPBES and IMAGE region definition, which is used for modelling purposes. In these analyses Bahrain and Iran included in Western Asia; Papua New Guinea was included in South-East Asia. Data Source: PBL (2012, 2014).

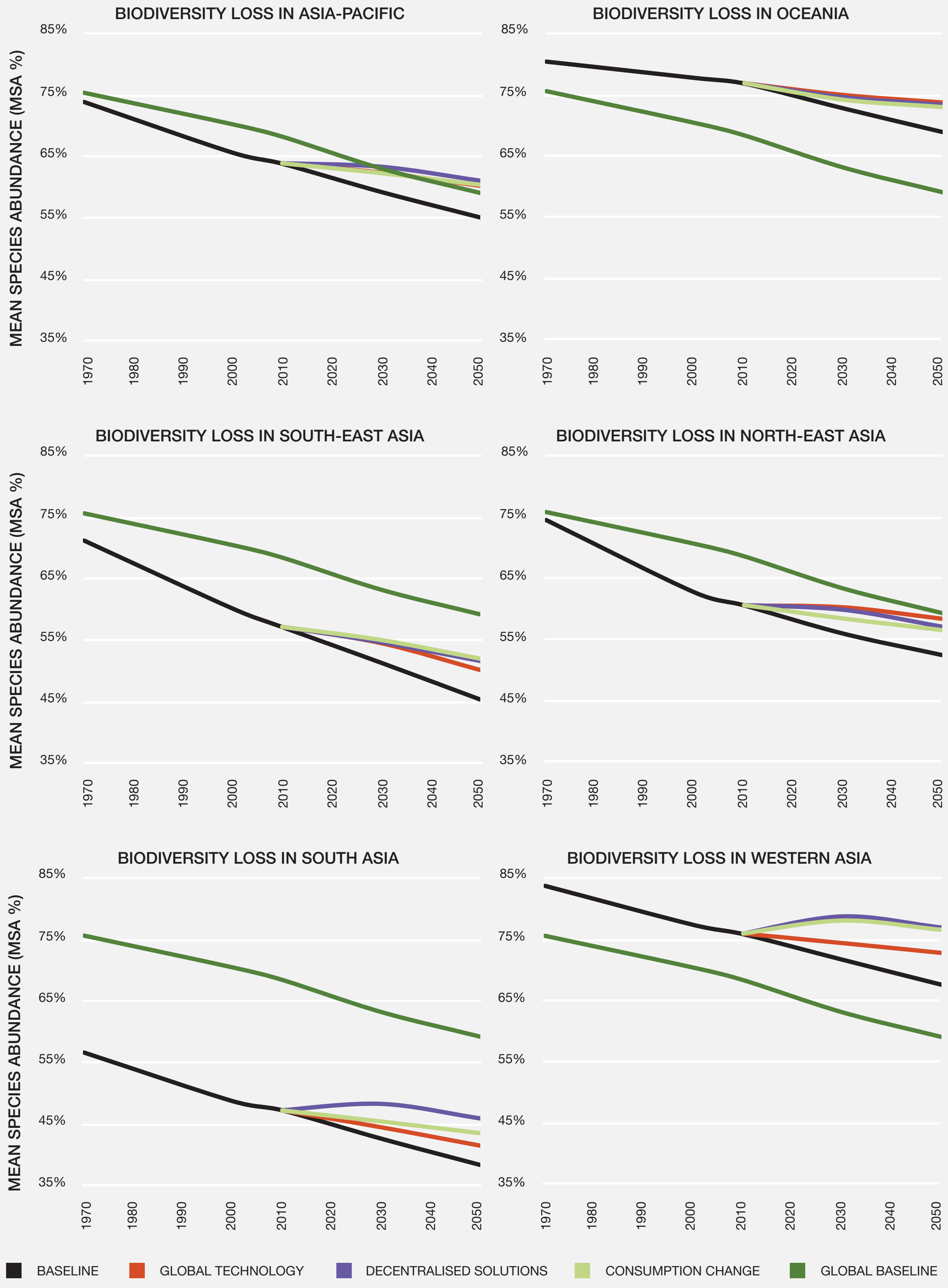


Figure 5 16 **Pressure driving biodiversity loss (left side) and projected land use changes (right side) under alternative scenarios for the entire Asia-Pacific region and its five subregions. Source: PBL (2012, 2014).**

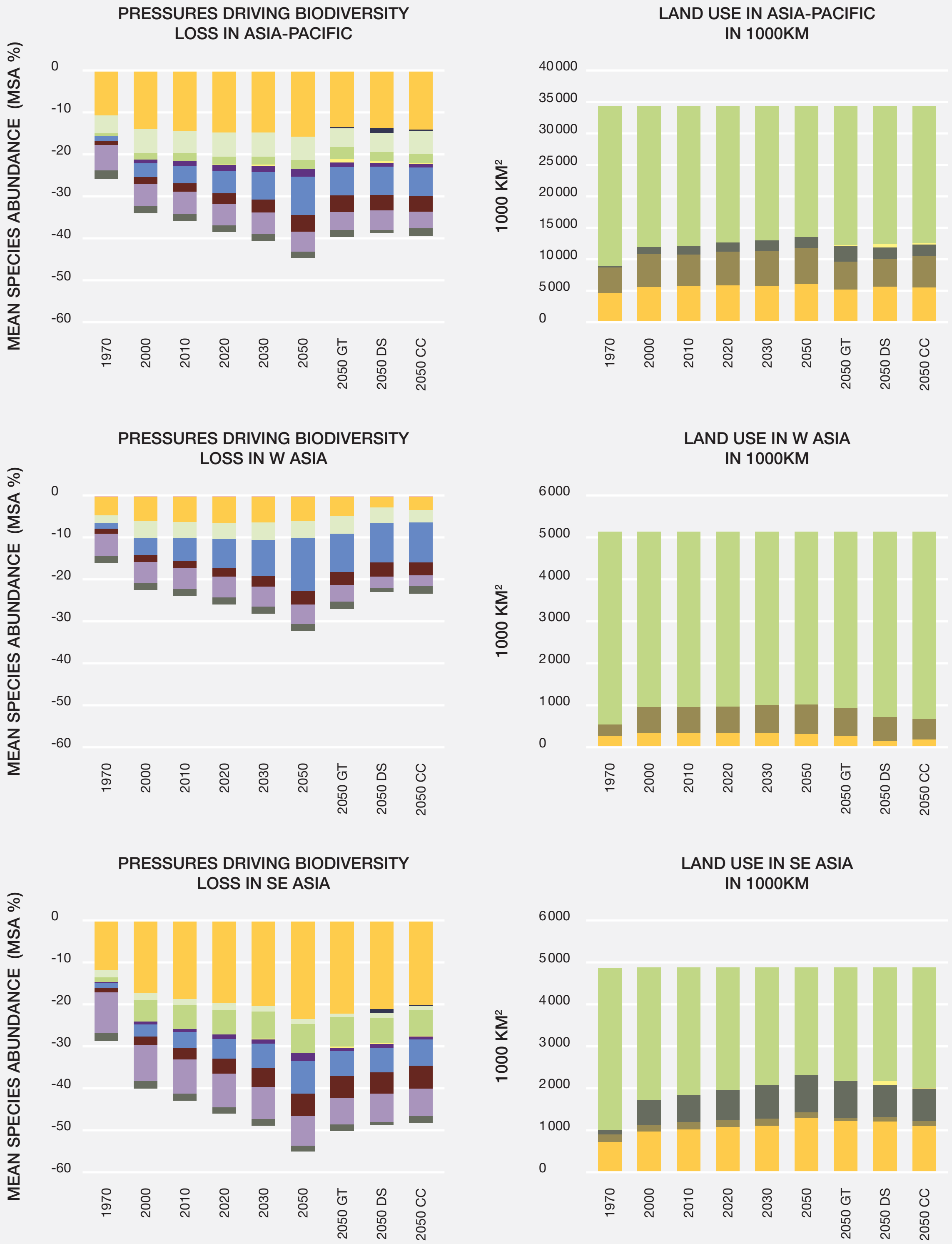


Figure 5 16


PRESSURES DRIVING BIODIVERSITY LOSS IN NE ASIA
MEAN SPECIES ABUNDANCE (MSA %)
0
-10
-20
-30
-40
-50
-60
1970
2000
2010
2020
2030
2050
2050 GT
2050 DS
2050 CC
LAND USE IN NE ASIA IN 1000KM
1000 KM²
14 000
12 000
10 000
8 000
6 000
4 000
2 000
0
PRESSURES DRIVING BIODIVERSITY LOSS IN S ASIA
LAND USE IN S ASIA IN 1000KM
6 000
5 000
4 000
3 000
2 000
1 000
PRESSURES DRIVING BIODIVERSITY LOSS IN OCEANIA
LAND USE IN OCEANIA IN 1000KM
9 000
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
FRAGMENTATION
ENCROACHMENT
INFRASTRUCTURE
CLIMATE CHANGE
NITROGEN DEPOSITION
ABANDONED AGRICULTURAL LAND
FORESTRY
PASTURE
BIOFUELS
CROPS
URBAN
BL = BASELINE
GT = GLOBAL TECHNOLOGY
DS = DECENTRALISED SOLUTIONS
CC = CONSUMPTION CHANGE
NATURE
BIOFUELS
FORESTRY
GRAZING
CROPS
URBAN

