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Prepared by Paul Steele, Ina Porras, Pete Smith, Anders Pedersen, Nena Espiritu and Paris Kazis: supervised by Bruce Dunn

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OPPORTUNITIES FOR INVESTING IN SUSTAINABLE NATURAL CAPITAL IN ASIA PACIFIC

Report for the Asian Development Bank

10 March 2017

Prepared by

Paul Steele, Ina Porras, Pete Smith, Anders Pedersen, Nena Espiritu and Paris Kazis.

Supervised by Bruce Dunn

ADB

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Executive summary

This report presents how investments in natural capital can benefit the people and economies of Asia Pacific. It looks at the justifications for increased investment, the priorities for natural capital investment in specific ecosystems, and how these investments may be financed – including by the Asian Development Bank (ADB). The report is based on a state-of-the-art review of science and policy in Asia Pacific with lessons learnt from ADB and other development banks including the World Bank.

The report's purpose is to make the case for increased investment in natural capital in Asia Pacific, in particular through lending. Its audience includes Asia Pacific governments and other country stakeholders. Already, some Asia Pacific countries such as People's Republic of China (PRC) are starting to borrow large sums for natural capital investments and this report will demonstrate why this is likely to increase in other countries.

What do we mean by natural capital?

Natural capital refers to the stock of ecosystems within the countries of the Asia Pacific region. Natural capital covers renewable natural ecosystems and resources like forests, water and agricultural farmland, and non-renewables like minerals and fossil fuels. This report focuses on renewable natural capital resources and ecosystems, looking at a combination of resources (soil, water, forests and fish) with a set of ecosystems (croplands, pasturelands, watersheds and coastal ecosystems).

The report addresses sustainable investment in natural capital, by which we mean the sustainable use, conservation and restoration of this natural capital. Sustainable approaches to natural capital are vital as natural capital is special. It cannot easily be produced or manufactured like produced capital, such as factories and man-made infrastructures. Natural capital is inherently scarce and its loss may even be irreversible. Certain forms of natural capital such as underground water aquifers or topsoil may take generations to regenerate once they are exhausted. Other renewable natural capital, like forests or fish stocks, are often slow growing and may be easily over-extracted. Only some types of "secondary" natural capital such as tree plantations and fishery aquaculture are more easily reproduced, but their biodiversity value is generally lower. Furthermore, the destruction of some ecosystems often has repercussions in the form of associated externalities, for example health implications, undermining agricultural productivity or increasing vulnerability to climate change.

Natural capital investment in the Asia Pacific: why now?

The report is timely given the global and regional policy context, and ADB's priorities. At a global level, the report responds to the Sustainable Development Goals with their greater emphasis on land-based and marine ecosystems. The regional relevance is the unprecedented pressure on natural capital across the Asia Pacific. Rapid economic growth and ever increasing populations, especially in cities, means the demand for energy, food and water is intensifying as the natural capital is depleted. How to maintain this natural capital and strive for equitable and inclusive growth is a key issue in the region. The relevance for ADB is its 2030 strategy which is looking anew at the opportunities for increased lending for natural capital, including for ecosystem-based adaptation.

Natural capital in the Asia Pacific: status, threats and opportunities

Competing agendas often drive Asia Pacific government investment priorities away from sustainable natural capital. Traditional investment priorities such as infrastructure are often perceived as better suited to promote growth, and more in line with domestic priority agendas. However, a better understanding of the scientific and economic arguments for natural capital, as well as a change in discourse of what is economic growth, is slowly propelling new trends in the region. This is being led by the People's Republic of China (PRC), which is boosting investment in natural capital.

There are strong environmental, social and economic justifications for investing in natural capital in Asia Pacific. Natural capital is under serious threat in Asia Pacific and without significant investment to protect it there will be major negative biophysical impacts. Asia Pacific is experiencing severe natural capital scarcity and decline across all major ecosystems, for example:

- Soil erosion is a major challenge in tropical and subtropical countries in South Asia, in the humid subtropical and temperate regions of in East Asia, semiarid regions in China, and the arid regions in Mongolia and East Asia.
- Old-growth forests[1] have been cut and degraded in most countries with Pakistan, Korea, Timor-Leste and Indonesia losing more than a quarter of their forest cover in 1990–2015.
- Over 75% of Asia is water insecure and this is particularly severe in Central Asia and northern PRC. This means millions of people without access to sufficient quantities of clean water and sanitation.
- Marine and coastal ecosystems, including mangroves, seagrass beds, coral reefs and associated biota are under threat from conversion, pollution and overfishing in much of Asia Pacific, particularly in Indonesia and the Philippines.
- Urban ecosystems are under unprecedented pressure as cities become more polluted and congested.

But there are also some positive signs with regard to natural capital in Asia Pacific. These include massive tree-planting campaigns in PRC, Viet Nam and the Philippines. There are expanded protected areas – both terrestrial and marine – with Asia Pacific having 11.5% of its total land mass now protected and 7.9% of its territorial waters protected (which rises to 12.7% for the Pacific alone). There is also some evidence that mangrove loss is less rapid than before. This shows that while much natural capital loss is inherently irreversible, destruction trends can be reversed and natural capital rehabilitation and restoration is possible in Asia Pacific.

Benefits of natural capital investments

Natural capital provides benefits to the people and economies of Asia Pacific. These benefits include the direct goods and services (provisioning of food, water, wood and fuel etc.) and the significant ecosystem services of the natural capital which encompass supporting services, regulating services and cultural services (e.g. natural hazard mitigation, carbon sequestration and eco-tourism opportunities). Natural capital is key to Asia Pacific economies as an estimated 30% of the wealth of Asia Pacific comes from natural capital, while in the high-income countries like those in the OECD only 2% of wealth is derived from natural capital. Asia Pacific's Natural Capital therefore represents an investment opportunity, and a risk if this base is exhausted.

[1] Old growth forests are natural forests that have not experienced severe disturbances (e.g. logging, fires) for over 120 years.

The environmental benefits of natural capital investment explain their high economic rates of return. Investments in land management, forestry and wildlife protection, and coastal-based ecosystems can all have high economic rates of return (ERR), over the 12% ERR required by ADB. These natural capital investments can have specific benefits in reducing risks to certain other infrastructure investments, such as roads and energy projects.

Natural capital benefits are particularly significant for poor people including women, who are often most dependent on natural capital. There is clear evidence that poor women and men are most dependent on natural capital for their health and livelihoods and most exposed to climate change when natural capital declines. Poor people, particularly women, may also suffer from limited access to natural capital. In India, Nepal and Thailand, less than 10% of women farmers own the land they farm. Natural capital provides a "safety net" when crops fail, and can also provide a route out of poverty through small- and medium-scale enterprises involved in processing of wood, fish and tourism services.

Natural capital investments also have major macro-economic benefits in terms of government revenues, jobs and exports and reducing risks from conflict. Bhutan and the Lao People's Democratic Republic (Lao PDR) receive significant government revenues from hydropower; the Maldives and many Pacific island countries are dependent on natural-based tourism and fisheries; while PRC is generating thousands of jobs through its reforestation programmes.

Natural capital investments can make a significant contribution to ecosystem-based adaptation in urban and rural areas, particularly in relation to tackling climate extremes including urban drainage and the impacts from sea-level rise. Here again, PRC is taking a leading role with an ecosystem approach being applied to urban development.

Finally, natural capital projects are part of Asia Pacific's commitment to international agreements. The highest profile of these are the recent Paris climate change agreement made at the 2015 Paris Climate Conference and the Sustainable Development Goals adopted in September 2015, but there are other natural capital-specific agreements that have also played a role. For example, the Convention on International Trade in Endangered Species (CITES) has been critical in reducing trade in threatened plants and animals across Asia Pacific.

While there are many benefits from investments in sustainable natural capital, the report also identifies the challenges to these investments, including market, policy and management failures and how these can be overcome. While the shortcomings of the market mean that natural capital management often requires government intervention, this brings its own challenges. Governments may lack the technical skills or be under political pressures that undermine investment in sustainable natural capital. Finally, there are management and capacity challenges that need to be overcome including the spatial complexities of managing transboundary ecosystems and the need for effective monitoring and enforcement.

Priority natural capital investments

The main section of the report presents a comprehensive review of priority natural capital investments in soils, agriculture, water use, pasturelands and agrobiodiversity; watersheds and freshwater; forestry and protected areas; aquatic, marine and coastal ecosystems; and urban ecosystems. This review includes a particular focus on those investments that will achieve ecosystem-based adaptation. While specific investments are useful, the section begins with a review of the strengths and weaknesses of economy-wide and "landscape-level" investments that ADB has

promoted through its regional natural capital initiatives in the Coral Triangle, Heart of Borneo and Living Himalayas. For specific investments, the reports identifies a range of options (see Table A.1 below).

Table A.1 Natural capital priority investments

Type of natural capital	Area of focus	Priority investment
Agricultural natural capital: water, soil, pasturelands, agrobiodiversity	Crosscutting	• Agricultural intensification: crop and animal breeding • Agricultural intensification: crop protection • Reducing post-harvest losses and food waste • Tenure and land allocation • Greening supply chains
	Agricultural water	• Higher-value crops • Surface-water irrigation efficiency • Groundwater management • Wastewater re-use • Rain-fed agriculture • Salinity management
	Soils	• Soil conservation by changing cropping practices • Soil conservation by physical structures • Fertilizer use
	Pasturelands	• Technical interventions: vegetative structure and infrastructure • Institutional and policy interventions
	Agrobiodiversity	• In situ, ex situ and circa situ conservation
Tropical forests, including plantations and agroforestry	Crosscutting	• Governance reforms: rights, tenure and reducing illegality
	Old-growth forests	• Sawmill efficiency • Sustainable forest management
	Plantations	• Access to land, technologies, credit, markets and inputs
	Agroforestry	• Incentives, technical support and access to markets
	Protected areas	• Financing for protected areas
Watersheds, freshwater		• Integrated and participatory watershed management, Integrated water resource management
Coastal and marine ecosystems		• Marine protected areas • Sustainable aquaculture
Urban ecosystems	Reduce heat island effect	• Green infrastructure
	Stormwater and flood management	• Parks and wetlands • permeable pavements and green roofs • Tree planting
	Amenity	• Parks and tree planting

These natural capital investments can be put into a framework and grouped according to ways to **reduce the demand** for provisioning services from primary natural capital, including providing alternatives as well as ways to **increase the supply** of primary natural capital. This is illustrated by Figure A.1 and Table A.2.

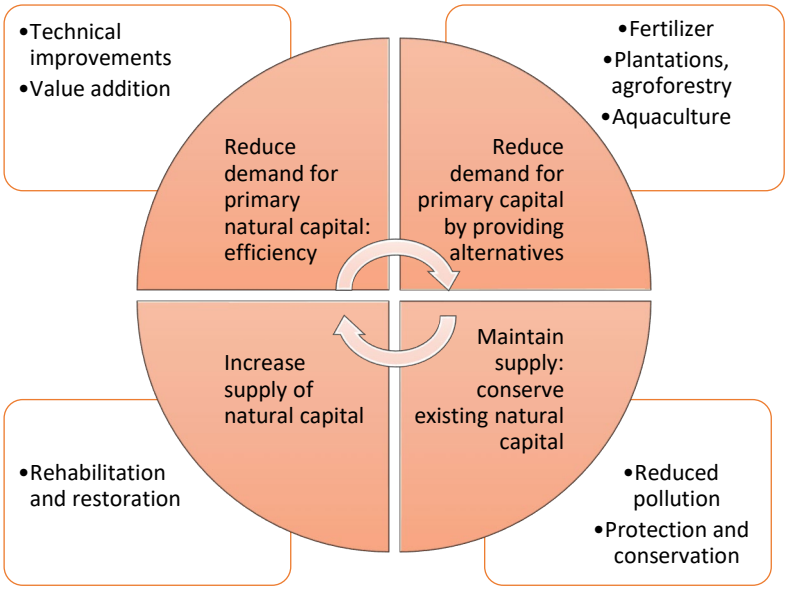


Figure A.1 Framework for investments in natural capital: reducing demand and increasing supply. Source: authors' own.

How can we finance natural capital investments?

While these natural capital investments may have high economic returns, there is a need to finance them in practice, particularly if loans need to be repaid. The report summarises the growing examples of natural capital investments being financed from domestic and international public and private sources. It finds that an increasing number of Asia Pacific countries are reforming subsidies and taxes to benefit natural capital investment. This includes reforming forestry subsidies in Indonesia, raising fishery taxes in the Pacific and introducing water charges in PRC.

Some of the revenues from these natural capital taxes are being spent on sustainable management, for example forest funds and conservation funds. Payments by ecosystem users can be one source of natural capital financing, but these schemes tend to be small scale with the exception of Viet Nam's national Payments for Forest Ecosystem Services (PES) programme. A more effective source of finance may be from domestic government expenditure that combines public works programmes with ecosystem improvements as in PRC, India and the Philippines. Another alternative for natural capital financing is local government spending by provinces and cities, as in the case of PRC.

Development agencies banks such as the World Bank, United Nations and the European Investment Bank (EIB) are increasing their spending on natural capital with the EIB recently launching a Natural Capital Financing Facility. The private sector is also playing a more active role with some exciting developments in sustainable plantations and aquaculture in the Asia Pacific region and investments in sustainable tourism and water-use efficiency.

Table A.2 Framework for natural capital investments: reducing demand and increasing supply

Resource/ ecosystem	Crosscutting investments	Demand for wild natural capital		Supply of wild natural capital	
		Increase use efficiency	Promote alternatives of "assisted" natural capital	Maintain supply of existing wild natural capital	Increase supply of wild natural capital
Soils for agriculture	Tenure reforms	Agricultural intensification	Better fertilizers	Zero or reduced tillage	Soil terracing
Rangelands/ Grasslands	Tenure reforms	Animal productivity	Farm feeding of livestock	Maintain protected areas	Increased protected areas
Water for agriculture	Pricing and regulatory policies	Agricultural intensification, Higher value crops	Water from desalination	Groundwater protection	Groundwater recharge
Tropical forests	Reduced illegal logging, tenure rights	Sustainable forest management, Sawmill efficiency	Plantations/ Agroforestry	Maintain protected areas	Increased protected areas
Watersheds	Payment for Ecosystem services	Participatory management	Reforestation	Maintain protected area	Increased protected area
Aquatic	Monitoring and enforcement	Value addition eg fish processing	Aquaculture	Protection of fish spawning grounds	Increased marine protected areas
Coastal ecosystems	Participatory management	Higher value uses eg tourism	Artificial reefs	Reduced agricultural and urban impacts	Increased marine protected areas
Urban ecosystems	Awareness of ecosystem benefits over hard engineering	Not relevant	Constructed ecosystems/ green cities	Not relevant	Not relevant

1 Introduction

This section defines natural capital and also provides some discussion on why a natural capital approach is important. It contrasts different definitions and components (e.g. stocks of natural capital, flows of ecosystem services, contribution to economic wealth), and then identifies the focus of this report. It also looks briefly at the key threats to natural capital in Asia and the importance given to natural capital in recent global policy frameworks, particularly the Sustainable Development Goals. Finally, it will look at the importance of the concept of natural capital to ADB and why ADB is interested to explore opportunities to increase investments in natural capital.

1.1 What is natural capital?

Natural capital refers to the stock of ecosystems within an economic unit –for example a company, or a country. It includes renewable natural ecosystems and resources like forests, water and agricultural farmland, and non-renewables like minerals and fossil fuels (The World Bank 2011).

Natural capital provides benefits to people and economies. These natural capital benefits can be divided into the direct goods and services (provisioning of food, water, wood and fuel etc) and the ecosystem services of the natural capital which include supporting services, regulating services and cultural services (see Figure 1.1 and Box 1 for an example of the benefits provided by wetland ecosystems).

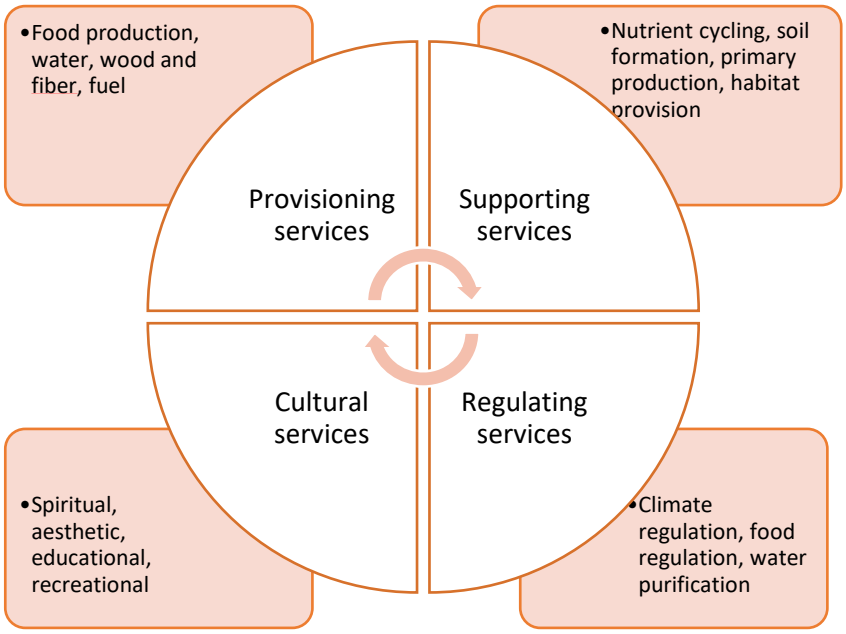


Figure 1.1 Natural capital and ecosystem services: the basics
Source: Adapted from MEA (2005)

One of the most important contributions of regulating services is its role in promoting adaption to climate change in a process known as Ecosystem Based Adaptation or EBA (MEA, 2005) where adaptation is achieved or assisted through climate regulation, flood regulation and other ecosystem services.