5.3.3 Assessment of scenarios from regional and subregional literature

5.3.3.1 Systematic review of regional/ subregional scenario exercises

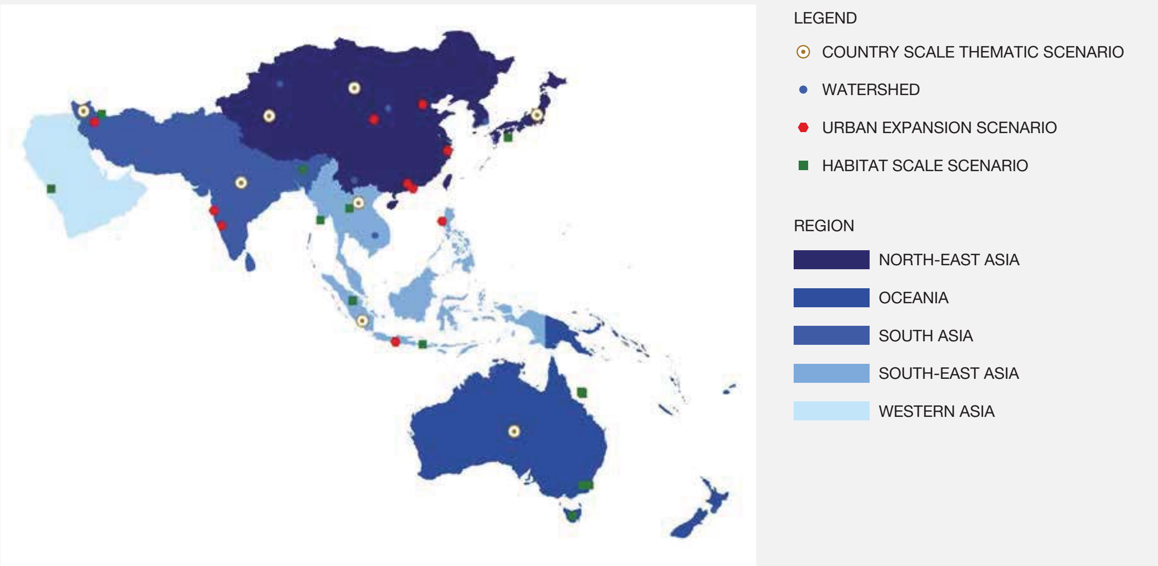
To assess the findings from regional/subregional scenario analyses, we conducted a systematic review of peer-reviewed literature and appropriate grey literature deemed valuable to include in the assessment. We searched the Scopus database (https://www.scopus.com). Specific keywords such as *'scenario'* AND *'ecosystem AND/OR biodiversity'* were used as primary search criteria. Further, articles were screened based on their geographical origin and as such, search results yielded 2,454 articles for the Asia-Pacific region. The majority of literature identified from the Scopus search, however, were not directly relevant to the assessment of interactions between BES and human well-being in the Asia-Pacific region. For instance, the word 'scenario' has been inconsistently used for depiction of ecological states and/or biodiversity status reporting rather than depiction of 'plausible alternative futures'. Hence, after preliminary screening, we relied on snowball-sampling method and included only articles that have a relevant scenario depiction of alternative futures. The latter criteria yielded a total of 61 articles from 18 countries, including national assessment reports (e.g. JSSA (2010)). Out of the 61 studies, 60 studies are from different subregions and countries, while one study conducted scenario analysis for the entire Asia-Pacific region. Articles were further classified according to their subregional distribution, spatial and temporal scales, depiction of influential drivers, and the critical synergies and trade-offs considered in relation to BES. To capture the linkages between the regional and subregional scenario exercises for future sustainability, and the 17 UN Sustainable Development Goals (SDGs) and the 20 Convention on Biological Diversity (CBD) Aichi Targets, further screening criteria were employed. These data were used to evaluate trends and gaps of current and future interactions of BES and human well-being in the Asia-Pacific region under different scenarios.

5.3.3.2 Geographical distribution of regional/subregional scenario exercises

Overall, greatest number of published scenario exercises originated from North-East Asia (18 studies), followed by South-East Asia (16 studies), Oceania (13 studies), South Asia (12 studies) and Western Asia (1 study) **(Figure 5.17)**, while one study used the entire region for scenario analysis. About 38 per cent of the literature had its geographical origin from either Australia or China.

Spatially-explicit, quantitative and exploratory scenarios dominated the regional/subregional scenario studies. Nearly 93 per cent of the selected studies explored plausible alternative futures, in comparison to five studies delivering 'policy-screening' scenarios (e.g. Cotter *et al.* (2014); Suwarno *et al.* (2016)). No studies could be retrieved which either provide 'target-seeking' or 'back-casting' scenarios - marking an outstanding research gap in development

Figure 5 17 **Map showing the distribution of regional/subregional scenarios studies.**



of normative scenarios in the region that would assist governments with policy development. Within spatially-explicit scenarios, nearly half of the studies utilized land-use transition pathways as proxies to determine competing claims over ecosystem goods and services. These delivered understanding of critical sustainability issues, such as food productivity, water availability, changing life-styles and energy consumption, and carbon sequestration. (e.g. Schaldach *et al.* (2011); Zhao & Wu (2014); Connor *et al.* (2015); Bryan *et al.* (2016)).

Regional and subregional scenarios covered a wide range of spatial scales. We segregated them into four representative spatial extents: national (or larger) scenarios, habitat-scale, urban-only scenarios, and watersheds. The first category depicts country or regional-scale scenarios which illustrate trade-offs of ecosystem services at a large spatial scale and are generally guided by national-level policies or international agreements. Habitat scale scenarios include terrestrial and aquatic conservation and/or management scenarios, limited to smaller geographic scales, including biodiversity hotspots such as national parks, biosphere reserves and world heritage sites. The third category describes distinctive urban expansion scenarios, focusing on the urbanization process and transformation of peri-urban production landscapes. Spatial extent of this category is limited to city boundaries and the peri-urban areas within the immediate vicinity. The fourth category represents watershed scale scenarios which address ecosystem services of large lakes, rivers, and wetlands, and utilizes the watershed boundary as their scale for scenario development. Watersheds are also considered as a focus of political and economic activity, for example under the MEA Adapting Mosaic scenario (Millennium Ecosystem Assessment, 2005).

Segregation based on spatial scales reveals that the greatest proportion of scenarios (35 per cent) are developed at country or even larger-scale regional levels, with habitat-scale scenarios (31.6 per cent) also featuring prominently. Watershed-scale scenarios (16.7 per cent) and urban/cityscape scenarios (16.7 per cent) occurred less frequently.

Among country-scale scenarios, land use transition pathways and their subsequent impacts on ecosystem services were developed for Australia (e.g. Bryan *et al.* (2016); Connor *et al.* (2015)), Japan (e.g. JSSA (2010)), China (e.g. Zhao & Wu (2014)), India (e.g. Schaldach *et al.* (2011)). Habitat scale scenarios, included a multitude of terrestrial and aquatic conservation/management pathways and involving biodiversity hotspots such as the following:(1) Ramsar sites and World Heritage sites, such as the Great Barrier Reef in Australia (Bohensky *et al.,* 2011; Butler *et al.,* 2013); (2) Deepor Beel, a Ramsar-designated wetland in North-East India (Mozumder & Tripathi, 2014), and (3) the mangroves of the Ayeyarwady (Irrawaddy) Delta in Myanmar (Webb *et al.,* 2014). Watershed-scale scenarios, considered ecosystem services of lakes and rivers, particularly future water availability across narratives. However, the majority of the scenario studies from the region focused on smaller river systems and watersheds (e.g. Herzig *et al.* (2016); Shooshtari & Gholamalifard (2015)). Lastly, urban expansion scenarios were dominant particularly from India and China, covering important cities such as Beijing (Han *et al.,* 2015), Hong Kong (Zheng *et al.,* 2015) and Pune, for example.

5.3.3.3 Consideration for influential drivers in regional/subregional scenarios

The review of regional/subregional scenarios identified a total of 11 conventional drivers, including both direct and indirect drivers, which would shape the future nature-society interactions. As such, many studies considered combinations of drivers, in line with section 4.3 in chapter 4. Accounting separately for individual drivers, ‘population growth/demographic changes’ was identified as the most influential regional driver (40.9 per cent), followed by climate change (32.3 per cent), agricultural expansion (20.2 per cent) and urbanization (20.9 per cent). The selection of dominant drivers, in general, aligns with existing global assessments such as the MEA (2005) and GEO-3/4 (UNEP, 2007); and the PBL (2012, 2014).

Subregional distribution of influential drivers shows moderate variation in their intensity (see **Figure 5.18**). For instance, in Oceania and North-East Asia, indirect drivers are less integrated in plausible scenarios, whereas in South Asia and South-East Asia, indirect drivers are explicitly considered, particularly changing lifestyle and consumption patterns (e.g. Hubacek *et al.* (2007)), expansion of biofuel use (Schaldach *et al.,* 2011), governance reforms (e.g. Ornetsmüller *et al.* (2016); Webb *et al.* (2014)). Climatic direct drivers, such as sea level rise and rise in sea surface temperature have been captured more often in Oceania including the Pacific islands, compared to the other subregions, in part because of the well understood vulnerability of small islands and low-lying coastal areas of Pacific origin (c.f. IPCC). Several direct drivers are highlighted that have not been rigorously considered in scenario development and the articulation of plausible futures. Most notable are introductions of non-native species and threats from emerging zoonotic disease.

Crucially, the *time-horizon* and *number of alternative futures* considered in scenario developments are important to understand impacts of drivers in alternative pathways. Exploration of time horizons facilitates understanding of the trade-offs between BES and human well-being, whilst the number of alternative scenarios captures plausible socio-ecological pathways or trajectories. Accordingly, studies have tended to formulate intermediate scenarios to examine synergies and trade-offs more accurately, dividing

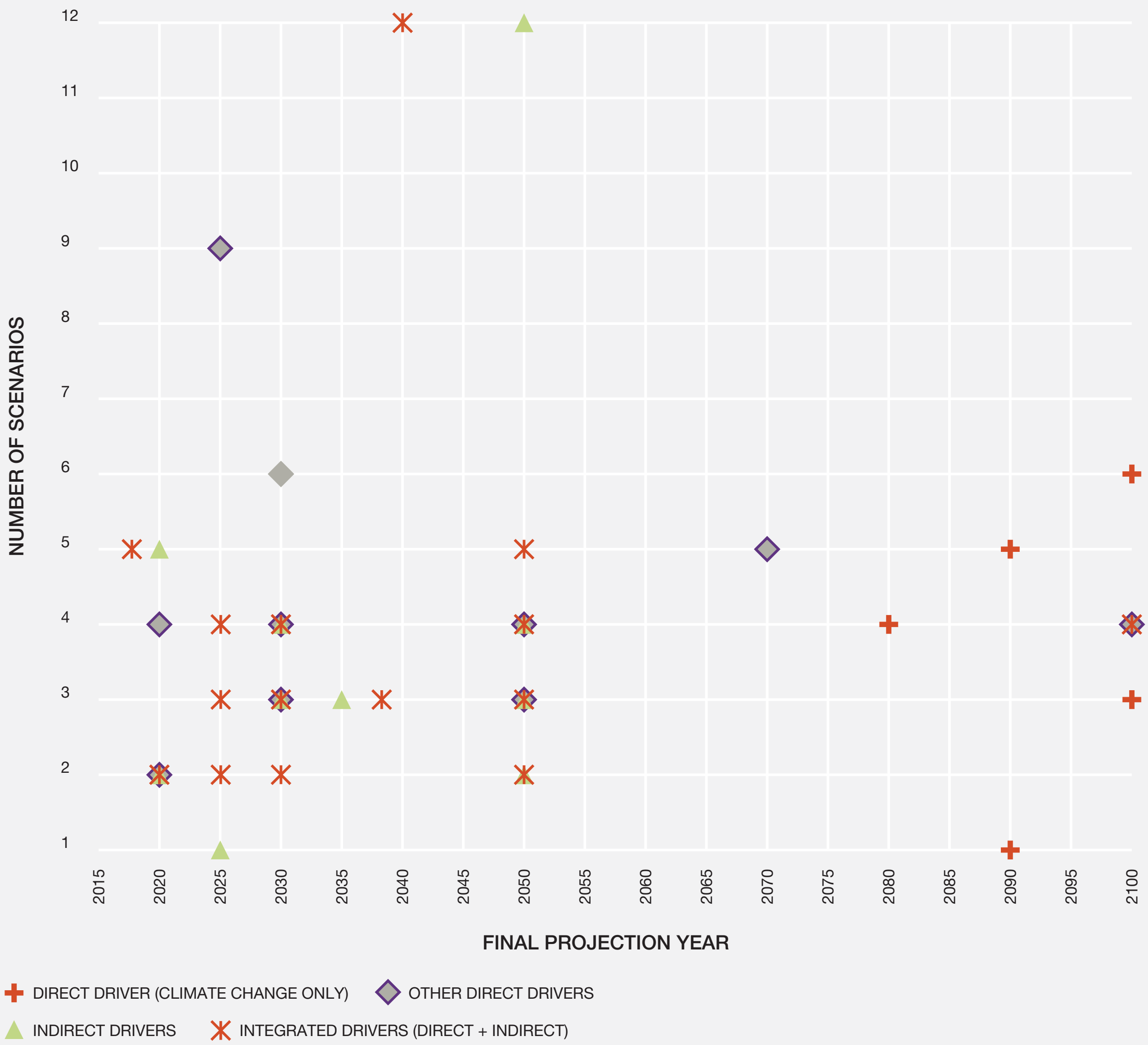
Figure 5 18 **Subregional distribution of drivers considered for scenario development.**

Cell values correspond to per cent share of literature from each subregion. One study covering the entire Asia-Pacific region was not included for this analysis. ** Denotes inconclusiveness due to lack of representative literature.

		Western Asia (n=1)	South Asia (n=12)	South-East Asia (n=16)	North-East Asia (n=18)	Oceania (n=13)
DIRECT DRIVERS	Degradation of Land	**	8.3	31.3	22.2	23.1
	Natural disasters	**	0.0	6.3	16.7	7.7
	Climate Change and all related impacts	**	25.0	18.8	33.3	46.2
	Water related drivers (pollution etc.)	**	16.7	0.0	0.0	23.1
	Agricultural expansion	**	16.7	31.3	11.1	23.1
	Urbanization	**	25.0	25.0	27.8	7.7
	Other direct drivers (Invasive species, Fire, New Breeds etc.)	**	8.3	6.3	0.0	15.4
INDIRECT DRIVERS	Population Growth and demographic Changes	**	41.7	50.0	44.4	30.8
	Economic drivers	**	33.3	25.0	11.1	7.7
	Policy Drivers	**	8.3	31.3	16.7	15.4
	Other indirect drivers (Global development etc.)	**	0.0	6.3	0.0	7.7

Figure 5 19 **Segregation of regional scenario exercises based on number of alternative pathways (y-axis), type of drivers and final year of projection (x-axis).**

Since nine studies did not specify final projection year, the current analysis shows the result of 52 articles.



longer time horizons into two or more periods, often in line with global assessments (e.g. MEA (2005)). While, in general, the sample set of literature captured broad time-horizon, however, nine studies did not specify any specific projection year.

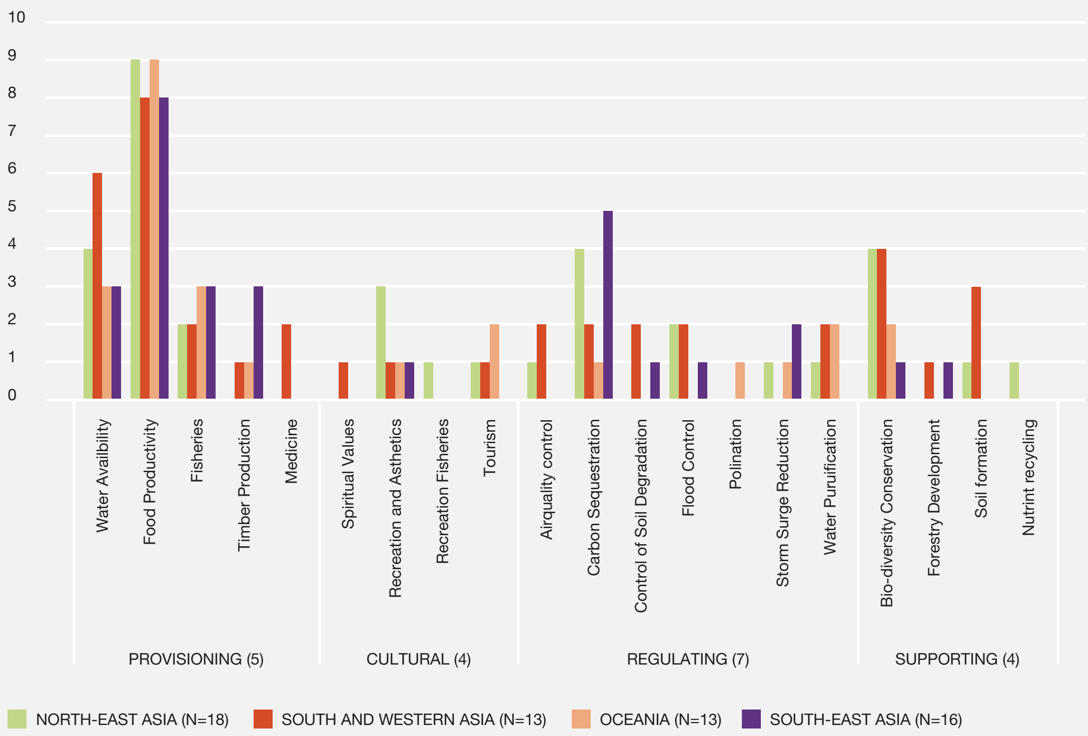
It is inherently difficult to generalize the number of alternative futures, however, 40 out of the 61 selected studies used three or four alternative scenario archetypes to depict the uncertainties in various driver sets. A further ten studies portrayed more than four alternative scenarios and identified long-term, cross-scale relationships between influential drivers. Across the Asia-Pacific, 'indirect' drivers (mainly population growth, consumption changes, economic drivers) and integrated drivers (including non-climate direct drivers and other indirect drivers), were examined in three or four alternative scenarios over short-term frames (i.e. 2015-2045). Conversely, mid-term scenarios (i.e., 2045-2075) typically considered direct drivers and/or integrated drivers cutting across climate change and economic growth. Longer-term scenarios (i.e., 2075-2100) characteristically focus on climatic direct drivers alone and depicted larger numbers of (>4) alternative scenarios. **Figure 5.19** depicts the cross-scale relationship between drivers, number of alternatives and final projection year.

5.3.3.4 Consideration of Ecosystem Services and Nature's Contribution to People

In our review of regional and subregional scenarios, the greatest emphasis was on provisioning ecosystem services, followed by regulating and supporting ecosystem services **(Figure 5.20)**. Even though we encountered variety of regulating (n=7), cultural and supporting ecosystem services, over 50 per cent of the scenario exercises examined plausible future trends in food provisioning services (e.g. Fox *et al.* (2012); Baral *et al.* (2014)). These in turn primarily focused on agricultural production landscapes (including expansion of biofuels and land-competition), as well as limited attention on productive marine and coastal areas. The trade-off between agricultural intensification and consequent loss of habitat quality was *well established* in almost all the spatially explicit scenarios (e.g. Fox *et al.* (2012); Baral *et al.* (2014)). Furthermore, the impact on the food provisioning services of demographic and economic drivers including trade reforms, global and domestic policy changes, and urbanization were addressed in various policy-screening scenarios (e.g. Corner *et al.* (2015)). Water availability was also addressed by studies examining potential impacts of indirect drivers, such as changes in life

Figure 5 20 **Proportion of ecosystem services addressed in scenario exercises for the Asia-Pacific region.**

Bars represent the number of studies considering specific ecosystem services. (N=60).



styles and consumption, and the intensification of direct drivers such as climate change, land use alteration, crop intensification, and urbanization (e.g. Herzig *et al.* (2016); Yang *et al.* (2016)). In general, however, regional scenario exercises generally lacked assessments of cultural or non-material ecosystem services, probably due to lack of *well-established* models and methods, highlighting a significant research gap.