Natural capital also includes biodiversity. Biodiversity covers the variety and variability of life on Earth and refers to either genetic variation, ecosystem variation, or species variation (number of species). Sometimes there will be a trade-off between the different ecosystem services – for example the more provisioning services provided by a forest in the form of timber, the less trees there will be for regulating services such as flood regulation. Investments in natural capital that promote sustainable management of ecosystems can have important benefits to people, by impacting different ecosystem services. These impacts can be assessed through the individual consumption or production functions, or at macroeconomic levels by aggregating societal benefits (MEA 2005, De Groot et al, 2013, Perret et al 2010). Section 2 of this report and Annex 1 discusses in more detail the science behind ecosystems, natural capital and benefits provided to people.

At the country level, natural capital complements **produced capital**, or manufactured like infrastructure and machinery, and **intangible capital** (e.g. like human, social and institutional capital) to generate **wealth** (see Figure 1.2)

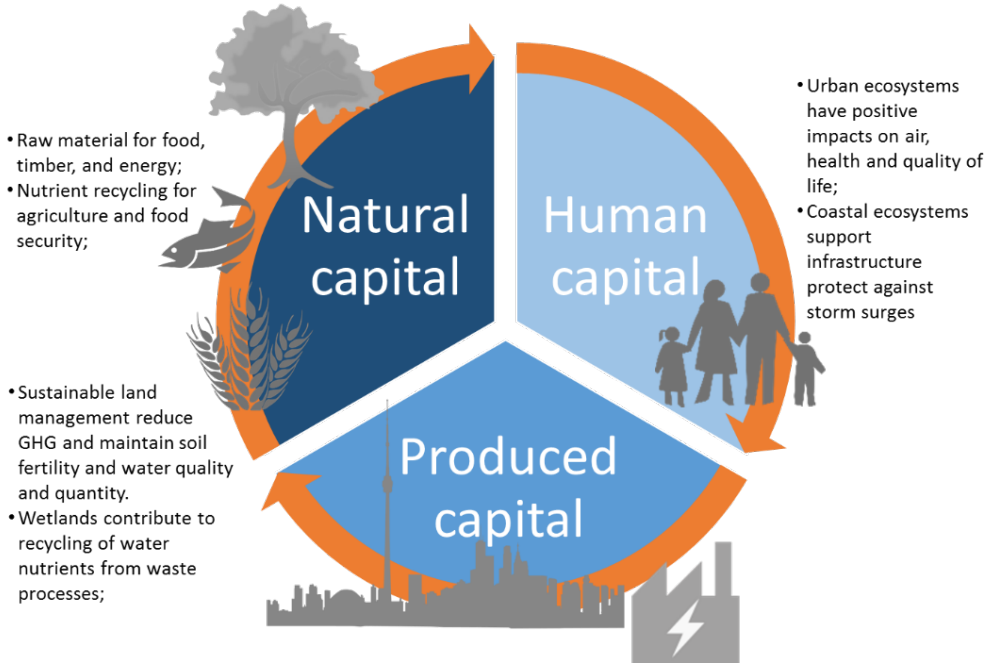


Figure 1.2 Natural capital as part of a country's wealth Wealth in a country is measured by the changes in their main assets: produced capital, natural capital, and intangible capital (which includes measures of human and institutional capital, as well as financial assets). Source: authors' own.

Natural capital is special as it cannot easily be produced or manufactured like produced capital such as factories and machinery, so it is inherently scarce and its loss may even be irreversible. Certain forms of natural capital such as underground water aquifers or topsoil may take generations to regenerate if they are initially used up. Other renewable natural

capital, like forests or fish stocks are often slow growing and may be easily over-extracted. Only some types of natural capital such as tree plantations and fishery aquaculture can be more easily reproduced, but their biodiversity value is generally lower. This is set out in Table 1.1.

Table 1.1 Estimated regeneration rates of selected natural capitals

Resource/ecosystem	Estimated time to naturally regenerate (without external pressures or external inputs)
Soils for agriculture	Over 100 years
Rangelands/grasslands	10-20 years
Old growth tropical forests	>100 years with natural regrowth
Forest plantations	10 years for fast growing plantations (eg eucalyptus) – but requires initial planting
Biodiversity	Extinct species will never return
Groundwater	10-100 years depending on location
Surface water	1-2 years
Wild fisheries	5-10 years depending on fish species
Aquaculture	1-2 years – but requires intensive manmade inputs
Coastal ecosystems	10-100 years depending on ecosystem

Source: Authors

Despite high scarcity and hence social values, natural capital is not always traded in the market so it may be often undervalued by the price system, resulting in low financial benefits. Even when prices exist they usually fail to reflect true social cost, for example not taking into account the negative externalities their production generates.

There are some components of natural capital that are sold directly in markets and so these natural capital values can be approximated by market prices– e.g. food from crops - or contribute directly to goods sold in markets, such as water flows generating hydro-electricity. Other aspects of natural capital have social values through affecting the health and quality of life for people, for example natural forests and wetlands contribute to the purification of water and air, and to ecosystem based adaptation and the provision of recreational and spiritual sites, all of which contribute to economic growth and development, yet fail to be reflected in prices. Many biodiversity values of natural capital may not be easily measured, adding to the tendency to undervalue natural capital.

1.2 Purpose and focus of this report

This report's purpose is to make the make the case for increased investment, in particular loans for natural capital. So its audience is Asia Pacific governments and other country stakeholders and development professionals including the staff of the Asian Development Bank.

In this report we focus on natural capital from renewable resources and ecosystems, in particular:

- soil and water for agricultural croplands
- rangelands/grasslands and pasturelands
- agroecosystems and forests
- protected areas
- watersheds and freshwater resources
- aquatic, coastal and marine capital
- urban ecosystems
- and links with ecosystem based adaptation

In particular, the report focuses on a combination of resources (soil, water, forests and fish) with a set of ecosystems (croplands, rangelands, watersheds, coastal ecosystems)

The report examines both "wild" natural capital such as old growth tropical forests and coral reefs and "assisted" natural capital such as croplands, plantations and aquaculture. In practice this distinction between "wild" and "assisted" natural capital is hard to determine since the world is now in the "anthropocene" where human interventions are having a dominant impact on natural systems. In addition, most actual landscapes in Asia Pacific combine patches of more "wild" and more "assisted" natural capital. However the distinction remains useful as both "wild" and "assisted" natural capital typically require quite different types of investment and they have quite different benefits in terms of ecosystem services. "Natural" capital and ecosystems will typically have higher biodiversity benefits and non-provisioning ecosystem services (eg high water regulation services of an old growth forest) while generally "assisted" natural capital will have lower biodiversity benefits and less non-ecosystem service benefits (eg plantations lower and even negative water regulation services) – although their provisioning services may be higher (eg timber benefits from certain fast growing plantations).

This report is focused on the supporting, regulating and cultural ecosystem services of natural capital given that provisioning services (in terms of direct consumption of natural capital) are better known (and often lead to unsustainable extraction). These supporting, regulating and cultural ecosystem services also provide the rationale for the more sustainable management, conservation and rehabilitation of natural capital as opposed to its extraction and unsustainable use.

1.3 Natural capital and Asia Pacific's economies

The region has a very high dependence on natural capital to propel economic growth. Higher wealth levels increase the demand for resources like food and energy.

An analysis of wealth accounts in 150 countries (The World Bank 2010) shows that as much as a quarter of the wealth generated in Asia Pacific comes directly from natural capital, which includes forests, protected areas, agricultural lands, energy and minerals.

Results show that in 2005[2] natural capital amounted to **US$7,512 billion in East Asia & Pacific**, **US$3,796 billion in South Asia and US$6,256 billion in Europe & Central Asia** -of which US$5,235 billion were from China (see Figure 1.3). The values could be even higher, as they do not reflect the impact of ecosystem services on economic goods–like the contribution of natural pollinators to crop production.

The high dependency on natural resources displayed across the Asia Pacific is consistent with most developing regions, which show that on average 30% of their national wealth comes from natural capital. The average percentage worldwide is lower (5%), and high income countries like those in the OECD have the lowest dependency of natural capital for national wealth (2%). The study suggests that –for most countries – the initial high dependency on natural resources is reduced as countries "manage their assets in the long term and reinvest in human and social capital as well as in building strong institutions and systems of governance" (The World Bank 2011).

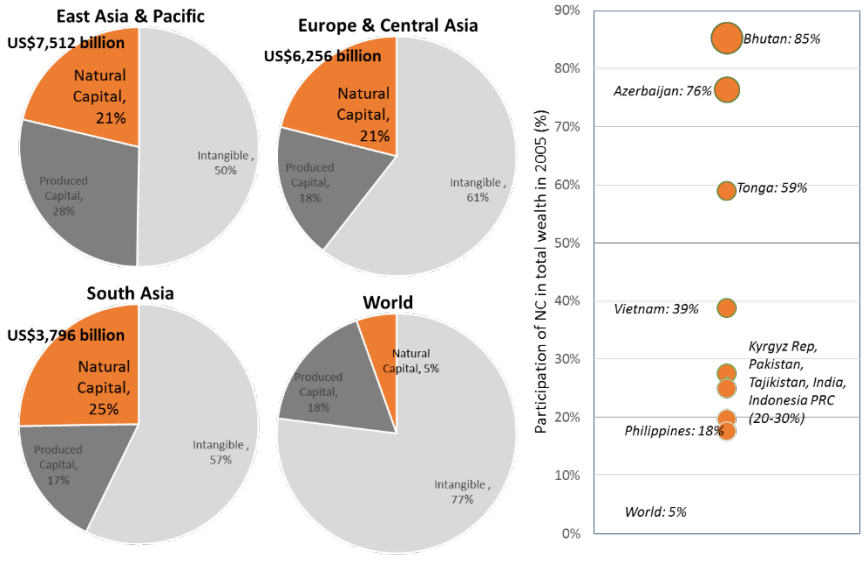


Figure 1.3 Wealth composition in Asia with respect to rest of the world
Note: Natural Capital is a very important source of wealth in Asia, showing a much higher share in total wealth in relation to world averages. Within the region dependence varies widely, for example as high as 85% in Bhutan and 18% in the Philippines in 2005. Source: authors' own, using data from World Bank (2011): Wealth of the Nations. Note: natural capital in this figure does not include sub-soil assets.

[2] The study conducted detailed wealth accounts for 150 countries for 1995, 2000 and 2005. Monetary figures are provided in billions of dollars for 2005 current values.

Figure 1.4 Composition of natural capital in Asia
Note: The components of natural wealth vary across the region. Agriculture and forests are important sources of wealth for East and South Asia, while countries in Central Asia depend more on their subsoil assets-many of them non-renewable. The higher the dependence, the higher the rate of use and extraction. Source: prepared with data from World Bank (2011).

As Figure 1.4 shows, the composition of natural wealth within Asia varies significantly across the regions, reflecting initial endowments while highlighting the need for differentiated management strategies. The region of Europe and Central Asia for example show the highest contributions of natural capital to wealth, highly reliant on subsoil assets (38%) and valuable (yet non-renewable) resources like natural gas (19%) and oil (17%). Renewable resources have a larger share in terms of natural capital in South Asia (crops 43%, pasture land 22% and timber/protected areas 11%), and East Asia & Pacific (crops 45%, forests/protected areas 12%, and pastures 5%). With such high dependencies on natural capital, governments must ensure that use of the resources does not undermine their future availability.

With nearly 5 billion people, Asia Pacific hosts nearly a third of all the world's population and is growing at a steady pace. The annual growth rate in the region has fluctuated significantly since the 2000, but with relative higher growth rates than the world average (see Figure 1.5). Six of the top ten fastest growing economies, measured as a GDP growth rate of more than 9%, are in Asia and the Pacific region. These are Papua New Guinea (1st), Turkmenistan (3rd), Myanmar (4th), Bhutan (7th), Lao PDR (8th), and India (9th) (IMF, 2015). As wealth increases so does the demand for goods and services including for natural resources –food, energy, fuel and waste associated with this consumption- that leads to decline and loss of natural capital.

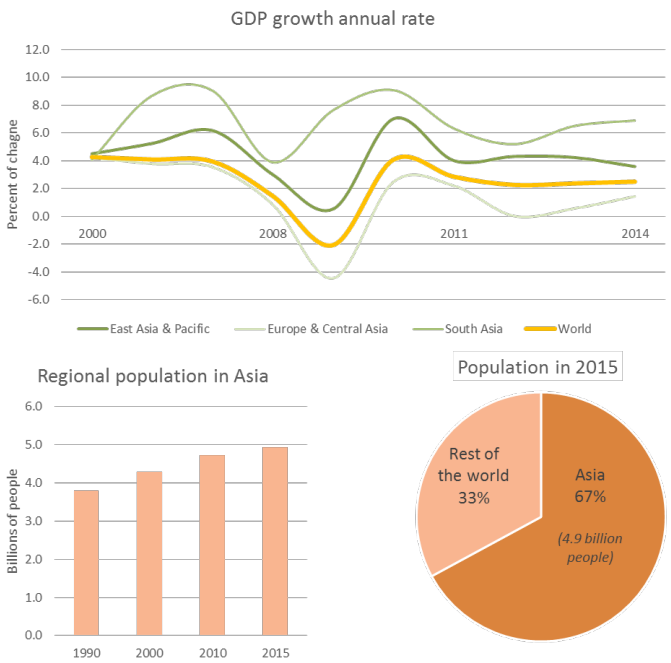


Figure 1.5 General growth trends in GDP and population in the Asia region
Population has been growing in the region and currently represents nearly 70% of the world population. As incomes increase so does the demand for goods and services, putting enormous pressure on existing resources in and outside the region.
Source: World Bank databank, accessed 10/06/2016

1.3.1 Energy demand, natural capital and climate change

Electrification varies across the Asia Pacific region (see Figure 1.6, left-hand side): from 100% in China, Brunei and Malaysia down to 32% in Myanmar and 26% in DPR Korea (OECD and IEA 2015). Access to electrification varies between urban and rural areas, and there is a total of 526 million people without electricity in developing Asia which will be demanding electricity coverage in the short and medium term.

Viet Nam is an example of the successful electrification investments. In 1975 electrification among poor households was less than 2.5%, and by the end of 2009 the country had provided electricity to 96% of households and industry, taking advantage of the country's natural thermal and hydropower resources (ADB 2011). ADB has supported several key projects in the area, including the $196 million Song Bung 4 Hydropower Project (which addresses environmental and social impacts and promotes integrated water resource management in the river basin) and a $151 million project financing several mini-hydropower plants of less than 7.5 megawatt capacity in the northern and central provinces of Viet Nam and connecting them to the grid.

At the same time, there are 1,895.1 million people in the Asia Pacific region depending on traditional sources of biomass for energy – the majority in India and China, but with countries like Myanmar and Bangladesh having over 90% of their total population relying on biomass –much of it from woodfuels from forests which can lead to a decline in natural capital (see Figure 1.6, right-hand side).

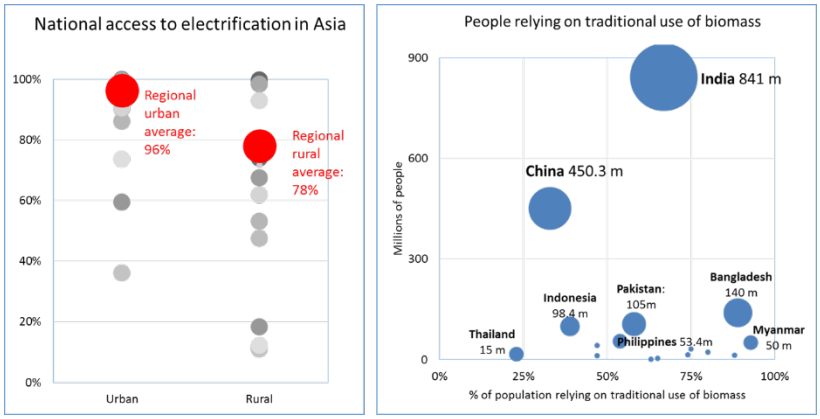


Figure 1.6 Use of energy in Asia
Most areas in Asia have access to electrification, especially in urban areas, although there is still a high reliance on traditional biomass for cooking. This creates opportunities for renewable forms of energy. Source: authors' own, prepared with data from OECD and IEA (2015).

An energy outlook for the Southeast Asia region predicts that energy demand will increase by over 80% between 2013 and 2015 (OECD and IEA 2013) – with a high reliance on oil, coal and natural gas (a worrying trend as stocks diminish and population grows). The study predicts that demand for biomass will decline as people switch to modern types of energy. The study predicts that energy-related CO2 emissions will almost double, reaching 2.3 Gt in 2035.

Asia Pacific is one of the main contributors to CO2 and greenhouse gas emissions in the world (see Figure 1.7). Just five countries in the area (China, India, Japan, Indonesia and Korea) produced 35% of the world's greenhouse emissions in 2011. Within Asia, Turkmenistan and Korea are among the largest per capita contributors of CO2 emissions, and are several times higher than the world's average emissions. Much of these atmospheric emissions have also local impacts. The amount of population exposed to ambient concentrations of PM2.5 (fine particulate matter, one of the most hazardous pollution for the human health) that exceed the WHO guideline value is nearly 100% in nearly twenty countries in Asia – higher than the world's average.