5.3.4 Harmonizing global, regional and subregional scenarios

The section 5.3.2 synthesized the relevant assumptions and implications for BES in the Asia-Pacific region from the GEO-3/GEO-4 scenarios, Millennium Ecosystem Assessment scenarios, and the target-seeking scenarios developed by the PBL Netherlands. In the following section (section 5.3.3), the contingent of 61 regional/subregional scenario studies illustrated a total 224 plausible alternative futures, depicting multitude of possibilities involving conventional uncertainties (e.g. changes in social and technological systems, trade liberation, regional integration, and globalization). Particularly, the subregional scenarios provided place-specific, competing assumptions on local drivers and their likely implications. As such, within the reviewed regional and subregional studies, we observed four principle means of scenario development, including localization of global scenario narratives. Nearly 35 per cent of the existing studies utilized the assumptions of one or the other global scenario narratives. This includes the IPCC SRES scenarios (e.g. Khoi & Suetsugi (2014); Soora *et al.* (2013); Ty *et al.* (2012); Zhao & Wu (2014)), RCP (e.g. Dai *et al.* (2016); Wang *et al.* (2017)), the GEO scenarios (e.g. Connor *et al.* (2015)), and the Millennium Ecosystem Assessment scenarios (e.g. Schaldach *et al.* (2011)). Some studies further applied cross-selection of narratives, by integrating global scenarios with domestic policy provisions (e.g. Bryan *et al.* (2016)). However, the other three modes of scenario development, i.e. 'participatory scenario' approach (e.g. Mitchell *et al.* (2015; 2016)), 'policy review' approach (e.g. Cotter *et al.* (2014); Suwarno *et al.* (2016)) and 'trend manipulation' approach (e.g. Thapa *et al.* (2013); Mozumder & Tripathi (2014)), which collectively constitute about 65 per cent of the regional/subregional scenarios, provided distinctive and place-based assumptions of influential drivers; and unlike the global scenarios, sometimes indicated asymmetric manifestations of influential drivers. For instance, Feng and Liu (2016) introduced an 'eco-storm' scenario archetype for Lingang New City in China, which identifies 'intensification of storm surges' alongside 'rejuvenation of coastal ecosystem services'. With these diverse variety of scenarios, it is extremely difficult to assimilate the underlying core assumptions of dominant drivers for the region/subregions and to depict the plausible trajectories on how the regional future might emerge.

To have a common agreement on plausible futures, an archetype-based harmonization, thus, remains imperative to synthesize vast selection scenarios, and to integrate the local scenario assumptions with their global counterparts.

5.3.4.1 Scenario Archetypes

All scenarios, irrespective of their scales, domain and development methods, are orchestrated around some common expectations of plausible eventualities, and thus it is essential to group them into small number of 'similar futures' according to the underlying assumptions, storylines, and logic (IPBES, 2016). The purpose of having an archetype is to describe a generalized set of compatible scenarios and to develop a collective logic from variety of scenario assumptions. This eases decision-making by comprehending similarities among diverse assumptions, allows mapping of plausible futures and facilitate comparison among and within the region. Some researchers suggest that 'archetypes' essentially depict plausible 'end-world' state - i.e., how the world would look in future (Hunt *et al.,* 2012), it can be equally understood from the driver perspective, i.e., having consensus on influential drivers that will impact future interactions between society and environment. Despite these differences, archetypes provide good approximation to depict the possible eventualities amidst wide interlaying uncertainties. The purpose of this section is, therefore, to provide archetypes that best explains the regional/subregional scenarios from the Asia-Pacific region and broadly interlink them to global scenario narratives.

Since the pioneering work of Global Scenario Group (GSG) group on Great Transitions (P. Raskin *et al.,* 2002), global scale environmental assessments have used scenarios for projecting plausible futures, and in doing so, they often used archetypes of predominantly four scenario variants. In particular, the IPCC's Special Report on Emissions Scenarios (SRES) (Nakicenovic *et al.,* 2000) paved the way for a generation of climate scientists to conceive, elaborate and analyse range of plausible futures (Alcamo & Henrichs, 2008; Wardropper *et al.,* 2016). In fact, from the third Global Environmental Outlook (GEO3) report, the first UNEP report to introduce scenarios, to the recently formulated Shared Socio-economic Pathways (SSPs) for IPCC's fifth assessment report (2014), there is no dearth of scenario families at the global scale, which are not only rich in vocabulary, but also cater to wide thematic purposes. The choice of scenario archetypes, however, differ considerably among researchers/institutions, based on the understanding of dominant drivers and pre-defined objectives (Boschetti *et al.,* 2016). Despite many such global-scale scenarios, there are a limited number of overviews that synthesize them into groups of plausible futures (e.g. Raskin (2005); Hunt *et al.* (2012) and Cheung *et al.,* (2016)). Of these, Raskin (2005) was among the first to harmonize the global scenarios. The IPBES methodological assessment on scenarios and models have also grouped the global scenario families using six representative scenarios, adopted from an archetype proposed by Van Vuuren *et al.* (2012). The six pathways are: Global Sustainable Development, Business-As-Usual, Regional Competition, Economic Optimism, Reformed Markets, and Regional Sustainability. These studies provide an established method to group the popular global scenarios, including IPCC SRES, Millennium Ecosystem assessment, and GEO-3/4.

Focusing specifically on subregional and local scale scenarios, Hunt *et al.* (2012) provided archetypes based on the existing Global Scenario Group scenarios and synthesized a large number of global, regional and subregional scenarios. The three-world archetypes, i.e. *'Conventional World', 'Great Transitions' and 'Barbarization'* denotes the 'official future', 'the sustainable future' and 'what could go wrong' and follows the Bezold's (1999) argument on having thee-world scenario archetypes. Each of these three-world end-states was further categorized into two sub-scenarios, depicting an archetype of six alternative pathways (i.e. *'Policy Reform', and 'Market Forces' under 'Conventional World', 'Eco-Communalism' and 'New Sustainability Paradigm 'under 'Great Transitions', 'Break Down' and 'Fortress World' under 'Barbarization'*). Supported by some broad selection criteria of likely changes in STEEP drivers, Hunt *et al.* (2012) used this archetype to classify an enormous number of available scenarios, including global, regional, country and local-scale scenarios. Despite certain approximations, we adopted the same archetypes to classify and map the reviewed global, regional/subregional scenarios. The specific reason behind the adoption of Hunt *et al.* (2012) archetypes is that we found that the underlying assumptions of the three-world archetypes better suits the subregional scenarios, particularly due to very site-specific information provided in the scenario literature. 224 subregional scenarios were mapped using these archetypes with the following broad criteria **(Table 5.4)**.

Grouping based on the criteria mentioned above, under the six-scenario variants, indicated that the bulk of the scenarios utilized the 'Conventional World' pathway (see **Figure 5.21**). We observed that researchers generally considered 'Market Forces (MF)' as the most dominant scenario variant (32 per cent), followed by 'Policy Reform' (PR) (24 per cent)' and 'Eco-Communalism (22 per cent)' (EC). On the contrary, only a handful of studies could be identified that proposed revolutionary changes in institutional or human values leading to 'Great transition; or have outlined chaotic situations leading to complete 'Break-down'. The regional trend, by far, is indicative of the fact that globalization would be a dominant force in coming years and 'Market Force', would generally prevail over the entire region without any significant variation across subregions. Prominent narratives considered under MF scenario variants include a substantial number of exploratory scenarios depicting linear interpolation of current trends of urbanization, land-use changes, economic expansions, population growth and agricultural intensification and many other Business-As-Usual scenarios. Among the alternative scenarios, Policy Reform (PR) and Eco-Communalism (EC) are prevalent, as researchers

Table 5 4 **Screening criteria for regional/subregional scenarios as per Hunt *et al.* (2012).**

Archetype	Scenario variants	Key assumptions	Underlying assumptions from regional/subregional scenario exercises
Conventional World	**Market Forces**	*Free market optimism*	Trade-liberalization, Continuing foreign investments, strong international co-operation, rapid urban growth, agricultural intensification, expansion in aquaculture, heavy water-withdrawal without any efforts for conservation of BES.
	Policy Reform	*Necessary regulatory mechanisms*	Although the above drivers continue to occur, zoning, incentives, regional policy targets, new conservation policies, new protected areas, technological intervention, and fuel efficiency are enforced to reduce the loss of BES.
Great transitions	**New Sustainability**	*Societal values towards sustainability*	Restoration scenarios, the increment in social values, changes in dietary habits, eco-system based resilience planning for disaster risk reduction.
	Eco-communalism	*Semi-isolated and self-reliant communities*	Local scale community mobilization, participatory resource management, Incentives for conservation, sustainable but isolated society.
Barbarization	**Fortress world**	*Elites control an impoverished majority*	Widespread poverty and isolation, great disparities and inequality.
	Break-down	*Collapse of civil order, conflict all-over*	Disintegration, war and political breakdown

Figure 5 21 **Archetype based mapping of regional/subregional scenarios.**

Darker shade implies more scenarios are inclined towards the specific scenario variants, while lighter shade implies lack of data or inconclusive evidence.