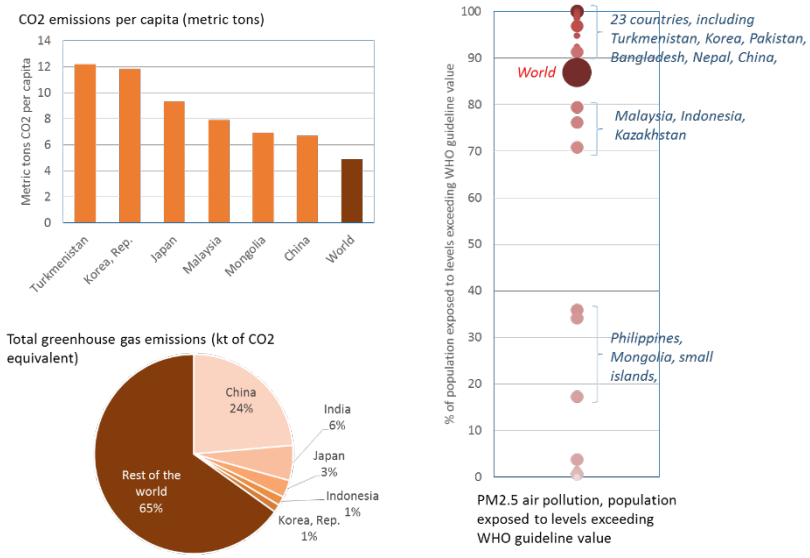


Figure 1.7 Air pollution, CO2 and other GHG in Asia in 2011[3]
The increased demand for energy –for example for transport, electricity and cooking directly increase air pollution like CO2 and particulate matter. This has global impacts on the ozone layer, but direct and immediate impacts on reduced health and quality of life in Asian cities. Source: authors' own, using data from http://databank.worldbank.org and Brauer et al., (2016)

The interaction of emissions from burning low-quality (sulphurous) coal used by homes and industry, and the photochemical smog from car pollutants mixed with high sunlight in Asia has direct and dangerous impacts on human health –e.g. chronic bronchitis and asthma, heart disease and strokes and several forms of pulmonary diseases (Chung et al. 2011, WHO 2014). In 2012 there were 7 million deaths attributable to household and ambient air pollution, 32% of which were in South East Asia and 40% in the Western Pacific region. An ADB report on air pollution in China puts the cost of air pollution between 3 and 6 percent of GDP and up to 13.% when considering other environmental degradation (Dominguez 2015). Natural capital is also severely affected by air pollution, both through increases in acid rain and other impacts.

Greenhouse gas emissions from Asia Pacific and elsewhere are leading to global climate change, which is impacting people and ecosystems in the region. There is a growing likelihood that global efforts to reduce greenhouse gas emissions will not meet the global target of limiting global temperature rise to below 1.5°C (Rogelji *et al.,* 2016). Already, over the last 100 years the global climate had warmed by approximately 0.80[C] (Hansen *et al.,* 2010) with 2015 being almost 0.9 C above the 20th century average. Global temperatures are expected to continue to rise into the foreseeable future with a further increase of 1.3 to 1.8 C projected by the end of the century (Meehl *et al.,* 2007).

Corresponding with the rise in global temperatures are changes in other climate and physical processes including changes in total and seasonal precipitation, altered ocean

[3] **CO2 emissions (metric tons per capita).** Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring. **Total greenhouse gas emissions in kt of CO2 equivalent** are composed of CO2 totals excluding short-cycle biomass burning (such as agricultural waste burning and Savannah burning) but including other biomass burning (such as forest fires, post-burn decay, peat fires and decay of drained peatlands), all anthropogenic CH4 sources, N2O sources and F-gases (HFCs, PFCs and SF6).

currents, sea level rise and changes in climatic extremes including more extreme rainfall days during the wet season, potential intensification of cyclones and intensification of drought in some regions (ADB 2016). Regardless of how fast the world moves toward a sustainable, low-carbon economy, greenhouse gas concentrations are expected to rise for many more years, the biosphere will continue to warm, ecosystems and the services they provide will inevitably change and shifts in climate and alterations in climate extremes will impact heavily on both social systems and physical infrastructure.

1.3.2 Food production and natural capital loss

Two-thirds of the world's hungry live in Asia and the Pacific. But as Asia' population and incomes grow, the demand for food increases (Alexandratos and Bruinsma 2012). In Asia the areas under permanent crop production have been expanding steadily over the years (see Figure 1.8).

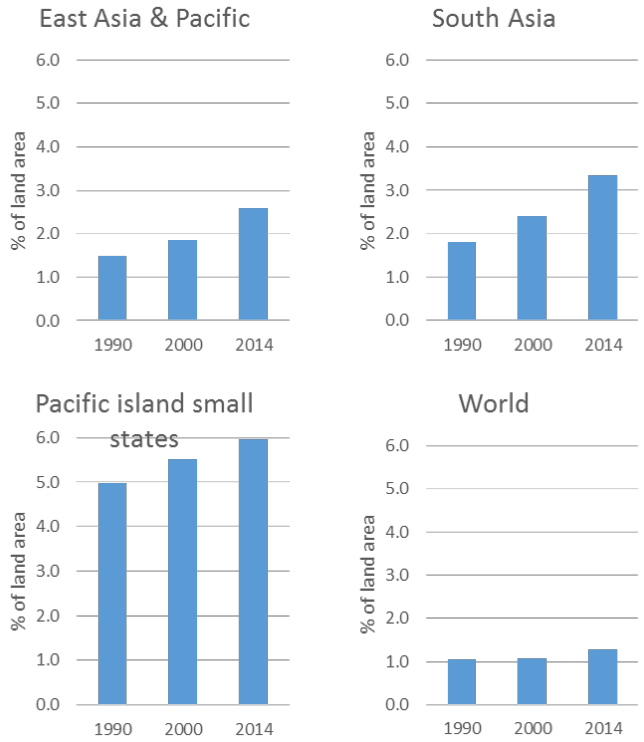


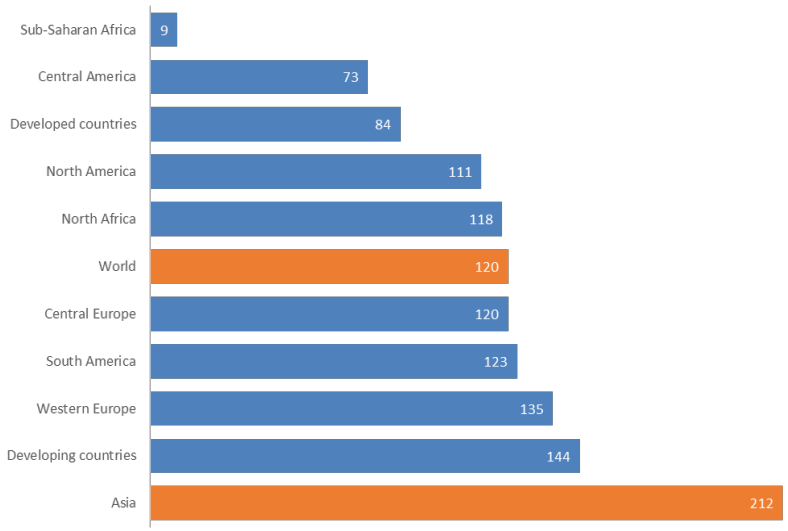
Figure 1.8 Area under permanent crop in Asia (1990, 2000 and 2014)
More people means higher demand for food. The area under permanent crop in Asia has been increasing at faster rates than the rest of the world. Agriculture is highly reliant on basic ecosystem services, like pollination, steady and clean water, and nutrient recycling. Unsustainable agriculture results in the loss of many of those functions. Source: Prepared using data from FAO available in http://data.worldbank.org/

Agricultural expansion puts pressure on forests, wetlands and other natural capital, for example by converting natural ecosystems, entering into direct competition for resources like water, and through non-point pollution. Agricultural intensification for example is linked to very high application rates of fertilizers and pesticides which can harm natural capital systems – see Figure 1.9.

Asia Pacific is part of the growing shift towards livestock production and consumption. The increase in demand is not only reflecting population growth but is further driven by the significant trend of an increasing middle and upper class which desire meat-rich diets. Globally, livestock production currently accounts for 35-40% of the gross value of agricultural production. In the developed countries this share is half of total production and in developing countries it is about one third. Meat consumption constitutes a particular

challenge for natural capital as the demand has serious impact on fodder/feed consumed, derived pollution, and carbon footprints. Livestock production is the world's largest user of land, either directly through grazing or indirectly through consumption of fodder and feed grains (FAO 2012).

Figure 1.9 Use of fertilizers in the Asia region, compared to rest of the world (kg/ha)



The Asia region use far more fertilizer than other regions in the world: 212 kg/ha compared to a world average of 120 kg/ha, even superseding the levels of the "Developed countries" (Source IFDC 2013[4])

1.3.3 Urbanisation and natural capital loss

The past two centuries have seen not only rapid growth in the human population but also the proportion of that global population who live in urban centres. This process, known as urbanisation, broadly involves both expansion of the land surface area of urban centres and a demographic shift from rural to urban centres. Before the 21st century the majority of people lived and worked in rural areas. In the 1800s only 3% of the population lived in urban centres. By the middle of the 20th century that had risen to 30% and by 2014 the UN estimated that more than half of humanity, 54%, lived in urban settlements. The trend of urbanization of the population is expected to continue and by 2050 this proportion is projected to rise to over 66% or some 6.25 billion people (UN Secretariat 2014).

Whilst the Asia Pacific region as a whole is less urbanized than the global average with some 48% of the population in urban settlements it has the largest urban population and is the most rapidly urbanizing region in the globe. In 2014 the urban population of the Asia Pacific region was estimated to be over 2 billion which is larger than the entire populations of the European Union and the USA combined. Asia is home to 53% of the global urban population and two countries alone, China and India, accounted for 30% of the world's urban citizens.

From 2010 to 2015 the global annual rate of urbanisation was 0.9% with Asia having the highest rate at 1.5% in comparison to Europe at 0.2% and Oceania at 0% (UNDESA 2014). Nevertheless, there is wide variation across the region with western and eastern Asia being the most urbanized with 70% and 59% of the population in urban centres respectively. In terms of the rate of growth in urbanisation, again there is also much variation with some counties undergoing rapid urbanization. Between 2010

[4] IFDC. 2013. "APPI Gross Margin Survey: FDP's Yield and Financial Benefits Proven," IFDC Report Vol. 38/2. Accessible at: <www.ifdc.org>.

and 2015 seven countries in Asia had an urbanization rate at more than 2% (Bangladesh, Bhutan, China, Maldives, Nepal, Solomon Islands, Thailand, Timor Leste and Viet Nam).
In a global review of the impacts of cities Grim *et al.,* (2008) listed five main types of environmental change that occur as a result of urbanisation. These are changes in land use and cover, biogeochemical cycles, climate, hydrological systems, and biodiversity (see section 2).

2 Why invest in natural capital?

This section presents the case for natural capital investments. Such investments can be justified based on scientific, economic and social grounds. The section starts with a review of how countries decide their investment priorities including borrowing from MDBs and how natural capital has entered this decision-making process.

2.1 Policy investment priorities

Competing agendas often determine government investment priorities away from sustainable natural capital. Traditional investments –i.e. infrastructure- are perceived as better suited to promote growth, and more in line with domestic priority agendas. A better understanding of the scientific and economic arguments for natural capital, as well as a change in discourse of what is economic growth, is slowly propelling new trends in the region, led by China which is increasing its investment in natural capital.

Public and private investment priorities are set by many complex economic and political processes. It is the nature of this policy process which needs to be understood to present the case for natural capital investment.

In the rational choice model, Government's set investment priorities to achieve certain socio-economic objectives including economic growth, employment and poverty reduction. However in practice, there may also be political factors such as the demand for certain investment from powerful lobby groups connected to the government or to particular individuals or groups in power.

Many aspects of this policy process will tend to undervalue investments to sustainably manage, conserve and rehabilitate natural capital. As section 3 will demonstrate, natural capital conservation is undervalued by the market and suffers from multiple market failures, so will be undersupplied by the private sector and by governments that focus primarily on financial rather than economic rates of return.

Natural capital may be particularly affected by political factors at play. Sustainable natural capital use is more critical to the poor and marginalised, while certain elites tend to benefit from natural capital extraction and unsustainable use (eg large commercial forest and fishery harvesting). So where a government or political leaders choose investment priorities and policies based on links to elites that damage natural capital, this will undermine investment in sustainable natural capital.

Even when these overt political factors may play less of a role, there will be a bureaucratic and institutional process within government departments which may limit the prioritisation of natural capital investment. Decisions about public sector investment, including which international loans to request from ADB and others, will typically be made by the Ministry of Finance. The current focus of Asia Pacific Ministries of Finance is on economic growth, often driven by public infrastructure investment. It will be a challenge for politically weaker Ministries related to natural capital, such as Ministries of Agriculture, Forestry, Fisheries and

Wildlife to persuade the Ministry of Finance to deviate from an emphasis on infrastructure investment.

One of the reasons that infrastructure is given priority in the poorer countries of Asia Pacific is that this is seen to be the way that the PRC and other high growth Asia Pacific economies succeeded in achieving economic growth. There is a dominant view that PRC's rapid growth has been achieved through a high degree of public investment in infrastructure including energy, transport and industrial services. This same approach is seen to have driven the economic growth of Korea, Thailand and other high income Asia countries. This infrastructure model is now being exported by the PRC itself through its export credit agencies and its banking system as well as by new institutions such as the Asia Infrastructure Investment Bank (AIIB). However, in some respects, the PRC is starting to vary its own investment priorities. An increasing share of investment is going into natural capital enhancing investment as Box 2.1 illustrates. It remains to be seen whether other Asian Pacific countries notice this changing trend of investment by PRC and change their own investment priorities to give more priority to natural capital.

China has realized that causing further damage to natural capital may result in irreversible consequences, so is beginning to shift from being the biggest polluter to a more eco-friendly economy. The first signs of this could be seen in China's 12th five-year plan, where for the first time they set significant targets for a series of environmental issues such as air pollution and sustainable development. The 13th FYP includes an ecosystem approach to environmental management and measures to promote the use of green technologies. Environmentally friendly economic policies and green finance, along with ambitious goals for environmental conservation. This had led some to argue that China is now emerging as a future leader in environmental management

Box 2.1 Changing trends towards natural capital investments in PRC
Source: Kolodziejczyk and Smith 2015

The other challenge with prioritising natural capital investment is that this investment may be driven by two relatively weak aspects of the policy process. This includes a scientific led basis for policy making and international commitments to natural capital. There is growing scientific evidence supporting physical and biological justification for natural capital investment (as set out later in this section). At the same time, this scientific evidence plays a limited role in policy making and investment priorities in many countries in Asia Pacific. Factors for this limited attention to science include gaps in information, lack of scientific understanding in the overall population and particularly from among politicians many of whom have a background in law or business with no scientific training. An exception is the PRC of China where many political leaders are engineers and so science has played a major role in policy discourse (ref).

The second weak link between natural capital and the domestic policy process is the importance of international environmental commitments. It is not unusual for natural capital protection to be perceived as driven by international environmental treaties and commitments. These are typically given less importance than domestic political priorities such as growth, employment and poverty reduction. So whilst countries may sign up to

international environmental treaties, these may often be downgraded in the face of competing policy objectives.

Whilst this section has focused on the reasons for natural capital investment to be given low priority, there are ways for this to change and the role of natural capital to be given greater priority:

- Firstly, natural capital may receive greater political and public attention. It is clear that in a number of Asia Pacific countries, natural capital loss is starting to impact public discourse and thus be taken more seriously by Ministries of Finance and political leaders who decide investment priorities. For example, Mongolia and Kyrgyzstan are part of the Partnership for Action on Green Economy (PAGE). An increased prioritisation of natural capital investment may also be part of a gradual process. As wealth and education increases the public becomes more aware of the impact of natural capital loss and will demand greater investment as set out in section 6 of this report (Chung et al. 2011)..
- Where the investment prioritisation policy process is opened up to wider stakeholders, this may allow an opening beyond a narrow infrastructure focus. For example there is evidence that PRC willingness to borrow from development banks, including ADB for natural capital is driven by Provincial and municipal governments who now set their own investment priorities.

2.2 Growing threats to natural capital

This section presents the status, trends and threats to natural capital. It demonstrates the growing overall evidence of natural capital scarcity and damage, but with some positive signs such as increased forest plantations and increased protected areas – both terrestrial and marine.

2.2.1 Land, soils and grasslands

In general, the Asia Pacific region enjoys a warm and seasonally humid climate and is well-endowed with natural resources for agriculture. The unique combination of the monsoon climate and the exceptionally large lowland area has made Asia the rice basket of the world. Sustained high levels of staple food production have enabled many of its countries to support a large population within a limited area of arable land. However, the region faces rapid changes in both socio-economic and natural factors and these have had major impacts on agro-environments in the region. Rapid economic development and urbanization are changing land management systems in many countries, and climate change has emerged as a significant source of risks. These changes are having major impacts on the status of soil resources in the region (FAO and ITPS, 2015).

Soil erosion is a major threat to land quality, sustainable food production and water infrastructure across Asia and is a major challenge in tropical and subtropical countries in South Asia, in the humid subtropical and temperate regions of in East Asia, semiarid regions in China, and the arid regions in Mongolia and East Asia. Soil erosion is the action of external processes such as water flow and wind to move soil from its location.

Most regions of Asia are affected by the Asian-Australian monsoon which causes dry and wet seasons. Water erosion is the major type of erosion in the regions of South and East Asia with alternating dry and wet seasons. On the other hand, wind is the crucial driving force inducing soil erosion in the drier and desert areas. Soil erosion by rainfall and surface water flow is generally affected by five factors: rainfall erosivity, soil erodibility, topography, surface coverage, and support practices. In humid regions, soil erosion is of little concern in well-established forests and in paddy fields. However, bare lands such as logged forests, construction areas and upland crop fields on slopes are exposed to a high risk of soil erosion. Annual soil loss in paddy fields is low. By contrast, soil loss from upland crop areas on slopes is very large – for example, 38 million tonnes/ha/year from fields in South Korea where no conservation practices were applied (FAO and ITSP 2015). In semiarid regions, soil erosion is also of concern especially for slope areas with scant vegetation. In these areas, heavy episodes of rainfall in the rainy season can result in massive gully erosion. Soil acidification, and loss of soil biodiversity are seriously and increasingly impacting the soil stability and productivity. Further factors include waterlogging, nutrient imbalance, compaction, and sealing and capping also impacting – especially in urban areas.

One important agricultural ecosystem in Asia Pacific is grasslands or pasturelands. Figure 2.1 shows that Asia Pacific has more grasslands and pasturelands than other regions, with particularly large areas found in Central Asia, Mongolia and parts of PRC.

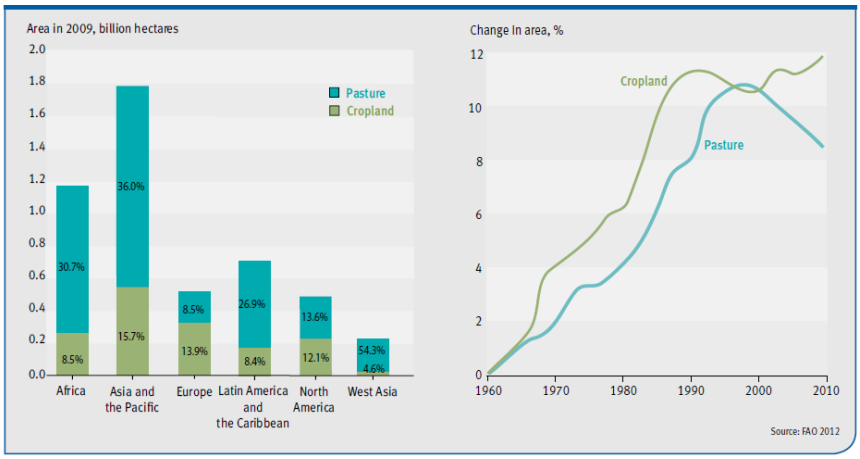


Figure 2.1 Areas of cropland and pasture 2009, by region (left); global change 1960–2010 (right)
Source: UNEP (2014) based on FAO (2012).

2.2.2 Forests, watersheds and protected terrestrial areas

Forest ecosystems provide a variety of ecosystem services that benefit people (see Annex 1). Around the world, forests goods and services support the livelihoods of over 1 billion people (TEEB 2009). For example, they provide timber, paper and fibre products traded in markets, formal and informal. Through their higher evapotranspiration rates (with respect to shorter vegetation), forests help regulate water flows by reducing flood risks downstream. This provides important benefits for watershed management. Dams, hydroelectric projects and water utilities highly benefit from natural forests located in the upstream areas of watersheds, through their ecosystem services in the form of regulation of water flows and sediment delivery. Forests also capture and store GHG emissions, helping

with climate regulation. Natural forests also protect biodiversity, provide access to recreational and cultural values.

The forestry industry sector has been expanding over the last decade, driven by the abundance of labour, relatively abundance of forest resources, and general policies to encourage investment in the sector (Lebedys and Li 2007). In many places, this has led to a short-term liquidation of forests assets via deforestation, degradation and conversion of old-growth natural forests for forest plantations (Grieg-Gran and Bass 2011)). The limited private gains obtained from this conversion do not compensate for the loss the ecosystem services provided by conversion of natural forests.

The Asia-Pacific region has experienced heavy deforestation and forest degradation. The region lost about 0.25 million ha of forest annually during 1990 to 2000, which approximately represents 125 million hectares of degraded forest land and 145 million hectares of degraded forests (FAO and RECOFTC 2016). The direct causes can be found in a mix of unsustainable logging practices, fires and conversion for other uses. Indirect causes are a mix of mixed market signals which undervalue forests, poor regulations and their enforcement, and unclear rights.

While massive afforestation and forestry plantation programmes introduced in China, Viet Nam and the Philippines during the past decade reversed the overall forest cover trend in Asia (bringing the overall regional trend upwards to 1.35 million ha annually, see Figure 2.2), the degradation and deforestation processes evident across the rest of the region have resulted in what is described as a "mosaic of land uses, ranging from agriculture to underutilized open areas, heavily encroached forest patches and intact forests some distance away from human activity" (FAO and RECOFTC 2016).

While this recent data on forest cover shows positive global trends it is also evident that forest loss and degradation persist in poor tropical countries, including in East and South Asia (FAO 2015b, Sloan and Sayer 2015). Positive trends are observed in in some countries in South Asia, with stronger forest institutions conserving the remaining areas of forest and encouraging the expansion of plantations. Nepal, for example, has seen positive effects following the implementation of community forestry from the 1990s onwards (FAO and RECOFTC 2016). However, total forest area is now critically low in many countries. Countries like Pakistan, Korea, Timor-Leste and Indonesia lost more than a quarter of their forest cover between the period of 1990 and 2015 (FAO database, see Figure 2.2). The expansion of commercial estate crops such as oil palm, sugar, and wood fibre drive the rapid conversion of forests in South East Asia. The disparities in power over land and rights create a further chasm in terms of distribution of benefits and loses between corporate interests and conservation-minded local communities (Sloan and Sayer 2015).

Even in countries where forest cover has increased, it has not been a "like-for-like". The growth in forest cover is driven by reforestation for timber or biomass purposes, while the losses are in the majority from natural forests (FAO 2015b). Many ecosystem services are lost when natural forests are converted, and not necessarily regained through forest

plantations, for example better water quality and regulation of water flows, cultural values and biodiversity conservation.

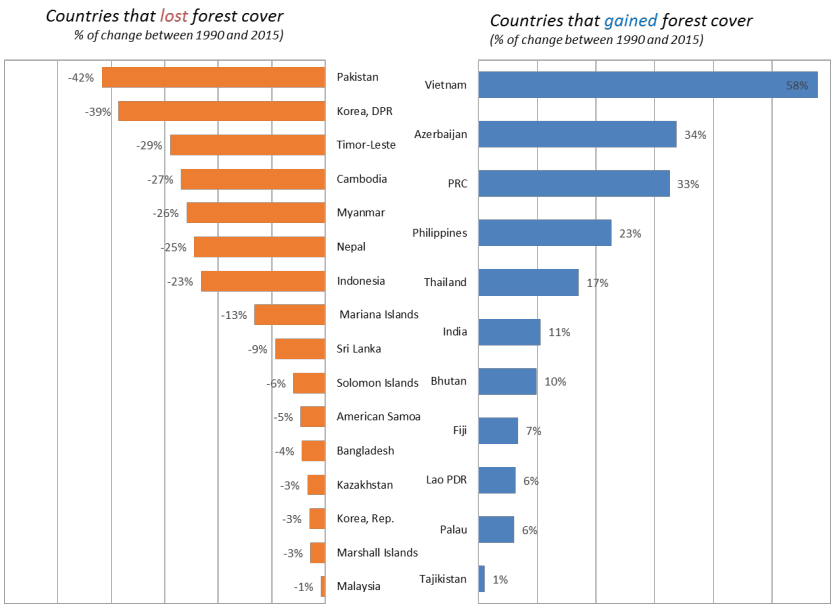


Figure 2.2 Changes in forest cover in Asia Pacific (1990-2015) Forest cover in the Asia region show an upward trend, driven mostly by large reforestation programmes for example in China and the Philippines. But in most other countries natural forests have been lost, and with them multiple ecosystem benefits like protection of water sources and of biodiversity. Source: Authors' own, prepared using data from FAO (Accessed in June 2016) through http://databank.worldbank.org

These trade-offs between ecosystem services have not always been considered in the design of some large scale reforestation programme, for example planting trees against desertification. A study in China by Cao (2008) suggests an approach less focused on the trees on their own but rather as part of their local ecosystems:

"the long-term results of [afforestation to combat desertification] this practice increasingly show that these projects are actually increasing environmental degradation in arid and semiarid regions, with ecosystems deteriorating and wind erosion increasing. Rather than focusing solely on afforestation, it would be more effective to focus on re-creating natural ecosystems that are more suitable for local environments and that can thus provide a better chance of combating desertification"

According to Cao's review, evidence shows that afforestation depletes the already stressed soil water reserves, reducing the survival rates of the introduced woody vegetation. The reported survival rate of trees planted during afforestation projects is very low: only 15% across arid and semiarid northern China (Cao, 2008). His study points that although the area of afforestation is increasing rapidly, the area of degraded land has continued to expand and the severity of desertification has continued to intensify throughout the country.

In general terms, forest landscape restoration across the Asia region has mostly followed a traditional approach mostly concerned with wood production and less on the ecosystems and their functions and services. "Landscapes" are often constrained by boundaries –i.e. of the forest reserve – and rarely incorporate downstream or upstream impacts (FAO and RECOFTC 2016).

A focus beyond the tree and into their natural ecosystem characteristics means more attention to water balances in the areas where afforestation takes place, looking into alternatives such as natural grasslands, instead of fast growing species that use a lot of water. Similar studies to Cao (2008) looking at hydrological balances and afforestation clearly point that a better understanding to carrying capacity of each ecosystem is necessary to ensure permanence of forestry activities. On the ground, initiatives promoted by different organisations like WWF and IUCN, and initiatives such as the Global Partnership on Forest and Landscape Restoration (FAO and RECOFTC 2016). This is of particular importance for watershed conservation and water management strategies which promote integrated watershed conservation approaches where trees play a key role (Calder 2005).

Protected areas are useful tools to promote protection of ecosystem services and biodiversity conservation, as well as disaster risk mitigation and climate change adaptation (Juffe-Bignoli et al. 2014). Global initiatives, such as the AZE alliance for Zero Extinction Sites and The Aichi Biodiversity Targets signed in 2010 – specifically Target 11 – are reviving the discussion of the role and status of protected areas in Asia Pacific.

A positive development in the Asia Pacific region has been an increase in the number of protected areas (PA), as strategies to respond to rapidly disappearing forests, biodiversity hotspots (there are about 15 in Asia) and other key ecosystems, which increased between 1990 and 2012 (Juffe-Bignoli et al. 2014).

Asia Pacific currently protects 11.5% of its total land mass, compared with 14.3% globally and the 17% CBD target for 2020. Specifically, East and North-East Asia had 16%, South-East Asia 14%, and South and South-West Asia 6% (UNESCAP, 2014). In the Philippines for example protected areas are set aside for protection, conservation, development, regulation and management of biodiversity and ecosystem services (FAO and RECOFTC 2016). By 2012 Myanmar had established a total of 32 protected areas (including wildlife sanctuaries and national parks), equivalent to over 3.5 million hectares or about 5.7% of the total country's land area. The government of Nepal has also promoted a good network of protected areas which cover almost one fifth of the total surface area.

Very few countries have reached the 17% Aichi Target of protected area. Additionally, the positive outcomes in creation of protected areas has not always been matched by their sustainable management - a recent analysis of some protected areas in Asia for example shows that only 24% of them had "sound management" (Juffe-Bignoli et al. 2014). Limited budget allocations, lack of staff to support law enforcement, weak local community consultation, and top-down selection of sites not always guided by nature conservation objectives have resulted in what IUCN calls "paper parks". The creation of new roads as part of development strategies also opens the way to further degradation in otherwise remote areas. In the Philippines for example new roads improved the access to protected areas and abandoned logged-over areas with remaining natural forests led to further bouts of illegal timber extraction activities (FAO and RECOFTC 2016). In Myanmar a recent study on natural capital calls the attention of the potential danger to upstream forested watershed in terms of water quality downstream arising from deforestation and conversion to crops following a new road in the northern parts of the country (Mandle et al. 2016).

An important development comes from new efforts to rethink the forestry sector across Asia Pacific, and the promotion of connectivity of these forests with other ecosystems and the people around them. For example, the Heart of Borneo Initiative (HoB), Greater Mekong Sub-region Core Environment Program (GMS CFP-BCI), the East Asian-Australasian Flyway Partnership (EAAFP) and the Terai Arc programme.

2.2.3 Freshwater and inland water resources

Water and the infrastructure needed to provide it remains a priority for policy makers in the region, according to the latest Asian Development Outlook (ADB 2016a). The demand for freshwater has been increasing alongside the fast population growth. A large amount of freshwater withdrawals come from the agriculture sector: 80% throughout Asia and the Pacific (ADB 2016b), as much as for 91% of in South Asia (with industry using only 2% of water), 72% in East Asia & the Pacific and 36% in Central Europe (see Figure 2.4). All across Asia domestic use withdrawals account for less than a third of all water flows.

ADB's latest water development outlook estimates that water demand in the region is expected to grow by about 55%. The different types of water users means that the water sector must cater for different needs, timing, and potential differentiation in water tariffs linked to availability and ability to pay per sector of the economy. The industrialization processes, couple with climate variability and water-related disasters like floods and draughts (where Asia has a low score in resilience to water-related disasters) puts extra pressure on already stressed delivery systems.

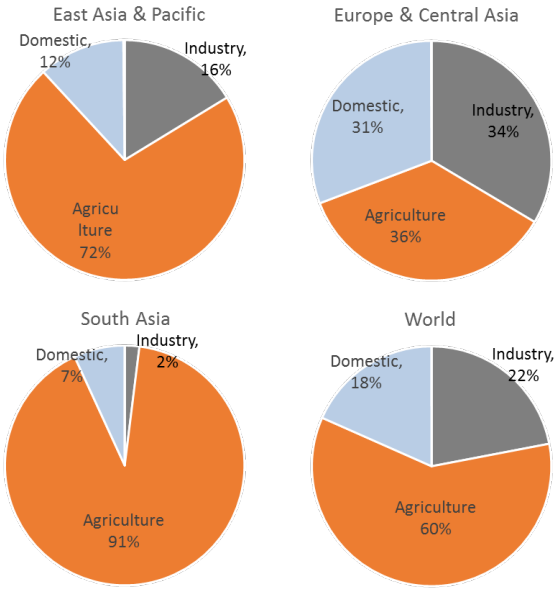


Figure 2.3 Percentage of freshwater withdrawals, 2014
Most of the water extractions in the Asia region – and the world – are for agriculture, industry and domestic use. In most places water for agriculture remains free or is heavily subsidized. Source: Prepared using data from Food and Agriculture Organization, AQUASTAT, accessed August 2016.

In Central Asia water problems are exacerbated by low rainfall, ageing infrastructure and lack of data. Most countries in Central Asia are dry (rainfall between 160-690 mm/year and as low as 70mm/year in plains and deserts), and water management is further complicated because its two major rivers – the Syr Darya and Amu – are transboundary. There is a constant shortage of freshwater for drinking and sanitation. Unsustainable extractions and excessive use of chemicals –mostly from irrigation – and uncontrolled waste deposits have caused severe ecological damage leading to dried up lakes, salinization and problems to

human, crops and biodiversity health (Bekturganov et al. 2016). According to ADB (2016b) over 75% of Asia is water insecure, and up to 3.4 billion people could be living in water-stressed areas by 2050.

Water scarcity is also a problem in the northern parts of China, Although China has made advances in control of industrial and domestic point sources of pollution it is greatly affected by nonpoint source pollution –e.g. from fertilizer runoff, pesticides, and discharges from intensive animal production facilities (Zhang et al. 2011). These discharges are having major impacts on water bodies, causing major damage to downstream users and ecosystems.

Conversion of ecosystems that play key roles for water management, like natural forests and wetlands, can have major impacts on water quality and quantity. Asia for example has lost 39% of its natural wetlands since 1970 (Dixon et al. 2016), with significant impacts that include:

- Increased sediments from upper parts accumulate on lower grounds decreasing storage area. In the lower reaches of major rivers wide floodplains typically develop, which have been increasingly converted into agriculture and settlement, reducing the area available for absorbing water. As a result floods are more likely to become more frequent and damaging.
- The introduction of modern systems, such as dams, irrigation, and diversion of river flows, prevent sediments from reaching wetlands, at a cost to fisheries and birdlife but also increasing accumulation of sediments in the dam barriers.
- Excessive loads of domestic sewage or industrial effluent can degrade inland wetlands, usually with a high cost of reverting damages. “Constructed wetlands” are sometimes used to mimic these functions as treatment plants, such as in the Ebro Delta in North-East Spain.

Increased attention is now being placed in some Asian areas on the role that wider ecosystems play both in the delivery of water and the effect from discharges from economic activities. For example, the Pacific islands have received a relatively high score in terms of environmental water security because of their limited river flow alteration, and good river health (ADB 2016b). ADB’s water outlook calls for a move away from ‘business as usual’ when it comes to water, promoting water efficiency methods that increase productivity, improved water management such as rainwater harvesting, reuse and desalination (ADB 2016b).

There is still room for expansion by incorporating the wider role that ecosystems play, and the role of integrated watershed management as part of any sustainable water management strategy, that considers the hydrological cycle in its entirety, all sectoral interests –present and future, and the governance systems required for the provision of water services.

The biggest challenge in Asia and the Pacific for water are the need to reconcile water needs to fuel the massive increase in food production required to feed its growing population, while providing water for domestic users, meeting industrial and energy demands and

ensuring the survival of key natural ecosystems. Agriculture projects are expected to grow throughout the region, but better care is now going into the type of projects promoted. For example in Uzbekistan the government has announced a shift from water-intensive crops such as cotton towards more sustainable crops with higher added value (ADB 2016a). Some of the Pacific Island States, like Fiji, are capitalizing on niche markets like bottle water, which accounts for important sources of export income (ADB 2016a). There is a call to provide tailored and targeted solutions. However, until now most most of the emphasis for water remains on traditional delivery infrastructure, and more attention is needed to the environment and water security, as well as risk reduction to water-related disasters.