GLOBAL SCENARIOS						
GEO 3/4	Market First	Policy First	Sustainability First		Security First	
Millennium Ecosystem Assessment	Global Orchestration		Techno-Garden	Adaptation Mosaic		Order from Strength
IPCC SRES	A1F1		B1 (A1T)	B2	A2	
SSPs (RCPs)	SSP 5 (RCP8.5)		SSP 1 (RCP 4.5)	SSP 2 (RCP 6.0)	SSP 3/4 (RCP 8.5)	
PBL, 2012	Baseline/BAU	Global Technology	Consumption Changes	Decentralized Solution		
REGIONAL SCENARIOS						
Hunt et al., 2012	Market forces	Policy reform	New Sustainability	Eco-communalism	Fortress world	Break down
Dominant Change Themes	Market	Policy	Social Values	Localized	Inequality	Collpase
	Current trend persists, free markets drive exploitation of natural resource, trade-libarization and strong integration	New policies related to wise use of biodiversity and ecosystem services, enforcement of protected areas, restrictions in land-use conservations.	Changes in energy consumptions, dietary consumptions, education for sustainable development etc.	Community mobilization, Participatory resource management, Incentives for conservation, strong copoeration between stakeholders	Widespread decgradation/ conversation of existing Biodiversity, Political isloation	Consideration for war, political breakdown
Western Asia						
South Asia						
South-East Asia						
North-East Asia						
Oceania						
Changes in value of Ecosystem services (currently $ 14 trillion/year)*	$11 trillion/year	$14trillion/year	$17trillion/year	–	$9trillion/year	–

believed that certain degree of sustainable practices would succeed through ameliorative policies and incorporation of 'green visions'. PR scenarios are mainly reflected in spatial considerations for protected areas, restrictive zoning, incentive-based conservation, whereas, the regional characterization of EC scenarios depict community-based forest management, development of agroforestry, facilitation of global incentive mechanisms (e.g. REDD-plus) and proliferation of carbon capture and storage schemes.

5.4 SYNOPSIS AND POLICY IMPLICATIONS

While addressing futures for the four subregions within the Asia-Pacific region: North-East Asia, South-East Asia, South Asia, and Western Asia, we acknowledge that while each face a specific set of challenges, there are commonalities across the region as a whole. GBO-4 identified five major challenges for business as usual scenarios leading up to 2050 (pp. 134-135): (1) Climate change is projected to become a major driver, of biodiversity loss and ecosystem change by 2050; (2) demand for fertile land is projected to increase, substantially; (3) many wild fisheries collapse and, increasing aquaculture for fish production; (4) water scarcity; and (5) combinations of drivers pushing some ecosystems, beyond recoverable tipping points at regional scales.

As we have shown, it is apparent that no single set of models and scenarios currently account for the myriad possible impacts on BES and human well-being across the Asia-Pacific region. We have shown how subsets of models and scenarios are addressing some issues pertinent to policy directives across the Asia-Pacific region and within subregions, both Aichi and SDG targets concerned with natural ecosystems. Despite these advances, approaches to date have largely failed to address targets and goals that encompass human economic and social development. The dependencies of human well-being on nature have been well articulated elsewhere in this assessment (e.g.

Chapter 1) and beyond. Through our assessment, complex interactions have been demonstrated for a number of drivers of BES and the implications for human well-being are shown to be equally complex, although the outcomes are often depressingly simple. Lack of clean water, food insecurity and poor health, inequitable access to natural resources, to name but a few, are widespread throughout the Asia-Pacific region and declining BES are a common linking feature.

In an attempt to draw policy relevance from our assessment of futures within the Asia-Pacific region, in this section we explore regional orientation towards the 20 'Aichi Targets (2011-2020)' and the 17 'Sustainable Development Goals (SDGs) (2015-2030)' and then go on to briefly depict some of the pitfalls and counter-intuitive outcomes that can emerge from such explorations. As a first step, we thematically screen regional and subregional scenarios, particularly focusing on the 'alternative scenarios outlining sustainability measures' and capture specific sustainability components that contribute to both Aichi targets and SDGs, either fully or partially.

5.4.1 Synergies between the Aichi Biodiversity Targets and the Sustainable Development Goals (SDGs)

Both the "Strategic Plan for Biodiversity 2011-2020 (aka Aichi Biodiversity Targets)" and the "Sustainable Development Goals 2015-2030 (SDGs)" are important sustainability targets that have strong implications in sustainable development of the Asia-Pacific region. Despite being temporally disjointed, both have many similar and coherent targets. While 'Aichi Targets' are more technical, problem-specific and are essentially designed from in-depth understanding of underlying drivers and pressures, SDGs are thematic and broad-based, and oversee environmental sustainability from general developmental challenges. Nonetheless, the Convention on Biological Diversity (CBD) in 2015 listed 35 of 169 targets of SDGs which fully or partially corresponds to the 20 'Aichi Targets'. Of which, about 14 targets of SDGs have strong coherence with Aichi Targets (CBD, 2015). While environmental conservation, in general, remains a prominent theme of both the Aichi Targets and SDGs, unlike the Aichi Targets, SDGs have wider obligations in terms of social and economic goals. For instance, the first 7 SDGs (SDG 1 to 7) primarily include fundamental human needs, while SDG 8 to 10 mostly emphasize common drivers and cross-cutting developmental issues (Kumar *et al.,* 2016). However, goals depicted in SDG 11 to 15, in principle, have direct implication in environmental sustainability, of which, SDG 14 and 15 specifically address biodiversity and ecosystem services. SDG 16 and 17 are more aspirational and recognizes the role of appropriate institutions, coordination and collaboration among stakeholders to accomplish the other goals and targets.

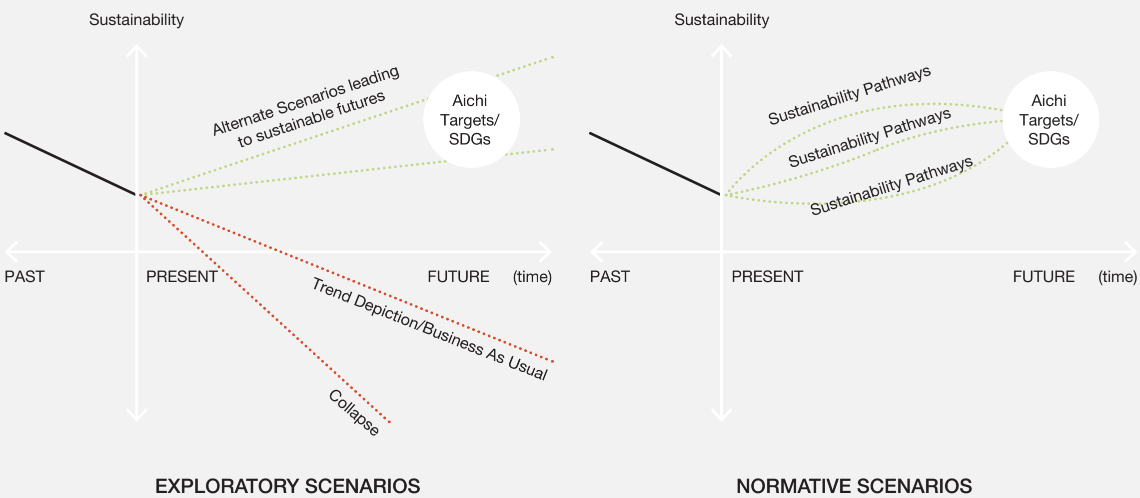
Many researchers/institutions further argued that the goals and targets mentioned under the SDGs have strong inter-linkages (UNEP, 2016); and therefore, provisioning of ecosystem services should not only be accounted against specific environmental goals/targets, rather, it is important to recognize the explicit role of BES across all the SDGs. For instance, achieving targets of SDG-1 (End poverty in all its forms everywhere) necessitates prudent management of biodiversity and ecosystems- to support livelihood, create new jobs and building resilience to climate change- which are also coherent with SDG 8, 10, 12 and 14. Nonetheless, despite strong synergies, some of the SDGs may also have significant trade-offs. For instance, fulfilling objectives of Goal 2 (End hunger and achieve food security), especially the targets mentioned in 2.3 (double agricultural productivity), may well lead to widespread conversion of natural ecosystems, in addition of putting considerable stress to the already depleted fresh water resources, thereby, putting other targets (e.g. 6.1, 6.3, 15.5) at risk. Section 6.8.3 in the following chapter highlights the major synergies and trade-offs in the Asia-Pacific region with respect to 17 Sustainable Development Goals.

Despite none of our reviewed articles explicitly mentioning SDGs or targets, there are significant consistencies among various scenario assumptions and objectives of the SDGs. These are primarily reflected in the alternate scenarios *'leading to more preferred futures'* or suggested *'sustainability pathways'* in exploratory and target-seeking scenarios respectively (See **Box 5.8**). These scenarios are depicted in specific consideration of future drivers, socio-political changes, trade-offs in ecosystem services and incorporation of global sustainability issues, such as climate targets. For example, scenario considerations for intensified food production, agricultural expansion, changes in agricultural land, open markets, and food prices can be considered as 'proxy' representatives of SDG-2 (zero hunger). Thus, to identify these linkages we first defined a set of qualitative demarcation criteria to interweave thematic matches between Aichi Targets and SDGs with appropriate scenario assumptions (Appendix 1). Scenarios were accordingly screened against their alignment towards specific sustainability goals. Scenario studies were allocated according to subregions, and incorporation of a specific SDG were assessed as simple 'yes/no' responses. Thereafter, we derived the total frequency (i.e. number of studies marked as 'yes') against specific targets for each of the subregion, and standardized the frequency data from 0 to 1 scale to harmonize varied sample size across subregions. The score obtained against each of the targets were classified into three intervals, namely 'strongly incorporated', moderately incorporated' and 'less integrated /lack of sufficient data'.

Box 5 8 Capturing sustainability targets from 'Alternative Scenarios with sustainability visions' and/or Suggested 'Sustainability Measures'.