2.2.4 Marine and coastal natural capital

Human activity is causing widespread changes to the marine environment via a raft of changes in physical, chemical and biological processes (WOA, 2015). The major drivers of these changes are not processes or actions directly within the marine environment but are related to activities originating in the terrestrial environment. This is particularly so within the world's densely populated coastal zones. The main drivers of degradation of marine biodiversity and marine environmental quality include the demand for food for increasing human populations and the expansion of international trade in agriculture leading to increased use of and run off of fertilizers and pesticides and particularly the rapid expansion or urbanisation of the coastal zone and concomitant industrial development. One third of the world's population lives in coastal communities and coastal zones are twice as densely populated as inland areas (MA, 2005; Barbier et al., 2008). To put the population expansion in the context of total global ocean assets, in 1950 there was 0.5 Km^3 of ocean waters per person by 2015 this was reduced to 0.2 Km^3 and by 2050 it is projected to be 0.125 km^3.

These impacts are broadly spread across the global ocean and a significant proportion of the ocean is considered to have at least a medium-high to high impact and a study carried out by the US National Centre for Ecological Analysis and Synthesis estimated that over 40% of the world's oceans are heavily affected by human activities and relatively few remain untouched. The waters of the South and East China Seas are also two of the most highly impacted areas in the global oceans (Halpern *et al.,* 2008)

Although estimates vary depending on definition of the coastal zone approximately 40% of the world's population 2.8 billion people live in the Coastal zone with population densities more than 3 times the global average (Small & Nicholls 2003,), Eleven of the world's 20 largest cities are located along coastlines in Asia, including Bangkok, Ho Chi Minh, Manila, Jakarta and Shanghai. Given the urbanisation trends this figure is expected to double by 2025. Many of the deltas, barrier islands and estuaries have been converted to large-scale and agricultural aquaculture and urban and industrial land uses (Valiela, 2006). UNEP (2011) estimates that a third of coastal regions run a high risk of degradation especially from infrastructure development and pollution.

The most direct impacts on the natural capital of the coastal regions include the drainage of coastal wetlands, discharge of sewage, fertilizers and other contaminants into coastal waters and the deforestation and reclamation of mangrove forests in particular for urban development and aquaculture. The natural capital of the coastal systems is also impacted by

the introduction of invasive species and by the construction of seawalls and other structures. Coastal engineering, in particular, such as damming, channelisation or diversions of the waterways change circulation patterns alter freshwater supply, sediment loads and nutrient delivery often degrading the value of natural capital (Lotze *et al.,* 2006).

In this section we present the main trends of three key marine ecosystems in Asia Pacific: mangroves, seagrass meadows and coral reefs. Annex 1 provides more in-depth detail of how these ecosystems benefits people.

- **Mangroves:** Global estimates of the spatial extent of mangroves in 2000 range from 14 653 000 by the FAO (2007) using a combination of national reported statistics to 13.8 million hectareas using fine scale remote sensing data (Giri *et al.,* 2011). Asia is by far the region with the largest extent of mangroves and combined with Oceania contain 54% of the total area of global mangroves (42% and 12% respectively). The Indo Pacific region is also the centre of diversity for mangrove species with about 80% of all mangrove species occurring in this region. Overall 118 countries have mangrove forests but 75% of mangroves are found within only 15 countries. Of these 8 are within the Asia Pacific Region, with Indonesia containing almost 22% of the total areal extent of mangroves. Giri *et al.,* (2011) estimate that only 6.9% of mangrove forests were protected in any form of IUCN classified Formal Protected Area.
  There has been a rapid decline in mangrove forests over the last half century: 2002 estimates that 30% of mangroves and seagrass have been lost over the past 50 years whilst the FAO estimated that there was a 25% decline in mangrove extent from 1980 to 2000 with the rate mangrove deforestation decreasing from 1.9% per year in the 1980s to 1.1% in the 1990s. A recent analysis of the rate of mangrove trends from 2000 to 2012 has shown that mangrove deforestation continues but potentially at a lower rates of between 0.16 and 0.39% per annum (Hamilton and Casey 2016). Nevertheless, of particular concern was the rate of mangrove destruction in South East Asia with a decline of mangrove forest cover of between 1.15% (Viet Nam) and up to 8.42% in Myanmar across this region during that period. This is of particular concern as this region contains almost half of the global extent of mangroves. Although Myanmar has the highest rate of loss at 8.42%, Indonesia was also of concern with a 3.11% decline over that period or 749km^2 which is almost half of the total global loss of mangroves (Hamilton and Casey 2016).

  The decline in mangrove forests and other near shore coastal ecosystems is due to the rapid urbanisation and industrialisation of the region and the dramatic growth in aquaculture in particular mariculture in South East Asia and tourism development across the Asia Pacific. Asia has the largest and fastest growing urban population in the world. Thirteen of the world's 20 largest cities are located on the coast 4 of which are in SE Asia and more than a third of the world's people live within 100 miles of a shoreline. Low-lying coastal areas represent 2 percent of the world's land area, but contain 13 percent of the urban population (McGranahan *et al.,* 2007). For example, Giesen *et al.,* 2006 estimate that a third of Malaysia's mangrove forests were lost due to rapid urban and industrial expansion as well as the growth of mariculture. Over the last 50 years across

the Asia Pacific More than 1.2 million hectares of mangrove forests have been converted to aquaculture ponds (Giesen *et al.,* 2006).

However, in the latest World Oceans Report by UNEP (UNEP 2015) there is hope that this trend of conversion of mangrove forests to mariculture is declining. They report that since the 1990s there has been a concerted action by non-governmental organizations and policy-makers focused on curbing the expansion of extensive, shrimp farms into mangrove forests in Asia. This has led to a reduction in mangrove clearance for shrimp farms via a program of mangrove protection policies across the region and the siting of new, more high-yield shrimp farms away from mangrove areas (Lewis et al., 2002).

- **Seagrass meadows**. Sea grasses are one of the most important marine ecosystems in the globe (Duarte *et al.,* 2008 and Vo *et al.,* 2012). Their high productivity are important for fish stocks and are critical nursery areas for a range of important commercial marine species that support commercial and subsistence fisheries. Most of the major commercial fisheries across the region occur immediately adjacent to seagrass beds (UNEP, 2014). Seagrass meadows provide regulatory services via a role in coastal protection, erosion control and sediment trapping, offer recreational opportunities and habitats for numerous charismatic faunal species, including species of turtle, dugong and seahorse (Hughes *et al.,* 2008).

  At the beginning of this millennium the extent of seagrass cover was estimated to be about 0.1-0.2% of the global ocean (Duarte 2002). Data from 2I5 studies in a global assessment of sea grass decline (Waycott *et al.,* 2009) found that seagrasses have been disappearing at a rate of 110 km^2 per year since 1980 and that 29% of the known areal extent has disappeared since seagrass areas were initially recorded in 1879. The major reasons for this decline are due to water pollution, mechanical disturbance from fishing and anchoring, dredging for new port and marine developments and rising sea levels (Duarte 2002). Since 1990 the rate of decline has accelerated to 7% per annum. On a global scale this rate of decline in seagrass could release almost 299 million tonnes of carbon into the atmosphere per year, which is more than the global emissions of Thailand and about 50% of the annual emissions of South Korea. Historically some of the most significant losses have been in the China-Korea-Japan region where the decline has been associated with heavy coastal development and extensive coastal reclamation. In the South China Sea region there has been a rapidly increasing rate of seagrass loss and decline. Indonesia has lost about 30-40% of its seagrass beds, with as much as 60% being destroyed around Java.

- **Coral reefs.** Coral reefs occupy less than 0.2% of the Global surface of the Ocean, equivalent to an area of between 260 000 to 600 000 km^2. Warm-water coral reef species diversity decreases with distance from the equator and is concentrated in the central Indo-Pacific (the “Coral Triangle”: see Box 5). Diversity also decreases the further away from the Indo- Australasian archipelago. This region is approximately 10 times more diverse than the other large area of corals in the western Atlantic with an

estimated 500 – 600 species in the Indo Pacific and only 60 in the western Atlantic. The Coral Triangle region in the centre of this region which includes Indonesia, the Philippines, New Guinea and The Solomon Islands, is home to almost 75% of all known coral species and 40% of reef fish species.

Coral reefs are subjected to many negative pressures. Potentially the greatest threat in the medium to long term to coral reefs are rising sea levels and ocean acidification (Hoegh-Guldberg *et al*., 2007). Nevertheless there are many existing pressures that are currently affecting coral reef health and these are already impacting on reef extent and health and will reduce the capacity of coral reefs to adapt to global environmental changes. These impacts include the direct destruction of coral reefs for port facilities and shipping lanes, the harvesting of the coral restructure for the production of lime, negative and destructive fishing practices and most significantly within Asia and Southeast Asia the effect of pollution from rapid urbanisation and industrialisation (Hoegh-Guldberg *et al*., 2007).

Coral reef health has been reported to be in serious decline with the World Resources Institute estimating that 60% of the global reefs are impacted by existing stressors to some degree. This issue is more significant in Asia where < 10% of reefs are considered to have low levels of existing impact as opposed to the Pacific nations where over half of the reefs are categorised as low level of impact and risk. In SE Asia half of the reefs are facing critical to high exposure to negative impacts and this is projected to rise to over 90% of reefs by 2050. Indonesia, which has the second largest area of coral reef in the world has the largest area of threatened reef, followed by the Philippines.

2.2.5 Urban natural capital in Asia Pacific

The dramatic shift in the global population demographics has increased the spatial extent or spread of cities. The expansion of the surface area of cities invariably involves the conversion of agricultural production or natural or semi natural landscapes into urban land surfaces. Globally the land occupied by cities is relatively small but it is growing at a rapid rate. In 2000 Angel *et al.,* (2011) estimated the urban land surface area to be 605,875 km^2 some 0.47% of the total global area, or if combined in one space, about the size of the Ukraine.

Not surprisingly considering the large urban populations within Asia, two sub regions, South East Asia and South and Central Asia had much higher proportion of urban land cover 0.85% and 0.49% respectively than the global average. By 2050 considering the faster rate of urbanisation within Asia the projection is for the urban land surface is to increase more than 7 fold to over 1.3 million km2: an area larger than South Africa.

- **Cities and biogeochemical cycles**. These are significant issues across Asia Pacific. In the UN 2000 State of the Environment report for Asia and the Pacific many of the regions rivers were up to 3 times the world average for human waste derived bacteria, mostly due to poorly functioning sanitation infrastructure in urban centres (UNESCAP, 2000). In the Chinese State of the Environment report for 2014 of the 74 cities tested for air quality only 3 met air quality standards and almost 20% of China's near shore marine

area were heavily contaminated where swimming or eating fish derived from these waters was considered dangerous (CHINA SoE 2014).

Cities and hydrological systems. Urban areas modify hydrological flows by increasing impervious cover (Grimes 2008), meaning that most rainfall is quickly converted to surface run off. Stream or river in urban landscapes tend to have greater fluctuations in the hydrograph with higher peak flows and longer low flow or even dry periods between rain events. For example in the Qinhuai River basin in southern PRC, a 3 fold increase in urbanisation and a 27% reduction in rice paddy fields led to stream flow increases of 58 % and evapotranspiration (ET) decreases of 23 % during 37 year period from1986–2013 27 %. Both high flows and low flows increased significantly by about 28% from 2002 to 2013 (Hao *et al.,* 2013). Low lying coastal cities are particularly prone to flooding yet 13% of the urban global population are found in low lying coastal areas (McGranahan e t al. 2007). In a study of 136 port cities Nicholls *et al.,* (2008) demonstrated that the largest coastal flooding exposure of population and assets is likely to be in cities in developing countries within East and South Asia (Nicholls *et al.,* 2008). Of particular concern is that the urban poor who are more often living in riskier urban environments such as floodplains or unstable slopes, working in the informal economy, and with fewer assets—are most at risk from exposure to hazards (Satterthwaite *et al.,* 2007).

Investments in natural capital in urban settings -such as parks, greenspace and urban wetlands, help increase urban infiltration, accommodate floodwaters and improve water quality and amenity (Satterthwaite 2007). The “sponge city” concept being adopted within PRC has considerable scope for using natural capital to improve urban hydrology management (see Box 4.10).

- **Cities and biodiversity**. Urbanisation reduces natural habitats, and simplifies the structure of those that remain. There is a shift and homogenisation in the types of species available in cities – for example bird communities become dominated by graminvores as opposed to insectivores. The lack of predators can result in expansion of population in some species –notably rodents that become pests. Nevertheless, even in the most densely populated cities planning for the incorporation of natural capital and wildlife habitat into a city can reduce some of the impacts of the homogenisation of urbanisation on biodiversity. For example, Singapore is one of the most urbanized nations on the planet however there has been a concerted effort to include biodiversity in the city planning. By the end of the 19th century only 7 % of the original native forests remained. In 1963 the city embarked on an ambitious program of habitat restoration and today 13% of the city area is in green space. Within the city boundaries 1,400 species of native vascular plants are still extant, 376 species of birds, 282 species of butterflies, 102 species of reptiles, 58 species of mammals and 27 species of amphibians, have been recorded.

2.3 Social justifications: equity, inclusion and poverty reduction

Natural capital loss affects millions of people in Asia Pacific, who depend on them for food, jobs and security. Coastal ecosystems in Asia Pacific for example protect over 30% of the world's coral reefs as well as being home to the largest concentration and diversity of mangroves. In addition to their exceptional global value as centres of biodiversity they are a critical component of food security particularly for the rural poor, and protect coastal communities from marine storm surges.

2.3.1 Food security

Economically, the agricultural sector is the world largest. It employs more than one billion people and generates over $1.3 trillion dollars' worth of food annually. Pasture and cropland occupy around 50 percent of the Earth's habitable land (e.g WWF 2016[5]). It entails all businesses operating in the production, processing, or retailing of food and beverage products. Farmers, traders, wholesalers, food manufacturing companies, and retailers together generates an approximate global value of around US$ 12.5 trillion based on revenue, or 17% of world GDP in 2013[6]. Historically this sector has in the Asia Pacific region received massive sectorial support from donors, banks, INGOs, NGOs, multi and bilateral donors – and from the private sector. Agricultural financing by donors has included a stronger emphasis in the last two decades on more integrated, holistic, community, or other approaches. National research, development, and extension institutions have tried to fill the gap from diminishing donor support by pledging domestic finance. Much research has been accomplished and technologies are available. However wide take up of improved technologies is limited by risks over whether the investments can or will provide the expected returns accompanied by market uncertainty, and high initial capital costs.

Demand for food is surging. In 2050 agriculture must produce 69% more food than it produced in 2006 as to feed another 2 billion people (from 7 billion as of today, coming to 9 billion) and to provide for more meat through more crops. To close this crop gap without large price increases or clearing more valuable forests and rangelands, yields must increase by one third in the next 40 years than they did in the previous 50[7] to avoid net expansion of harvested cropland. Achieving such massive yield growth is and will be a major challenge at research level and in terms of scaled up application of new technologies. Crop yield growth rates have been high since the 1960s, and utilises already 70% of the global water and fertilizer inputs, according to FAO (2011). At the same time, climate change may reduce agricultural productivity. Climate smart agricultural linked to Ecosystem Based Adaptation has developed to address these issues (see later section.)

2.3.2 Safety net for poverty reduction and means out of poverty

There is clear evidence (MEA, 2005) that poor women and men are most dependent on natural capital for their health and livelihoods and most exposed to climate change when

[5] http://www.worldwildlife.org/industries/sustainable-agriculture

[6] Natural Capital Coalition. 2016. Natural Capital Protocol – Food and Beverage Sector Guide". www.naturalcapitalcoalition.org/protocol

[7] WRI 2014: Searchinger, T. *et al.* 2014. "Crop Breeding: Renewing the Global Commitment." Installment 7: Creating a Sustainable Food Future http://www.worldresourcesreport.org

natural capital declines. Poor people may also suffer from limited access to natural capital – for example landless people and those living on marginal lands. There is long-term evidence that natural capital provides a "safety net", for example when crops fails, by providing access to fishing, hunting, and non timber forest products. etc) is shown in Box 2.2.

A number of studies have shown the dependence of rural households on common natural resources particularly forests:

- For **India**, Jodha (1986), analyses 502 households in 21 villages and concludes that poor rural households derive on average between 9% and 26% of their annual income from common property natural resources, while (relatively) rich households derive between 1% and 4% of their annual income from the commons resources.
- In the **Himalayas**, Reddy and Chakravarty (1999) analyse 232 households in 12 villages and conclude that poor households depend on common resources for 23% of their annual income, while it is 4% for the richer households.
- In **Nepal**, Adhikari (2005) analysing data from 330 households in eight "forest user groups" concludes that dependence on common natural resource increases with income, from 14% for the poor to 22% for the rich.
- Again for **India**, this latter finding is confirmed by the study of Narain *et al.,* (2005) analysing 537 households in 60 villages with the poorest depending for common property resources for 11% of their annual income, which rose to 13% of the wealthier households.

Box 2.2 Strong evidence of rural economies dependency on natural capital
Sources: various (in box)

Forests, fisheries and agriculture represent large proportions of poor rural households, as shown by the 'GDP of the Poor' study. The study, which shows the effective GDP or total source of livelihood of rural and forest-dwelling depending poor households, show a marked different in proportions of income sources. In Indonesia, for example, agriculture, forestry and fisheries have an aggregate value of 11% of GDP. But when looking at poor households (99 million in total), this proportion increases to 75%. In India the proportion of contribution of this natural capital increased from 17% to 47%.

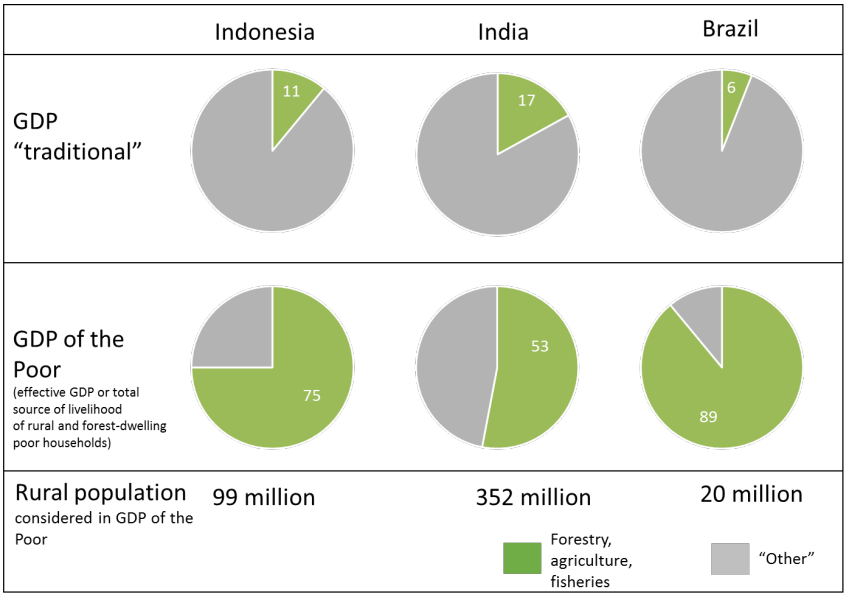


Figure 2.4 'GDP of the poor': dependency of income on ecosystems
Source: TEEB (2010).

It is difficult to overstate the importance to poor people of the resources provided by the natural capital of the marine areas within the Asia-Pacific. In 2006 the global intake of fish protein was about 16 ½ kg per annum. However, for Oceania, China and the rest of Asia this rises to 24.5 and 26.1 kg respectively (FAO 2008). The fishery sector plays a critical role in the economic, social and cultural fabric of those communities and the health of marine systems is vital to many subsistence and artisanal fishing communities spread throughout the region. Thus degradation of the marine environment can have a disproportionately large impact on the many poor and disadvantaged communities living in the coastal zone of the Asia-Pacific. Across the region the fishing sector provides almost 12% of the animal protein intake and is worth up to 20% of the national GDP through export earnings (Macusi *et al.,* 2011).

Emerging evidence that natural capital is not only a static "safety net" for poor people, but can also provide a dynamic route out of poverty through small and medium scale enterprises development and other income earning opportunities – as in the case of natural capital managed in protected areas as set out in Box 2.3. See also Box 2.4, which shows the benefits to poor households from investments in natural capital through enhanced soil conservation in an ADB-funded project in Fujian, PRC.

Thailand: Using household-level data and controlling for baseline scenarios, Andam et al., (2010) found protected areas in Thailand to have reduced poverty by approximately 30%. For the same PAs, Ferraro et al., (2011) find these win-win outcomes to be associated with areas of high poverty, moderate to low agricultural potential and close proximity to major cities and markets. From Dudley et al., (2008): WWF report on Protected areas and poverty reduction

Nepal - Royal Chitwan National Park in Nepal established in 1973. The Baghmara Community Forest User Group set up in 1996 in the park's buffer zone has earned more than US$175,000 from wildlife viewing activities, using the income to set up biogas plants and provide low-interest loans to community members through a micro-credit scheme.

Lao: In the Nam Et and Phou Loei National Biodiversity Conservation Areas in Lao PDR, 81 village communities depend on the area for non-timber forest products (NTFPs) valued at US$1.88 million/year. NTFPs from the area have been estimated to provide US$677 to each household living inside the PA, US$500 to those on its borders and US$250 to those located outside the PA. In the Nam Ha National Biodiversity Conservation Area, the Ban Nammat Mai community has been estimated to earn 40% of its total village income from tourism, through which half of its 33 village households have almost doubled their average quarterly income.

Viet Nam - Hon Mun Marine Protected Area established in 2002. About 5,300 people depend on the reserve, particularly for reef-related aquaculture and near-shore fishing and its gross fisheries value is estimated at US$15,538 per km2. A study found that 30 per cent of 259 respondent households in villages around the marine park indicated that their situation was better than before the protected area was established.

Indonesia: Bunaken National Park (79,060 ha, established 1989): Thirty per cent of the park entrance revenues are used for development programmes in local villages, for example the construction of a water-supply tank and public toilets (Leisher et al., 2007). Forty thousand people benefit economically from the park and over 1,000 jobs have been created for local people. Komodo National Park (181,700 ha, established 1980 and declared a World Heritage Site in 1991): Between 1980 and 1997, it was calculated that about US$1.25 million and over 600 jobs had been generated by the park; although distribution of these benefits has not been even across all stakeholder groups.

Philippines: MPA in Apo Island established 1994. A fee system for tourists has generated mean monthly revenues of US$3,741, 75% of which goes to the local community.

Others: Leisher et al., (2007) demonstrates how four marine protected areas (MPAs) located in Fiji (Navakavu), the Solomon Islands (Arnavon Islands), Indonesia (Bunaken) and the Philippines (Apo Island) have contributed to poverty reduction. Higher household incomes were observed in three out of four MPA sites, in two cases being more than double of those in the control sites. This increase is mostly attributed to the creation of new livelihoods through growth in tourism. For example, Davis (2005) found that the tourism sector had created more than 1,000 jobs in Bunaken, a significant number considering its population of 15,000 people. Another significant benefit from MPAs were higher fish catches in the adjacent areas, contributing to higher income as well as greater protein intake for the local populations.

Box 2.3 Protected areas, natural capital and poverty reduction: the evidence. Sources: Andam et al., (2010); Dudley et al., (2008); Ferraro et al (2011); Leisher et al.,)

2.3.3 Gender equity: roles and access to natural capital

In rural areas, in particular, women and girls are most exposed to certain types of natural capital decline as they spend more time on household chores that involve the use of natural capital including accessing water from natural sources and collecting biomass for cooking and heating. Gender differentiated roles related to natural capital use are also apparent in agriculture and fishing. Women's tasks are mostly in labour-intensive preparation and processing activities, for example in the case of small-scale agriculture they specialize in seed selection and storage, manual weeding, cross-pollination, harvesting, collection and storage of manure, while men are responsible for crop cultivation (Bhawana 2005; Das 2011). In fisheries, they are mostly involved in fish processing such as sun-drying, salting and smoking, but also in fish marketing and value addition (Bhawana, 2005, FAO, 2015c).

However, while women often play a major role in agriculture and fishing, they have the least access to natural capital with very low levels of land ownership in many countries. In India, Nepal and Thailand, for example, less than 10 per cent of women farmers own the land they farm (IFAD, 2008).

In terms of natural capital from forests, rural households living in proximity of forests greatly depend on forest resources for their livelihoods, both to meet their daily food requirements as well as to generate income and sustain their households. Due to physical constraints as well as culture, the division of household tasks tends to be gender-based, with some responsibilities traditionally allocated to women, such as the collection of non-timber forest products (NTFPs) for household nutrition and consumption (Das 2011; Sunderland *et al.,* 2014). Women are primarily responsible for collecting and processing forest food and medicinal products to supplement the nutrition and health of their households. They rely on forest resources to collect water, fuelwood for cooking and heating, as well as for grass and fodder to feed the livestock (Guarascio *et al.,* 2013). In these roles, they carry valuable knowledge regarding the distribution, characteristics, and diverse uses of indigenous species of trees, shrubs and herbs (Bhawana 2005). Besides for subsistence purposes, women also depend on forest resources to increase their income.

Despite the general perception that women are mostly dependent on forest resources for subsistence while men for cash, the results from the global comparative study of forest products by Sunderland *et al.,* (2014) demonstrate that gender dependence on forests products for income varies by region and type of product. Women earn income both from unprocessed and processed forest products, adding to the purchasing power and thus food security of the household. In Asia, women receive a higher share of their income than men from firewood, forest food products, fodder and manure. Men on the other hand receive a larger share of their income from timber (structural and fiber) and hunting (food: animal), as well as from processed products in general as they dominate higher positions in the value chain (Sunderland *et al.,* 2014).

2.3.4 Indigenous peoples

Indigenous peoples often live in the remoter regions with the higher extent of natural capital and are often hardest hit by natural capital decline. Other vulnerable groups such as lower caste groups in South Asia may be most dependent on natural capital (see Box 2.5).

Indigenous peoples comprise an approximate 5% of South, Southeast and East Asia total population (260 million), for many countries forming more than 10% of national population: Burma/Myanmar (30-40%), Pakistan (21-25%), Indonesia (20-29%), Lao PDR (35-70%), Nepal (37%), Philippines (10-15%), Viet Nam (13.8%) (Chakma *et al.,* 2010). Adapted to the forest, mountain, lowland and coastal areas they inhabit, their livelihoods are directly dependent on natural capital for subsistence and income generation through small-scale agriculture, farming, livestock raising, hunting and gathering, fishing, and the trade of local handicrafts, among others. The natural capital relationships, knowledge and management systems that have evolved over many centuries are very diverse and intricate, and tightly tied to the geographical, cultural and socio-economic context of the regions and the groups that have inhabited them.

Indigenous communities particularly rely on forests for habitat, hunting, and gathering of water, wild food, fuel wood, medicinal plants and other non-timber forest products. They have developed a holistic understanding of the ecosystems they inhabit, evident in traditional agroforestry systems of high productivity and species diversity (Parrotta and Trosper 2012). Agriculture in the form of rice fields, vegetable gardens, and other crops provides for the livelihoods of many indigenous groups in the region, mostly for subsistence but also for the market (Chakma *et al.,* 2010). Examples of high-value marketable products that are important sources of income for indigenous people's include silk, where leaves and bark of mulberry trees are used to raise silkworms in China, mushrooms, honey and medicinal herbs (Yeo-Chang *et al.,* 2012).

Forests are valued in other essential functions as well, and are managed accordingly. For example, in traditional Korean shifting cultivation systems, certain forest areas are set aside as seed reserves (Yeo-Chang *et al.,* 2012) . For many indigenous people groups in the region, forests are used as fire and wind protection strips between cultivation areas to aid productivity with the microclimate they provide (Ramakrishnan *et al.,* 2012; Chakma *et al.,* 2010). Last but not least, forests are often endowed with sacred, spiritual and cultural values and thus serve in preserving those communities' unity and cultural identity. Such functions often preclude the use and extraction of natural resources through strict rules and social conventions, as for example in large tracts of areas in the Himalayan Region conserved and worshipped as homes to multiple deities by Tibetan Buddhists (Fui *et al.,* 2012).

Box 2.4 Employment for low-caste and poor people in India to sustain natural capital
Source: Extracted from a review of conditional transfers by Porras *et al.* (2016).

The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) in India is the world's largest social protection scheme. It has covered all of India since 2008 and aims at enhancing livelihood security in rural areas by providing at least 100 days of guaranteed wage employment in a year, to every household whose adult members volunteer to do unskilled manual work, which means its focus is on low caste and other vulnerable groups. The type of projects allowed to be included are public works linked to natural resource management (mostly watershed-related projects); improving conditions of individual assets for vulnerable sections, and building common and rural infrastructure.

It provides jobs to about 50 million households every year- equivalent to nearly 25% of the total rural households in India (see Figure below). Woman participation rate at national level has ranged between 40-51 per cent since the introduction of the programme. There is great variation at state level though. States that have introduced pro-poor targeting, for example by how they apply rationing, showed a significant improvement on pro-poor participation.

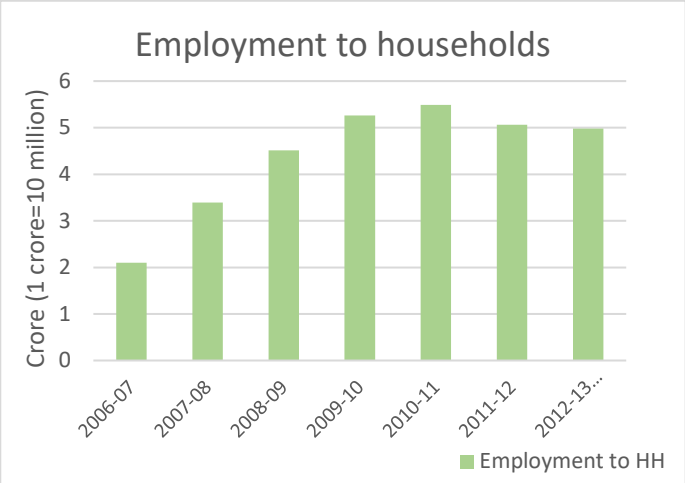


Figure 2.5 Employment provided to households by the India's MGNREGA programme
Source: Government of India (2014).

MGNREGA public works investments in soil and water conservation include water harvesting, small-scale irrigation, water supply schemes, afforestation, rural infrastructure development and social services. Almost 53% of the works are linked to soil and water conservation. Several studies have looked at the impact of these works. For example, Tiwari *et al.* (2011) study in Karnataka suggests that the programme provided "multiple environmental services and reduced vulnerability, apart from providing employment and income to rural communities". The main impacts included better groundwater recharge, water percolation, more water storage in tanks, increased soil fertility, reclamation of degraded lands and carbon sequestration.

2.3.5 Vulnerability to climate change impacts

Losing natural capital increases the vulnerability of people to the impacts of climate change as it reduces the adaptive protection that ecosystems provide. As land becomes more degraded it loses its natural ability to soften hydrological changes, exacerbating the impacts of climate related disasters. Climate change affects millions of people across Asia. In China for example over 8% of its population (104 million people) were exposed to droughts, floods and extreme temperature between 1990 and 2006. The percentage is similarly high in countries like Cambodia and Tajikistan and the number of people that are affected by hydrological disasters has been increasing over time (see Figure 2.5).

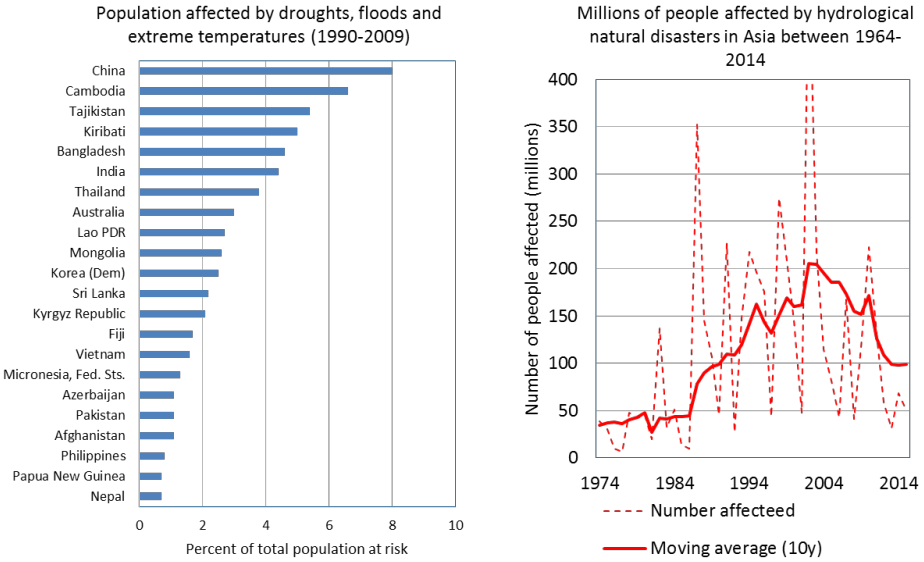


Figure 2.6 Percentage of people exposed to risk of droughts, floods and extreme temperature (average 1990–2009)
Source: prepared with data from OFDA/CRED International Disaster Database (Guha-Sapir et al., no date)

Ecosystem based adaptation is likely to be of significant benefit for poor people as they are most impacted by climate change. Recent reports (Fay *et al.,* 2015, IPCC 2014) show why the impact of climate change is likely to be more significant for the poor ():

- Climate change is likely to lead to higher agricultural prices and could threaten food security in some of the poorest regions in the globe and in particular South Asia and sub-Saharan Africa.
- Urban poor are more exposed and vulnerable to the effects of climate extremes such as floods than are the average urban population.
- Climate extremes can exacerbate the exposure and the vulnerabilities of poor households to natural hazards, which in turn increase the likelihood of households falling into poverty.
- Climate change will exacerbate the current threats to health as poor people are more susceptible to climate related diseases such as malaria and diarrhoea.

According to Fey *et al* (2015), without a concentration on green development and adaptation more than 100 million people are likely to live in extreme poverty by 2030. Many of these vulnerable groups are already heavily affected, especially those living in Pacific Island states, where many communities live on low lying coral atolls and have little opportunity to move away from coasts or to higher ground. Most of the population of

Kiribati, for example, lives less than 3m in elevation above sea level on an island and less than half a kilometre wide. Without substantial adaptation, the economic impacts of climate change and sea-level rise on Kiribati are estimated to be equivalent to 17–34% of its 1998 GDP by mid century. (Ruckelshaus *et al.,* 2013)

2.4 Economic and financial reasons to invest

This section reviews the main economic and financial benefits flowing from natural capital investments, highlighting the importance of ecosystem services which are traditionally excluded from economic and financial analysis. Project selection can be calculated by the Economic Internal Rate of Return (EIRR) or a positive Net Economic Present Value (ENPV) using the EIRR as the discount rate. ADB's current required EIRR is 12%. Financial returns are traditionally calculated from the perspective of private entities, while economic returns take account of the full costs and benefits to society.