In scenario exercises, policy intentions are often reflected in consistent storylines that enunciate 'assumptions' for preferred futures, concurrent with regional priorities and targets (Hunt *et al.*, 2012; Schmitt Olabisi *et al.*, 2010; Volkery *et al.*, 2008). In exploratory scenario studies, researchers principally depict three types of scenarios, broadly ranging from 'what may go wrong', 'official future' or 'trend depiction', and 'preferred futures' portraying transitions towards more sustainable future. Although, at times, these scenarios can be speculative, more often, they are shaped by regional priorities and policy intensions based on the understanding of critical demographic, economic and socio-political factors. Contrarily, normative scenarios (e.g. 'target-seeking' and/or 'back-casting' scenarios) primarily depict clear benchmarks and thereby, formulates pathways indicating specific *'sustainability pathways'*. Capturing this 'sustainability measures/pathways' provide critical information of regional priorities related to specific sustainability targets.

Figure 5 22 Visualisation of exploratory versus normative scenarios.



5.4.2 Incorporation of Sustainability Targets in regional and subregional scenarios

SDGs 11 to 15, which principally correspond to environmental goals and align with prominent 'Aichi targets' encompassing the first two strategic components (i.e. Targets 1 to 10), were relatively well-articulated within the alternate scenarios leading to more sustainable futures (see **Figure 5.23** & **Figure 5.24**) (*established but incomplete*). Particularly, subregional scenario exercises have stronger implications for SDG 14 and 15, which fully or partly cater to at least 11 Aichi Targets (i.e. 2,3,5,6,10,11,12,14,15,16 and 17) (CBD, 2015). For instance, subregional studies incorporated multiple targets of SDG-15 (Protect, restore, and promote sustainable use of terrestrial ecosystems) (42 per cent); SDG-14 (Conserve and sustainably use of marine resources) (30 per cent); and specific targets of SDG-11 (32 per cent) (Sustainable cities and communities).

Dominant examples of ameliorative scenarios in terrestrial ecosystem conservation include enforcement of protected areas (e.g. Estoque & Murayama (2012); Mozumder & Tripathi (2014)), policy reforms (e.g. Mitchell *et al.* (2015)), and favorable institutional changes, depicting participatory conservation, incentives and regime shifts. Likewise, scenario studies, predominantly from South-East Asia and Oceania, demonstrated analogous assumptions, while describing future occurrence, distribution, production, and consumption of marine ecosystems services (e.g. Webb *et al.* (2014); Takao *et al.* (2015); Bohensky *et al.* (2011)). Many of the studies characteristically considered protective zoning through enforcement of protected areas (e.g. Estoque & Murayama (2012); Mozumder & Tripathi (2014)) which, in principle, corresponds to the Aichi Target 11 and contributes partly to Aichi Target 12, 13 and 14. Similarly, some studies indicated improvement of provisioning and regulating services through ameliorative policy arrangements, such as participatory conservation, better incentives designs (through REDD +, or PES schemes).

Figure 5 23 **Thematic Incorporation of the Sustainable Development Goals in subregional scenario exercises.**

Darker shade implies strongly incorporated, while lighter shade implies less incorporated, or lack of sufficient data. The analysis is based on 60 subregional scenario studies, excluding one study depicting the alternative futures for the entire Asia-Pacific region.

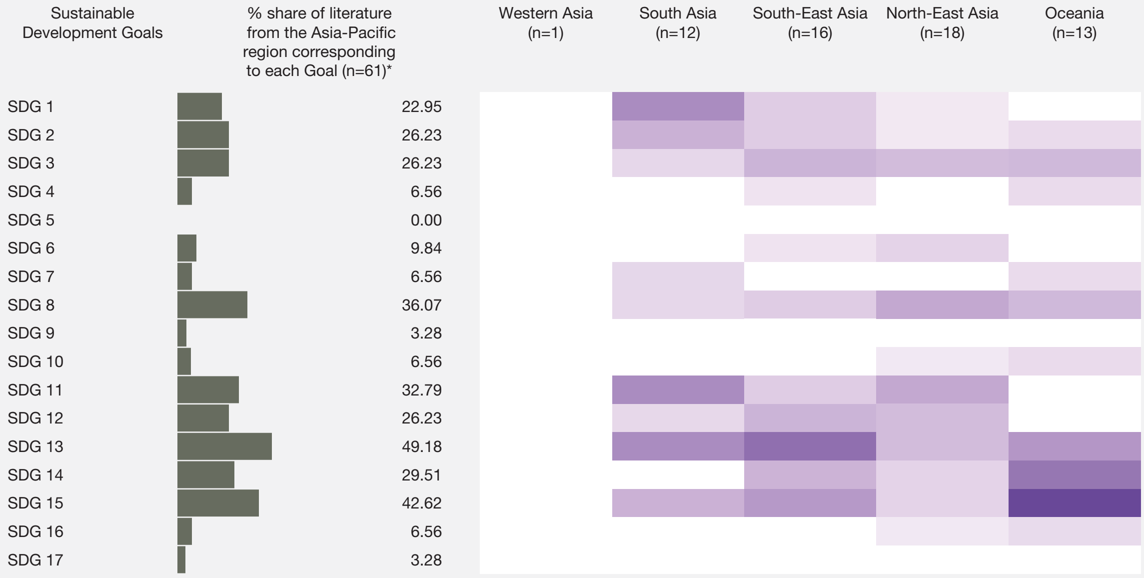


Figure 5 24 **Thematic incorporation of the Aichi Biodiversity Targets in regional/subregional scenario exercises.**

Darker shade implies strongly incorporated, while lighter shade implies less incorporated, or lack of sufficient data.

In addition, close to half of the studies depicted thematic association with SDG-13 and its targets (combat climate change and its impacts). Demonstrative examples comprise multitude of climate mitigation and/ or adaptation scenarios, including 'carbon capture and storage' (e.g. Yang *et al.,* (2016)), 'utilization of regulating ecosystem services for hazard mitigation' (e.g. Feng & Liu (2016)), 'assessing impacts and adaptation options for food productivity' (e.g. Soora *et al.* (2013)) and 'water availability' (e.g. Van Ty (2012)). By sharing advanced knowledge on crop-yields, agricultural productivity, water and energy demands under different climate regimes, these studies also contribute in fulfilling allied developmental goals; such as SDG-2 (end hunger and achieve food security), 3 (Good health and human well-being), 6 (clean water and sanitation) and 12 (sustainable consumption and production). However, despite an abundance of urban-expansion scenarios, particularly from South Asia (e.g. Hosseinali *et al.* (2013); Mozumder & Tripathi (2014)) and North-East Asia (e.g. Pei *et al.* (2015); Zheng *et al.* (2015); Feng & Liu (2016)), underlying linkages between ameliorative scenarios and SDG-11 only correspond to a handful of specific targets (e.g. target 11A) and principally focus on controlling ecological impacts of existing urbanization process. While the environmental goals expectedly remain closely reflected in regional scenario studies, the SDG 4, 5, 6 and 7, on the other hand, are under-represented in regional context. In addition, within the cross cutting developmental goals, SDG 8, i.e. 'decent work and economic growth' is partially included under urban expansion scenarios, yet the other goals, particularly SDG 9 and 10 are also unrepresented.

Regional scenarios are further lacked in SDG 16 and 17, since only a handful of studies actually considered strong regional and stakeholder collaboration for enduring sustainable and responsible development (e.g. Mitchell *et al.* (2015)). Similarly, within the Aichi Targets, the last two strategic goals, i.e. 'Enhance the benefits to all from biodiversity and ecosystem services' and 'enhance implementation through participatory planning, knowledge management and capacity building', especially covering Targets 15 to 20 have not been properly reflected in the regional scenario exercises. This is in parts, due to very specific targets, such as implementation of Nagoya Protocol or formulation/revision of NBSAPs/LBSAPs, which are beyond the scope of reviewed scenario exercises. Nevertheless, apart from the current set of reviewed literature, a reasonable amount of allied scientific works from the Asia-Pacific region, particularly from South and South-East Asia, pointed towards better community participation in ecosystem management, as well as systematic incorporation of traditional and indigenous knowledge into natural resource management policies. While this contributes towards the partial fulfilment of target 18 and 19, within the set of reviewed scenario studies, only a handful studies (e.g. König *et al.* (2013); Mitchell *et al.* (2015)) deployed multi-stakeholder based scenario development, therefore these components are assessed as "*Inconclusive*".

5.4.3 Regional future of Nature-Society interactions under Alternative Pathways

Archetype-based analysis of regional/ subregional scenarios depicts that most of the subregional scenarios tend to incline towards 'Market Forces', 'Policy Reform' and 'Eco-communalism', out of the six scenario variants under the Global Scenario Group archetype, albeit with some variations across the subregions. Moreover, there is also temporal variations, as studies tended to depict a wide range of alternative future spanning over the current century. It is also important to mention that although for many of these subregional scenarios, particularly from the region's developing countries, 'Market Forces' closely resemble with the Business-As-Usual scenarios, this is not uniformly applicable to the entire region. A similar variation of assumptions can also be attributed for other scenario variants, such as 'Policy Reform' and 'Eco-communalism,' given the broad socio-economic diversity across the Asia-Pacific region. Nonetheless, in this section, we portray the likely changes in major influential drivers (and nature-society interactions) under the three predominant scenario variants, i.e. *'Market Forces', 'Policy Reform'* and *'Eco-communalism,'* relying on the local assumptions furnished in the subregional scenario exercises.

The general scenario assumptions for 'Market Forces' can be summarized in a continued population and economic growth for the Asia-Pacific region, regional integration, together with rising demand for resources, especially land and water. Globalization also plays a vital role in regional integration under 'market forces', with better integration and trading among the region/subregions, ensuring a gradual uplifting of the region's least developed economies. For instance, Ornetsmüller *et al.* (2016) developed a scenario for Lao PDR, named as 'ASEAN', outlining greater trade relations with neighbouring countries that propel a large expansion of cash-crop cultivation. Subregional scenarios further depict that due to increased global demand, more investments will focus onto the agro-based production sector (in comparison to the service sector) with a rise in virtual water consumption. Particularly, biofuel and palm oil cultivation may flourish uncontrollably in the Asia-Pacific region (Koh & Ghazoul, 2010). As such, many of the Asia-Pacific region countries will graduate from 'poverty' to 'adequate food and clothing' due to economic development, and India and China will remain at the forefront (Hubacek *et al.,* 2007).