2.4.1 High benefit-cost ratios and rate of returns from soil and land management

There have been a series of recent studies focussed on calculating the national benefits and costs of land management:

- **China** is seriously affected by grassland degradation, deforestation and cropland degradation. A recent detailed study estimates that it would cost US$ 255.45 billion to rehabilitate these areas while the benefits, or avoided costs of degradation, are estimated at US $ 1,208 billion over a 30 year period. That is a benefit to cost ratio of over four (Deng *et al.,* 2016).
- For **India,** the costs of land degradation are estimated in 2009 at about US$ 5 billion. The benefits (avoided cost of inaction) exceeds cost of action against land degradation in every state. The ratio of action over inaction is about 20–40% in humid states and above 40 % in sub humid and arid states (Mythili *et al.,* 2016).
- Central Asia including the five countries of **Kazakhstan**, **Kyrgyzstan**, **Tajikistan**, **Turkmenistan** and **Uzbekistan** suffers severe land degradation from salinization of irrigated lands, soil erosion in rain-fed and mountainous areas and decline of rangelands. The most detailed study of land degradation in Central Asia shows that benefits of rehabilitation versus inaction are greater than costs by a factor of four. The results show that, over a 30 year period, it costs US$ 53 billion to reduce land degradation, while the benefits (or avoided costs of inaction) would be US$ 288 billionUS$ (Mirzabaev *et al.,* 2016).
- For **Uzbekistan** land degradation is a major challenge. A detailed study found that the economic value of land degradation costs -including the costs of lost ecosystem services- was 0.84 billion US$ (comparing 2009 to 2001). This was an equivalent to about 4% of the Gross Domestic Product (GDP) in 2007. The results show that the costs of action (about 11 billion US$) to deal with land degradation are around 4 times lower than the costs of inaction (about 50 billion US$) over the 30 year horizon (Aw-Hassan *et al.,* 2016).

2.4.2 High rates of return from sustainable forest management

The values of sustainably managed natural forests can be significant – see Table 2.1. TEEB (2010), especially when adding the economic impact of ecosystem services such as water and climate regulation to those generated by timber.

Table 2.1 Estimates of the values of forest ecosystem services

Service	Values
Fiber, timber	TEEB (2010) reports values of US$ 560/ha/year for timber, US$ 61/ha/year for firewood, and US$ 41-70/ha/year for Cameroon tropical forests.
Watershed services (e.g. flow regulation, flood protection, water purification)	Mullan and Kontoleon (2008) estimate values between US$ 200 to over US$1000 per hectare in tropical areas. TEEB (2010) reports flood protection in Cameroon's tropical forests in Cameroon US$ 24ha/year; NPV of water supply from the Leuser Ecosystem at US$ 2.42 billion; and US$ 1.42-2.63 billion from groundwater recharge in a 40,000 hectare watershed in Hawaii.
Climate regulation	IIED (2003) summarizes values between US$ 650-3,500/ha/year. TEEB (2010) reports values of tropical forests in Cameroon at US$842-2265/ha/year. Mullan and Kontoleon (2008) report values ranging between US$ 10 to over 400 in temperate forests.
Existence values	Various studies put ranges between US$ 0.2- 20/ha/year depending on location (Simpson *et al.,* 1996). TEEB (2010) reports US$46/ha/year as UK and Italian households' willingness to pay to protect Brazilian forests; and AU$18/ha/year in North Queensland. Recreation values vary significantly by location from US$ 0-2000 (Mullan and Kontoleon. 2008).

The extent of these potential revenues, the trade-offs involved (e.g. more timber, less existence values and viceversa), and their potential for investment is affected by a combination of factors that include: (see for example Duncker *et al.,* 2012):

- The specific types of forests,
- The management regimes proposed (which range from protection to clear-cutting and restoration, and landscape management approaches),
- The ecosystem's capacity to re-generate after the intervention,
- The governance systems regulating their use before, during and after (including how land values may be affected).

Table 2.2 presents some examples of instruments currently used to increase the financial return to forestry operations –especially those introducing a sustainable management aspect to their operations, including: a) value chain interventions: vertical integration, public-private-community partnerships; b) new market-based instruments like green bonds, carbon offsets and payments or compensations for ecosystem services; c) grants. These will be described in more detail in the Financing Section of this report. The degree of the returns with respect to cost of investment vary. According to a recent study on FSC, companies

selling certified timber earned on average an extra US$1.80 for every cubic meter of certified roundwood, with a stronger business case for tropical forest operations and small/medium producers. However, it takes an average of 6 years for companies to reach a break-even point on their FSC investment, and this is very difficult for small and medium producers to finance on their own (Breukink *et al*. 2015).

Table 2.2 Forest ecosystem services and capitalising potential

Main ecosystem services	Economic benefits and capitalizing opportunities
Fibre and fuel products	Improving efficiency and access to markets for timber for construction, veneers and flooring; wood chip for board, pulp for paper; timber products for wood fuel, including stumps and roots, and harvesting residue. Supporting sustainable management through better development of niche markets and certification.
Non-timber forest products	Supporting market opportunities for food products derived from plants (tree fruit, berries, foliage, syrup and nuts as well as edible products from plants other than trees – like fungi), wild deer or livestock raised in woodland or forest settings in agro-forestry systems; beverages; craft, ornamental and gardening materials such as bark chips for play areas, poles, stakes and fencing; toys, medicinal products and chemicals derived from gums, resins, waxes, oils and fatty acids.
Carbon storage	Selling carbon offsets in voluntary markets, REDD+
Recreation	Combining government funding to manage protected areas with user (entry) fees; supporting development of markets for recreation activities and providing incentives for habitat for recreation (e.g. recreational access management programme, improved access, etc ecotourism,community-based tourism PES) Examples in Asia include: • Public-private regional initiative Heart of Borneo, linking the public sector (governments of Brunei Darussalam, Indonesia, and Malaysia), and WWF to sustainable manage 220,000km2 of contiguous tropical forest on the island of Borneo through allocation of federal budgets, and commitments for SFM under the FSC certification (Greenwood et al. 2012). • Public-private regional initiative coral triangle, to sustainable manage coastal and marine resources in six countries (Indonesia, Malaysia, Papua New Guinea, the Philippines, the Solomon Islands and Timor-Leste). The area provides benefits to 363 million people, and have an estimated annual value of $2.3billion including fish production and nature-based tourism in the region. ADB is the implementing agency. • Increased coordination through regional initiatives promoting public-private-people partnerships, like the formation of the Asia Pacific Ecotourism Society (APES) with 328 provisional members in 38 countries.
Biodiversity protection	Biodiversity offsets: relatively new, operational or proposed in various jurisdictions. Implementation requires clarity on no-net loss, registry etc. Examples include: • Wetlands Banking (an example of BD offsets) used widely in USA and Europe. • BushBroker: native vegetation offset programme in Australia. Other potential sources of funding are through philanthropic/donor funding, and pharmaceutical R&D.
Watershed protection (water quality, quantity)	Payments for ecosystem services through agreements with downstream water users, including hydroelectric companies, and water utilities (see Section 4).

2.4.3 High cost effectiveness and rates of return from ecosystem-based adaptation

Ecosystem based Adaptation (EbA) solutions are often highly cost effective in relation to other types of adaptation response as they use the "free goods" provided by biodiversity and ecosystem services. For example, Rao *et al.,* (2012) compared the relative cost and benefits of ecosystem based as opposed to engineering solutions for flood mitigation and storm surge protection for Lami town in **Fiji**. They found that although engineering solutions may have a greater potential to reduce overall damage they are generally less than half the benefit /cost ratio of EbA solutions (see Table 2.3).

Scenario	Benefit-to-cost ratio (FJD)	Assumed damage avoidance
Ecosystem-based options	$19.50	10-25%
Emphasis on ecosystem-based option	$15.00	25%
Emphasis on engineering options	$8.00	25%
Engineering options	$9.00	25%-50%

Table 2.3 A CBA comparison of ecosystem-based adaptation to engineering solutions in Fiji
Source: Rao *et al.,* (2012).

Ecosystem-based adaptation responses also have an advantage in that they can provide a number of other ecosystem services including direct benefits such as improved fish production or more indirect but still important benefits such as the maintenance of key ecological processes and the conservation of biodiversity. For example, restoring coral reefs can not only provide valuable coastal protection but also improve food security for local peoples by increasing fish abundance as well as potentially improving recreational and tourism opportunities.

A global study by Ferrario *et al.,* (2014) on the role of coral reefs in wave attenuation showed that healthy coral reefs reduce wave energy by 97% and wave height by 88%, a degree of protection offered equivalent or at times superior to many coastal engineering structures. Coral reefs help protect up to 197 million people. The greatest number of at-risk people from lower reef protection are in Asia Pacific: Indonesia, India and the Philippines, with almost 48 million people living below 10 m elevation within 10 km of the coast.

According to Ferrario *et al* (2014), the construction of engineered tropical breakwaters can cost anywhere up to US$188,000 per lineal meter, while simple reef restoration projects can be as cheap as US$470 per lineal meter. Replacing lost reefs in the **Maldives** using hard infrastructure such as seawalls and break walls has been estimated to be between US$ 1.6 billion and 2.7 billion. In contrast conserving the reefs to prevent their ongoing degradation through activities such as the establishment of marine protected areas would cost US $34 million in start-up costs and US$ 47 million annually (Emerton *et al.,* 2009).

The construction of hard infrastructure on the other hand often leads to a degradation of many of those environmental services. In the Nam Dinh Province of **Viet Nam** restoration of mangrove forest after it was destroyed was estimated costs US $166 per hectare. The restored mangrove forest was expected to not only provide coastal shoreline protection but also had co-benefits of timber and honey production and the maintenance of fish populations, these benefits were estimated to be worth almost US $630 per hectare (Moberg and Ronnback 2003 (from Jones). In the **Philippines** Baig *et al.,* (2015) found that mangrove protection provided avoided damages for shoreline protection of US$ 206,621, as compared to building a seawall, which provided avoided damages of US$ 180,046 with a 10% discount rate. The cost of building a sea wall was estimated to be $6010 -7268 US$ while mangrove protection was estimated $338 US$ over a 20 year period.

2.4.4 High rates of return in MDB natural capital projects

A review of selected ADB and other MDB projects, show that natural capital project can have high economic rates of return (ERR, see boxes 2.7 and 2.8). Natural capital components, such as avoided human wildlife conflict, gender benefits and climate change mitigation can help increase the rate of return from its baseline of 12%. For example, a World Bank loan-funded project in Sri Lanka managed to increase their proposed ERR from 12% to 15.54% by widening their approach to ecosystems in protected areas. An IDB-funded project in Brazil achieved 14.3% ERR through a combination of biodiversity, climate and poverty benefits while promoting regeneration of tropical ecosystems.

Box 2.5 World Bank investments in protected areas, Sri Lanka
Source: World Bank, 2016

The *Ecosystem Conservation and Management Project* in Sri Lanka, financed through a US$45 million IDA loan by the World Bank from 2016 to 2021, aims at strengthening the management of the country's protected areas (PAs) while also enhancing the livelihoods of the communities living adjacent to them in a sustainable manner.

Project summary: From 2016 to 2021, the project will a) provide technical assistance and capacity building in landscape-level management planning, b) identify and implement biodiversity-friendly, climate-smart and participatory Community Action Plans (CAPs), c) finance the scaling up of successful human-elephant coexistence projects and d) finance the updating and development of Protected area management plans with provisions to improve the quality of nature-based tourism..

Overall economic rate of return: Implementation of these measures is expected to bring a wealth of economic, environmental and social benefits. Assuming that watershed benefits are at the lower bound (US$2,128) with a discount rate of 12 percent over 20 years, and if the project manages to preserve 975 ha of habitat, it will have an overall economic rate of return (ERR) of 15.54 percent. The components of these benefits are given below.

Biodiversity benefits: Sri Lanka's biodiversity is considered to be the richest per unit area in the Asian region and yet, despite conservation efforts, deforestation, forest degradation and biodiversity loss continue to take place with alarming rates. The project will focus on strengthening biodiversity management in Sri Lanka.

Avoided human wildlife conflict for poor people: Sri Lanka's dense elephant populations tend to roam outside of the assigned PAs where they graze on agricultural lands, causing crop and property damages to the farming communities and resulting in the "human-elephant conflict".

The benefits can be calculated in terms of avoided costs of property damage, avoided costs for human and elephant lives and avoided costs of time and equipment to stop elephant damage. Under various scenarios, avoided costs in damaged crops and property are estimated at US$32.9 million within a 20-year period. Avoided costs of human and elephant lives were not calculated, but would increase the net benefits of the project.

Social and gender benefits: The project will directly benefit approximately 15,000 people, 30% of which women from communities near the targeted PAs. It is also planning to provide 10,000 people with improved access to income generating activities. However these income benefits were not calculated.

Tourist revenues: Improvements in protected area management are expected to bring significant increases in the country's currently underexploited nature-based tourism, boosting visitor revenue up to 10% in selected PAs. Nature-based tourism has direct effects on the economy, especially in the immediate vicinity of a national park. A recent survey found the tourism multiplier in Sri Lanka as 1.14 which means that every dollar spent by a tourist will generate an additional US$0.14 in revenue for the economy. This was confirmed by a contingent valuation study which found that, with some improvements in facilities, tourists would be willing to pay an extra US$4 per day in the national parks. The target PAs higher revenue-earning potential will bring substantial benefits for local communities and contribute to their long-term financing and effective management.

Climate mitigation benefits: From the regeneration of 5,000ha of degraded land, the protection of 195,000ha of forests and the reforestation of 5,000ha of degraded forest land, carbon sequestered will amount from 6.62 to 14.36 million tCO2eq of GHG emissions during the implementation period – although this was not monetised in the project justification.

The *Serra do Mar and Atlantic Forest Mosaics System Socioenvironmental Recovery* project aims at the conservation, sustainable use, and socioenvironmental recovery of the Serra do Mar mountain range, the Juréia-Itatins Mosaic territory, and the marine conservation units and their surroundings, all located in the state of São Paulo. The program actions will generate social and environmental benefits and promote the effective protection of biodiversity and water sources that supply the metropolitan area of São Paulo and Baixada Santista. Its total cost of US$470 million is partly funded through a US$162 million loan from the Inter-American Development Bank, with the rest of the financing coming from the State of São Paulo.

Project summary: Running since 2010 and currently in its 2nd phase of implementation, the program's three components are a) protection of conservation units (CUs) through preparation and implementation of management plans, zoning, environmental restoration, improvement of existing infrastructure, creation of a botanical garden and a tree nursery, staff training, creation of incentives for the fishing communities to adopt economically sustainable activities, and support for an ecotourism project; b) social investments in the Serra do Mar State Park (PESM) through the voluntary resettlement of about 6,700 families into new residences that provide them with better living conditions, access to the job market, and a route out of social exclusion and poverty, as well as urbanization and regularization of land tenure for settlements located in former PESM areas, with plans to include another 12,000 households in the future, and c) monitoring of the CUs through training and equipping of the Environmental Division of the Military Police.

Overall economic rate of return: Through a cost-benefit analysis, the project's benefits were shown to clearly outweigh its costs, with an economic rate of return (ERR) estimated at 14.3%. Two types of benefits were included in the assessment. First, the willingness to pay (WTP) for the protection of the program's beneficiary CUs was estimated using the contingent valuation method where 1,209 households were chosen at random and interviewed. The median WTP in the Metropolitan Region of São Paulo was US$8.23 and for the other regions of the state US$7.80. Thus the total present value for the state of São Paulo was estimated at US$422 million. The second type of benefit regarded the aggregate present value of partial recovery, over a 25-year period, of the value of the homes given to the resettled populations, estimated at US$70 million. In total, the present value of total benefits amounted to US$492 million.

Box 2.6 IDB support to forest recovery in the Amazons
Source: Inter-American Development Bank, 2010

2.5 Macro-economic reasons: growth, exports, revenues and employment

Natural capital contributes to macro-economies in four main ways:

- *Economic growth:* Many Asia Pacific countries depend on natural capital for their economic growth. This includes traditional sectors such as agriculture and fisheries, but also new service sectors such as tourism, including ecotourism. Natural capital can also provide inputs to growth such as hydropower for energy.
- *Exports:* Agricultural exports are linked to natural capital in many countries, while some countries and regions are particularly dependent on forestry (Solomons) or fishery exports (Pacific).
- *Revenues:* Revenues from hydropower can be significant in some countries (eg Lao PDR, Bhutan), while forestry (Solomons) and fisheries (Pacific) are important in other countries. A careful balance must be found between sustainable use and conservation and there are issues about how these revenues are used and if they are reinvested in sustainable management.
- *Employment:* formal and informal, for exampled linked to transition to green economy initiatives. For formal employment there are examples of natural capital improvements through public works programmes including India's National Rural Employment Guarantee Programme and Philippines Greening the Nation. Informal employment from natural capital includes small scale fisheries and agroforestry.
- *Reducing risk* due to conflict, especially in transboundary situations and as natural capital base deteriorates.

Advances in tools such as economic valuation and natural capital accounting help reveal contribution of natural capital across different sectors of the economy. In **Indonesia**, according to a report by ITS (2011), the forest-based industry[8] contributes approximately USD21 billion or 3% of the country's GDP and employs 3.76 million people (1.5% of its population). Moreover, 1.3% of government taxation revenues come from forestry revenues (fees and royalties), with the annual contributions between 1999 and 2009 ranging from US$190 to US$376 million. Wood products, including pulp and paper, account for approx. 9% of non-mineral exports. Rural populations with limited alternative livelihood options tend to benefit more from forestry operations and their accompanying employment opportunities and infrastructure development.