Under the Market Forces, cities will continue to expand at an increasing rate, driven by high economic growth, migration of work-forces and subsequent changes in consumption patterns, mostly disregarding environmental concerns. Significant trade-offs in terms of environmental quality, thus, remain inevitable. For instance, Rutten *et al.* (2014) identified that, there might be a sharp decline in natural forests in Vietnam, replaced by planted forests. Koh and Ghazoul (2010) also mentioned that unplanned expansion of oil palm cultivation in Indonesia will trigger the highest loss of forest cover. At the same time, many researchers identified a sustained growth in agricultural produce, mainly due to the adoption of technology, high yield crop varieties, and better management. In general, in the south and South-East Asia, high demand for timber will lead to an expansion of commercial forestry, and as a result, the natural forested area may be occupied for commercial plantation (*established but incomplete*). Growing urbanization and migration towards cities will lead to significant deterioration of peri-urban production landscapes, with productive agricultural land/wetlands declining in the urban vicinity (*well established*). For example, several scenarios developed for Asian mega-cities cities outline a reduction of agriculture and natural land (open space) in existing peri-urban landscapes under the 'market force' (Han *et al.,* 2015; Rutten *et al.,* 2014). There is also a consensus that a lesser concern for the environment could intensify climate impacts under market forces, with a significant rise in extreme weather events, flooding and subsequent loss of agricultural productivity, particularly in low-lying coastal areas (Rutten *et al.,* 2014).

Subregional scenario studies have portrayed positive ecological impacts under policy drivers, with broad assumptions on punitive and incentive measures. Policy Reform scenarios have particularly highlighted that, despite high population growth and economic development (mostly in line with market forces), policy-drivers can play a significant role towards achieving some degree of sustainability (*well established*). For instance, under the Urban Expansion scenarios, zonation has been widely referred as a measure of safeguarding future nature-society interactions in the built environment. Zheng *et al.* (2015), for instance, developed two scenarios with different policy interventions for Urban Expansion in Hong Kong, assuming that city-council will thrive to provide 'more open space for the benefits of urban communities' [open space scenario], currently capped at 3.39 m^2 per person. The other scenario being 'Protection Scenario', under which historical sites and parks are restricted for future conversion (Zheng *et al.,* 2015). Han *et al.* (2015), on the other hand, described an Urban Expansion scenario of Beijing, named as 'Protection Scenario,' where woodlands and water bodies are designated as 'nature reserves' and hence remain unaltered even under intense urban pressure. The idea of designation and expansion of protected areas, in general, results in conserving vital ecosystem services have been *well established* in subregional scenario literature. 'Policy Reform' also results in some degree of passive and active restoration, for example through compensatory forestry, or reclamation of degraded areas. In summary, both for the habitat-scale scenarios and urban expansion scenarios, proactive policies are expected to make significant changes to BES, even as the other drivers remain similar to Market Forces (*well established*).

With the subregional scenario literature, Eco-communalism is represented through specific sustainability measures, such as taking 'balanced approach' to economic development, integrating incentives, community-based management, changing lifestyles and perspectives. For example, a 'Go-Green' scenario developed for a watershed in Yunnan, Southwest China integrated three major assumptions into one plausible future - i.e., a stronger protection of the ecologically valuable land, reforestation of farmland on sloping terrain, introduction of community-based agroforestry systems with incentives (or compensation) for abandoning rubber cultivation practices, while developing agroforestry system for sustainable cultivation of Traditional Asian Medicine (Cotter *et al.,* 2014). There are also some evidence that adoption of international forestry conservation schemes such as REDD-plus lead to better conservation and management of protected areas (e.g. Thapa *et al.* (2013)). These scenarios are, however, highly site-specific and as such cannot be replicated as a core characteristic of the entire region. Nonetheless, it is also important to understand, that once scaled-up, this might hold significant implications for future sustainability for the Asia-Pacific region.

5.5 SYNTHESIS OF THE PLAUSIBLE FUTURES IN THE ASIA-PACIFIC REGION – WHERE TO NEXT?

Reflecting on the remarkable heterogeneity of resources, societies and cultures in the Asia-Pacific region, the models and scenarios available in the literature were also diverse, as seen from the fact that there are several local story lines and models employed specifically to understand a particular decision-making context or the objective of the study. The synthesis of these studies on a common platform were marred by the fact that a very few studies looked at the whole range of nature's contribution to people using common sets of scenarios and models. Most of the scenarios considered were Business-as-Usual scenario and there is a dearth of 'target-seeking' and 'back-casting scenarios' that would assist governments with policy developments, constituting a significant research gap. The comparison across the models in the region has been difficult due to different set of temporal, spatial and units of analysis as well as socio-economic and cultural differences. Although the region is divided by boundaries, most often biodiversity does not know any administrative bounds, adding an extra layer of complexity (especially for transboundary resources).

Based on the systematic assessment of all the studies, and given the high diversity, subregional differences, and cross-scale variation, there is a worrying lack of systematic studies that comprehensively and consistently assess NCP future trends along plausible pathways in all subregions and countries within the Asia-Pacific region. The few regional and global scenarios and models that exist, are inadequate to fully address complex human-nature interactions, as all the possible and relevant pathways were not considered, such as socio-economic scenarios (population growth, consumption growth, trade, policies, technological interventions, etc.), but rather mostly focused on climate change scenarios (i.e., Business-as-Usual emissions or medium or strong mitigation emissions; RCPs and SRES). The multiple nature-society interactions (NCP) from each ecosystem were typically not explored exhaustively, being often limited to, for example forest area only, fisheries only, or coral reef cover only. These cannot, therefore, reflect the multiple NCP derived from an ecosystem and offer only limited analyses of trade-offs. As a result, our current understanding of projections of nature-society interactions within the Asia-Pacific must be considered largely fragmented and limited. Within the existing limitations, the predictive models under the Business-As-Usual scenario point out that biodiversity loss would continue and, if appropriate policy interventions are not initiated, the rate of species extinction would be similar to the global rate by 2050 (approximating 45 per cent). Appropriate proactive and regulatory policy interventions can help stabilize land/sea use changes, thereby improving nature's contributions to people and several such evidences of intervention exists in the region like that of adaptive multiple-use land management practices. The scenario analysis shows that a combination of old and new drivers such as human population growth, climate change, increasing urbanization, agricultural intensification are shaping the BES outcomes in the Asia-Pacific region at different spatial and temporal scales, which can impact the ecosystem health and thus further increase the disaster risk and risk of emergent zoonotic disease, with major implications for the poor. Under all scenarios, except those articulating major societal change (e.g. Great Transition, Eco-Communalism, or New Sustainability) greater disparity between social groups and entrenched poverty are anticipated, with Health Security worsening in poor communities as BES decline further.

Despite the implications of declining BES for the region, observations have also paradoxically shown increases in human well-being **(Figure 5.9)**, and another example is seen in the Bangladesh delta (Hossain *et al.,* 2016). Such improvements in human well-being are not necessarily linked to NCP and often result from new commercial activities or technologies, or donated foreign aid, masking fundamental BES and societal declines resulting in these interventions not persisting as viable future options. Scenarios such as *'Great Transition'* or *'Global Technologies'* often fail to incorporate changes, focusing instead in possibly short-term and/or small-scale outcomes. Other examples suggesting regional BES (and human well-being) in China may benefit from increasing urban industrialization (Hou *et al.,* 2014), also appear to offer counterpoints to the scenarios depicted for the Asia-Pacific region and the environmentalism viewpoint. Therefore the scales and measures of human well-being examined are not necessarily the most appropriate (W. Yang *et al.,* 2013), and not linked to NCP – thus, offering insights to a relatively small subpopulation over limited time scales. As a result it is often seen that countries which are exploiting their natural capital are often growing rapidly. One can break this paradox by arguing that the critical dimensions of human well-being have not been adequately captured. With the increase in production per capita, an important provisioning service, human well-being would increase regardless of the decline in other services (Raudsepp-Hearne *et al.,* 2010; UNU-IHDP & UNEP, 2014). It is often misconstrued that, due to the technology and social innovation, human well-being is less dependent on ecosystem services. It should however, be understood that due to the time lag between ecosystem service degradation and the negative impacts on human well-being, the negative impacts on human well-being have not yet occurred to a measurable extent. This further points out to the need for more synergistic and cross-cutting policies across multiple domains, themes and across regions to capture the trade-offs better.

As policies overlap across multiple domains, these pathways needs to be aligned with wider policies and anticipated plausible futures. There exists some policy initiatives within social and economic spheres in the Asia-Pacific region that envisage and anticipate complex interactions with nature, such as the recent efforts to adopt One-Health (OH) policies offering possible means for addressing multiple impacts by directly targeting the outcome of improved health (Binot *et al.,* 2015). Such approaches integrate across numerous policy fronts, including: Health Security, Food production and food security, Income and Livelihoods, and Water security. Development synergies can thus be identified that prioritize and optimize health as the key outcome, leading to improved human well-being and ultimately alleviating poverty. Attempts to link OH approaches to international aid in SE Asia (Asakura *et al.,* 2015) or provide more effective control for disease such as rabies (Aréchiga Ceballos *et* *al.,* 2014), a disease that disproportionately affects children in poor communities, have identified clear links to BES, highlighting self-reinforcing policy options with clear co-benefits. No projections or future pathways are presented for OH options, but we must consider that outcomes will differ under the different scenario archetypes we present.

In addition we require more collaborative and coherent actions by all stakeholders to better harness the economic, cultural and regulatory contributions of Nature. Effective participatory governance is likely to emphasise the synergies between multiple drivers and can facilitating progress towards the Aichi Biodiversity Targets and Sustainable Development Goals. The plausible future pathways described are likely to shift with altered needs and depend on whose voices are having the greatest influence on policy directions. As an example, the Daly River catchment in North Australia illustrates common trade-offs between economic, environmental, cultural and social outcomes of management options and plausible futures. When asked, stakeholders ranked social and cultural outcomes as the most important, with commercial considerations being lowest (Adams *et al.,* 2014). However, responses from indigenous communities differed to those from commercial farmers, the latter ranking economic concerned more prominently (Adams *et al.,* 2014). The way in which indigenous communities are engaged in these assessments is clearly important (Ens *et al.,* 2016; Fuentes *et al.,* 2015; Sangha *et al.,* 2015; Satterfield *et al.,* 2013) (c.f. Chapter 2), especially in countries where historical displacement by European settlers has created inequalities. Approaches that seek to identify the commonalities between stakeholders and build on consensus where it already exists are potentially more valuable than discussion of differences. This is illustrated in practise by water planning developments in New Zealand, where the hazards of purely top-down expert-driven policy framing are set against more inclusive participatory approaches (Tadaki *et al.,* 2015). Where economic considerations are deemed to be priorities, issues surrounding compensation often prove to be complex and controversial (Kaplan & Leonard, 2012; Ruzicka *et al.,* 2013; Wen, 2014; Xiao *et al.,* 2015). These approaches often consider notions of social justice, seeking fairness between the individual and society. Where individuals from poor communities are not directly benefitting from commercial activities (judged to be desirable by society more widely), justice through compensation is a frequent approach. The effective and equitable delivery of such justice necessarily requires bottom-up, participatory approaches to fully understand the values and needs of these communities (Chapter 2) and develop scenario frameworks that fully incorporate these world views. As we have illustrated, participatory scenario development is rare in the Asia-Pacific region and consequently the multiple voices required to elucidate fully the range of plausible future are often absent. Under Business-As-Usual, economic priorities are set above all others, with alternatives having little traction because often there are not the societal mechanisms in place to accommodate diversity.

Energy security is clearly framed as an economic development priority and clear BES influences and outcomes are also apparent under various scenarios. Overall, the energy sector is a contributing drivers of BES decline (Chapter 4). It is worthwhile to explore the details in India, which is projected to be the largest coal consumer by 2050. However, numerous hydroelectric power schemes are proposed or are under development, with much focus in the Himalayan states, such as Uttarakhand. Here, "run-of-the-river" hydropower projects, that either eliminate or substantially reduce the need for water storage, are being developed to avoid costs to local communities through the creation of large dams. Stakeholders are diverse, with often diverging interests, resulting in governance challenges centred on trade-offs between local electricity to energy-insecure rural areas and revenue from the sale of hydropower, on the one hand, and the impacts on irrigation, riparian ecosystem services, and other natural resource-based livelihoods, on the other.

Using a social justice approach, strategies can be identified that safeguard or enhance livelihoods, especially of women and the young, while also maintaining critical ecosystem services (Buechler *et al.,* 2016). Mitigation or compensation for loss of BES increasingly seek means of redressing ecological destruction and compensation schemes are often complex (e.g. Braun *et al.* (2015); Monjezi *et al.* (2009); Wen (2014)). Integration between adaptation responses to global change and human development are desirable in developing countries, ideally leading to no regrets, co-benefit strategies for the rural poor in alignment with Sustainable Development Goals (SDGs). The adaptation pathways approach provides a potentially useful decision-making framework because it aims to steer societies towards sustainable futures by accounting for complex systems, uncertainty and contested multi-stakeholder arenas, and by maintaining adaptation options.

A further example from Nusa Tenggara Barat Province, Indonesia, considered whether generic justifications for adaptation pathways are tenable in the local context of climate and global change, rural poverty and development. Although poverty is resilient, due to corruption, traditional institutions and fatalism, other trends around the erosion of traditional culture result in unpredictable futures. Tensions around formal and informal leadership, corruption, community participation in planning and female empowerment add further challenges to decision-making. Using an adaptation pathways approach, appropriate participatory processes and governance structures can be highlighted, including integrated livelihoods and multi-scale systems analysis, scenario planning, adaptive co-management and 'livelihood innovation niches' (Butler *et al.,* 2014). Under such circumstances, where governance structures are sufficiently flexible and responsive, we may divert off from the Business-As-Usual pathways and towards future scenarios that balances sustainable BES and human well-being both people and healthy and productive nature.

This points out to the need that the future efforts to develop more region-wide models needs to link the macro-economic conditions with more subregional or local conditions reflecting the diverse biodiversity and ecosystem services and the local knowledge, as well as ensuring spatial, sectoral and temporal consistency for a meaningful comparison of plausible futures across the region,including relevance for local contexts. We also recommend developing harmonized scenarios for the region, taking into account of multiple drivers and story lines that better reflect the attitudes, preferences, the biodiversity and ecosystem services as well as the overlapping and heterogeneous policy context of the region. Such scenarios can help policymakers make better decisions on the most plausible futures for biodiversity and NCP.

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APPENDICES

Table 5 5 **Selection criteria for identifying regional priorities against the 20 Aichi Biodiversity Targets.**

Aichi Targets	Theme	Components and/or assumptions within alternative scenario narratives that were presumed to have thematic linkages with the respective target or goal
Aichi Target 1	Understand Values	Synergies and Trade-offs assessment, enhancing knowledge and decision-making capacity as well as scientific novelty of the studies
Aichi Target 2	Mainstream Biodiversity	Suggests policies to incorporate BES in future development
Aichi Target 3	Address Incentives	Implementation of REDD/ REDD + mechanism, ameliorative conservation through incentives
Aichi Target 4	Sustainable Production	Control of deforestation, techno-economic development and implementation of conservation plans
Aichi Target 5	Halve the rate of Loss	Quantitative targets (in line with Aichi Target 5) for improvements in biodiversity and ecosystem services as well as conservation scenarios
Aichi Target 6	Sustainable Fisheries	Marine/Coastal ecosystem scenarios dealing with distribution, aquatic productivity, sustainable fisheries and aquaculture
Aichi Target 7	Manage within the limits	Trade-offs in agricultural expansion scenarios, crop productivity, sustainable agriculture
Aichi Target 8	Reduce Pollution	Control of nitrate population in agricultural expansion scenarios
Aichi Target 9	Reduce Invasive Species	Control of invasive alien species
Aichi Target 10	Minimize reef loss	Scenarios depicting fate of coral reefs, provisions for sustainable management
Aichi Target 11	Protected Areas	Consideration for enforcement of protected areas
Aichi Target 12	Prevent Extinctions	Scenarios depicting risk of annihilation of species or suggesting ameliorative management options
Aichi Target 13	Conserve Gene Pool	Specific mention of genetic pool in one of the scenarios
Aichi Target 14	Restore ecosystems	Alternative scenarios depicting restoration of specific ecosystems, such as forests
Aichi Target 15	Enhance Resilience	Restoration of 15 per cent of degraded ecosystems, or any other quantitative targets
Aichi Target 16	Implement Nagoya Protocol	Specific mention about Nagoya Protocol in scenario depiction
Aichi Target 17	Revise NBSAPs	Alternative scenarios outlining ameliorative conservation plan, including implementation of National biodiversity strategies and action plans (NBSAPs)
Aichi Target 18	Respect and Conserve TK	Integration of traditional knowledge and indigenous knowledge in development of one or more scenarios
Aichi Target 19	Improve Knowledge	Alternative scenarios providing targeted recommendation for knowledge and capacity building
Aichi Target 20	Mobilize resources	Specific mention of mobilization of financial resources for meeting conservation targets

Table 5 6 **Selection criteria for identifying regional priorities against the 17 Sustainable Development Goals**

Goals	Theme	Components and/or assumptions within alternative scenario narratives that have thematic linkages with the respective target or goal
SDG-1	End-Poverty	Livelihood and cross-cutting developmental issues, agricultural innovation, implementation of social security schemes, biofuel expansion and favorable techno-economic changes driving employment
SDG-2	Zero Hunger	Intensified food production, agricultural expansion, changes in agricultural land, open markets, food prices, and globalization
SDG-3	Good Health and Well-being	Changes in lifestyle and consumption patterns, Good quality of life (GQL), energy uses, water purification and control of soil pollution
SDG-4	Quality Education	Environmental education and Education for Sustainable Development (ESD)
SDG-5	Gender Equality	Women engagement in conservation and management of ecosystem services.
SDG-6	Clear Water and Sanitation	Water ecosystem Services of river, lakes and reservoirs including availability, quality and purification
SDG-7	Affordable and Clear Energy	Expansion of Biofuels, changing life-styles and consumption patterns, technological innovation
SDG-8	Decent Work and Economic Growth	Urban and economic expansion scenarios, International collaboration
SDG-9	Industry, Innovation and Infrastructure	Industrial and urban innovation, smart cities, environment friendly business
SDG-10	Reduce inequalities	Disproportionate economic growth, fragmented societies and social relations, regionalization
SDG-11	Sustainable Cities and Communities	Urban expansion including special economic zone, peri-urban landscapes, quality of urban life and urban ecosystems, including green spaces
SDG-12	Responsible Consumption and Production	Land degradation scenarios, exploitation of forests and other natural resources
SDG-13	Climate Action	Scenarios where climate change is one of the main drivers including scenarios utilizing IPCC SRES and RCP narratives
SDG-14	Life below Water	Scenarios which depict future state of marine and coastal ecosystems, including mangroves and coral reefs
SDG-15	Life on Land	Ecosystems, fragmentation and habitat quality
SDG-16	Peace, justice and Strong Institutions	Empowerment of social institutions, decentralized management and governance reforms
SDG-17	Partnership for Goals	Participatory, multi-stakeholder based resource conservation, bottom-up/agent-based scenario modelling, issues of regional collaboration (e.g. ASEAN/SAARC) for transboundary ecosystem conservation and management