In **Viet Nam**, the 2006-2020 Forestry Development Strategy is aiming for the sustainable management of 16.24 million ha of forestry land and an increase in its ratio of land with forest up to 47% by 2020. It plans to reach a forestry production growth of 4-5%/year so that by the end of the period the sector's contribution to the national GDP reaches 2-3%. Successful implementation is expected to increase annual export values from 1.5 billion in 2005 to over US$7.8 billion, create 2 million jobs throughout the supply chain and contribute to poverty alleviation by reducing by 70% the number of poor households in

[8] Including forestry and logging, wood and wood product manufacturing, and pulp and paper production.

important forest areas. Total fund requirements for the strategy were estimated at about US$6.6 billion in 2007 prices.

China reforestation and afforestation is estimated during 2005-2010, to have created an average of approx. 3.47 million direct and indirect jobs annually (Jiahua *et al.,* 2011). The country's ambitious plans for further expansion of forest coverage by 2020 would mean a total investment of about US$42 billion and the annual creation of 1.1 million direct and indirect jobs. Management of this newly forested area is expected to create 1.5-1.8 million jobs during that period, and another 1 million through growth in forest tourism. With more than 2,000 forests parks and investments of about US$170 million between 1990 and 2008, forest park tourism in China in 2010 had a revenue of US$4.2-4.5 billion and directly created about 178,000 jobs. Revenues from forest park tourism in China are expected to increase by an average of 20% annually and to create approx. 1 million green jobs by 2020 (Jiahua *et al.,* 2011).

Within the Asia Pacific region, **fishing** employs more than 6 million people with about 90% of those jobs in small-scale fishing enterprises (WOA, 2015; Macusi *et al.,* 2011). It is often a primary source of livelihood for a majority of the population living in rural communities along the coasts especially within the Pacific Islands. For example, in the Choiseul Province of the Solomon Islands 86% of people are involved in subsistence capture of finfish (Solomon Government, 1999).

As well as macro-economic benefits, decline in natural capital, coupled with weak natural resource management in some places, can contribute to conflicts over water, land and other resources. These conflicts can arise both between countries (eg India and Pakistan issues over Indus River, South East countries over the Mekong River) and within countries (eg control over natural capital revenues in India). So while declining natural capital can increase conflict and risk, improved natural capital management can improve security. Natural capital investment can include investments in institutions and policies that improve natural capital management to reduce conflict such as the Mekong River Commission as set out in Box 2.9.

The Mekong River Commission (MRC) started in 1959 when United Nations founded the Mekong Committee. In 1995 (through the Mekong Agreement) the Committee became independent and was no longer a UN organisation. MRC's management responsibility are with its four Member Countries; Cambodia, Lao PDR, Thailand and Viet Nam. It is the only inter-governmental agency that works directly with all these four governments on their common specific interests—joint management of shared water resources and sustainable development of the Mekong River. Since 1996 MRC has included PRC and Myanmar as upstream Partners.

As a regional facilitating and advisory body governed by water and environment ministers of the four countries, the MRC aims to ensure that the Mekong water is developed in the most efficient manner that mutually benefits all Member Countries and minimises harmful effects on people and the environment in the Lower Mekong Basin. Serving its member states with technical know-how and basin-wide perspectives, the MRC plays a key role in regional decision-making and the execution of policies in a way that promotes sustainable development and poverty alleviation.

The MRC is funded by contributions from the four Member Countries and development partners—country governments, development banks (incl. ADB), and international organisations.

Box 2.7 Promoting greater natural capital collaboration in the Mekong River
Source: Mrcmekong.org

2.6 Complementing 'produced' infrastructure investments

"Produced" capital, such as infrastructure for cities, urban and rural water, coastal areas and disaster prevention can benefit from natural capital investment. Conversely, the decline of natural capital in Asia Pacific imposes certain risks related to the loss or damage on this produced infrastructure. This is set out below.

2.6.1 Urban infrastructure

Natural capital can be incorporated as "green infrastructure" into urban areas using various combinations of aggregated small-scale interventions at household, community or municipal level. This can span from individual trees (gardens, parks) to large scale elements spanning entire watersheds[9]. Green infrastructure is an important supporting component to engineered or hard infrastructures in the peri-urban context with high importance for the EbA agenda (Krasny and Tidball, 2009; Cameron et al., 2012; Farrugia et al., 2013), and feature strongly in the concept of Green Cities in Asia supported by ADB[10].

Trees, wetlands and other forms of green infrastructure provide temperature regulation and reduction in particulate pollution which can parallel harder measures taken by governments to tackle road and building re-development of megacities – see Annex 1. Using natural vegetation with more permeable surfaces can support single-purpose gray and stormwater water infrastructure (e.g. piped drainage and water treatment systems). This reduces peak flows and allows the system to cope better during storms –see for example "Sponge Cities" example in Box 4.10.

[9] See https://www.epa.gov/green-infrastructure/what-green-infrastructure
[10] http://www.adb.org/green-cities/

Bioswales are vegetated channels that convey stormwater within a shallow channel. Bioswales are designed to slow the overland flow of stormwater and as such, can lessen peak flows and reduce pollutant loads by capturing sediments within the swale areas. Xiao & McPherson (2011) sow that bioswales were able to reduce overland flow by 88.8% and pollutant loads by 95.4% in a parking area in California

Natural and constructed wetlands are very effective at removing pollutants, nutrients and microbial contaminants thus improving downstream water quality. Ghermandi *et al.,* (2007) report that in a global analysis of effluent treatment and constructed wetlands, that these wetlands consistently provide a reduction of between 90 – 99% in the concentration of coliform bacteria and faecal streptococci. Wetlands also act as filters of sediments and other organic matter washed off surfaces during storm events. The wetland may become a permanent sink for these substances if the compounds become buried in the substrate thus having significant impacts on downstream water quality. In a review of the effectiveness of constructed wetlands in tropical and subtropical climates Zhang *et al.,* (2015) found that wetlands removed 91.3% of total suspended solids (TSS), reduced biological oxygen demand (BOD) by 87.6 % and a 53.3% reduction of total nitrogen.

However, in a long-term study of the effects of created wetlands on water quality over 15 years, Mitsch *et al.,* (2012) found that created wetlands reduced total phosphorus by 60% and nitrogen by 40% in the first years after being created. As the wetlands matured the amount of nutrient removal did decline. However, even after 15 years the wetlands were moving 30% of nitrates and still 10% of phosphorus load. This gives an indication that management and maintenance of constructed wetlands in urban systems may be required to maximise their performance in water quality management.

Using natural areas as urban amenity (scenic protection and recreation opportunities and improving wildlife habitat), which have demonstrated physical and mental health benefits and is increasingly recognised as a cost-effective tool for planning healthy cities –see for example Shanahan *et al.,* (2015).

2.6.2 Coastal infrastructure

In a global meta-analysis of the influence of coral reefs, mangroves, saltmarsh and seagrass/kelp beds on wave reduction and coastal protection, Narayan *et al.,* 2016, found that these coastal habitats have significant influence on wave heights and the risk of coastal erosion. They found that on average, coastal habitats reduce wave heights between 35% and 72%. Coral reefs and salt marshes were the most effective at reducing wave heights 70 and 72% respectively with coral reefs having a range of between 54 to 81% reduction in wave heights and saltmarsh a range of between 62 to 79%. Although an earlier study by Ferrario *et al.,* (2014) calculated that coral reefs can reduce wave height by up to 86% and can reduce wave energy by 97%.

An assessment across all habitats indicated that coral reefs have the greatest potential for coastal protection as they are highly effective at reducing wave heights and are also exposed to higher more powerful waves. Mangroves and seagrass beds are about half as effective as coral reefs but still had a significant effect on wave heights in more sheltered

environments (> 30%). Even though the protection from wave energy by mangroves is less than coral reefs they nevertheless can be quite significant in terms of human and economic impacts. A study on the effect of storm surge from a Cyclone in 1999 in the Odisha region in **India** showed rice croplands protected by the dense mangroves of Bhitarkanka Conservation area had lower levels of immediate impact after the cyclone. This impact also had lasting effects as It took 3 years for the areas impacted by storm surge to return to productivity levels similar to the area protected by mangroves (Duncan *et al.,* 2014).

The US Environmental Defence Fund recently published a compendium of the latest literature on the performance of natural infrastructure as coastal risk reduction features (Cunnif and Schwartz 2015). The report evaluated the effectiveness, strengths and weaknesses in current state of knowledge about best uses of a number of coastal natural systems used for coastal protection.

2.6.3 Water infrastructure

Natural structures can help reduce human and technological errors or failures associated with water supply systems. Regarding water quality, such failures could include disease outbreaks caused by distribution and filtration systems in poor repair, lack of proper maintenance, inadequately trained operators, or failure of operators to respond to warning signs (Kouskya 2010).

For hydroelectric projects, natural capital provides sediment retention services that maintain reservoir and dam functions. Sediment retention service not only contributes to clean drinking water, it also helps to maintain the functioning of dam and reservoir infrastructure. A study of 15 major dams within Myanmar suggests that already several major dams are at risk from upstream deforestation and agricultural expansion (Mandle et al. 2016). Several newer projects in the ADB portfolio reflect this viewpoint, for example the Assam Integrated Flood and Riverbank Erosion Risk Management Investment Program (Project No. 38412) and the Flood & Riverbank Erosion Risk Management Investment Program (Project No. 44167).

A recent study of natural capital in Myanmar shows how road development around the Tanintharyi mountain areas can lead to deforestation for mining and other activities, with important downstream impacts on drinking water (Mandle et al. 2016). The same study shows how several dams and other infrastructure projects are also risk from similar conversions upstream.

2.6.4 Disaster risk reduction

At the moment 85% of ODI related to Disaster Risk Reduction (DRR) is ex-post, despite the proven effectiveness of investments in DRR and community resilience[11]. Forests for example have shown to play an important role in the reduction of avalanche risks in Switzerland[12]. Unasylva recently published a series of example of how trees can be used to mitigate

[11] https://www.wetlands.org/blog/investment-in-natural-capital-for-risk-reduction-an-opportunity-not-a-cost/
[12] http://unfccc.int/files/adaptation/application/pdf/3eba.pdf

disasters, from typhoons in China, watershed management in Pakistan and Haiti, wildfires in Australia and the USA (FAO 2015a).

The role that forests and forestry play in the prevention of landslides and rehabilitation of landslide affected is drawing more attention, for example reinforcing and drying soils, and directly obstructing smaller slides and rock falls during normal intensity events, and in particular susceptible slopes. The vulnerability in major parts of Asia, landslides cause fatalities and damage residential and commercial areas, roads and infrastructure in the immediate vicinity, and contributes to downstream damage by blocking rivers and increasing downstream sedimentation (Forbes and Broadhead 2011).

2.7 Climate risks and ecosystem-based adaptation

Until very recently the overwhelming focus of adaptation strategies was on minimising the impact of climate hazards through the implementation of, or redesigning of, hard engineering structures. Examples include seawalls as a method to combat rising sea level or increasing dams and improving irrigation infrastructure as a response to declining rainfall or increasing climate variability (Jones *et al.,* 2012). These type of strategies are often referred to as hard infrastructure responses. However, adaptation to climate change can incorporate a range of actions and by multiple players and there has recently been a growing case for using so called "soft" approaches which focus on policy responses, capacity building and providing information (Jones *et al.,* 2012). At a government level these type of adaptation approaches can be facilitated through broad activities such as, altering policies and legislation such coastal development guidelines or setbacks, providing education about probable impacts and developing early warning systems for droughts and floods or extreme weather events such as cyclones. At the community and local level these have included more direct actions such as, changing land use practices or the redesign and construction of new engineering infrastructure such as sea walls to cope with rising sea level.

An additional approach that incorporates both soft and hard responses is to use the services and benefits provided by nature to help buffer against the impact of climate change. (MEA, 2005; Munang et al., 2013). This approach is often referred to as Ecosystem-based Adaptation, or EbA.

"EbA involves the use of biodiversity and ecosystems (or the natural assets of an area) as part of an overall adaptation strategy to help communities adapt to the impacts of climate change (MEA, 2005). "

Climate change and the interaction of other human impacts on ecosystems have led to many regions and ecosystems becoming degraded resulting in negative impacts on people's lives particularly those living in subsistence and agrarian based systems (Munang et al., 2013). Conversely, by maintaining healthy ecosystems many of the impacts of climate change on communities can be minimized. Healthy, well-functioning ecosystems enhance natural resilience to the adverse impacts of climate change and reduce the vulnerability of people. A healthy ecosystem in comparison to a degraded ecosystem has an elevated resilience to absorb additional environmental stresses including those associated with climate change and thus is more able contribute to adaptation to climate change and

disaster risk reduction as well as contribute to greenhouse gas sequestration. Ecosystem based approaches can also be applied at many scales and can easily be used at a national, regional or local scale (Devisscher, 2010)

This means approaching the challenges posed by climate change with solutions that are based on working with and using nature such as, maintaining healthy mangrove forests to minimize the impact of increased storm surge and sea level rise, using wetlands and greenspace as part of an urban flood mitigation strategy or vegetation and catchment management to improve water quality and security in response to altered rainfall patterns.

Forests also play an important role in ecosystem based adaptation as well as ecosystem based mitigation. For example:

- Integration of sustainable ecosystem management practices into broader landscape-level planning processes. Examples of this include integrated watershed management in peri-urban areas, which has proven to enhance water regulation to support the supply of water for drinking and hydroelectricity generation in cities[13]. In Colombia, CI conducted a vulnerability assessment, with an EbA approach, of the ecosystems that provide water to the city of Bogota and surrounding areas, covering a population of approximately 10 million people. Based on these findings, CI is now implementing a GEF project in the region that will ensure water provision to the city through activities such as forest restoration, development of climate-smart landscapes in rural areas, strengthening and supporting local institutions, and disseminating information on agricultural EbA activities[14].
- Climate mitigation by maintaining or enhancing carbon stocks with safeguards in place to support adaptation. For example, collective management of forested landscapes that promotes social learning to conserve forest function and structure, biodiversity and habitat connectivity, and climate-smart agriculture with agroforestry systems.
    - Agroforestry and coffee: Costa Rica, Honduras, Guatemala (CASCADE project): In Central America, CI is working to identify and test EbA management practices in agricultural landscapes — such as the use of live barriers, shade trees in coffee plantations, crop cover and the conservation of riparian forest — to help smallholder farming communities adapt to climate change. Using this information, CI helps strengthen the capacity of key local institutions, such as farm extension services, to support EbA project implementation[15].
    - Protective capacity of forests against avalanches – Switzerland. The Swiss government recognised that over-exploitation of trees was leading to serious avalanches, landslides and flooding and introduced a rigorous system of

[13] https://www.weadapt.org/knowledge-base/ecosystem-based-adaptation

[14] http://www.conservation.org/projects/Pages/Adapting-to-a-Changing-Climate-in-Colombia.aspx

[15] http://www.conservation.org/projects/Pages/Ecosystem-based-Adaptation-for-smallholder-farmers-in-Central-America-CASCADE.aspx

protection and restoration. Legislation recognises the protective function of its forests, and private and public landowners are incentivized to manage forests to provide protection from natural hazards, rather than for commercial timber production. This includes managing stands to help protect against rock fall, landslides and avalanches and restoration of previously degraded areas[16]. The benefits of protected forests are estimated between US$ 2 to 3.5 billion per year.

- Integration of climate change risk and resilience into forestry management, **Samoa**: The project will seek to integrate climate change risk considerations into lowland agroforestry and upland native forestry management plans and national development planning. Rehabilitation activities will include areas damaged by cyclones, forest-fire, and unsustainable land-use practices using a combination of native species that are more resistant to the increasing incidences of damage caused by cyclones and drought[17].

Another example of forestry and water management to promote climate resilience is a World Bank project from Bangladesh set out in Box 2.10.

[16] http://unfccc.int/files/adaptation/application/pdf/3eba.pdf
[17] http://unfccc.int/files/adaptation/application/pdf/15eba.pdf

The Coastal Embankment Improvement Project Phase-I aims to increase the climate resilience of coastal populations by rehabilitating and strengthening the embankment structures of selected polders in Bangladesh. It will increase the area protected from tidal flooding and frequent storm surges (disasters affected by climate change), improve agricultural production by reducing saline water intrusion, and enhance the Government of Bangladesh's emergency response capacity. It is financed through a US$375 million loan by the World Bank and a US$25 million grant from the Climate Investment Funds' Pilot Program for Climate Resilience (CIF-PPCR).

Project summary: Implemented from 2013 until 2020, the program has five components: A) rehabilitation and improvement of polders, including embankment afforestation, which will protect assets and enhance agricultural production and economic growth to the coastal population; B) implementation of social and environmental management frameworks and plans, including the establishment of participatory Water Management Organizations (WMOs); C) construction supervision, monitoring and evaluation of project and coastal zone monitoring, enhancing the technical capacity of local institutions through training and procurement of advanced technology and equipment; D) project management, technical assistance, training and strategic studies for further institutional capacity building; E) contingent emergency response in case of a major natural disaster.

Overall economic rate of return: Through a cost-benefit analysis the project's economic rate of return (ERR) was estimated at 20%. For the analysis a 33-year time horizon was used to account for the project's long-term benefits related to climate change. The benefits assessed related to: i) avoided damages to crop production, fisheries, livestock, non-agricultural sectors, roads, property due to storm surge (or river flooding) ii) improved crop production due to better drainage iii) shelterbelt benefits due to afforestation. To calculate the avoided damages, the *reduced probability of inundation* as a result of the upgraded embankments was calculated. The probability was reduced from 17% in year 1 and 50% in year 33 to 2% in year 1 and 4% in year 33. The reduced probability was then multiplied by the *expected damage ratio* and the *value of assets exposed*. Estimated total avoided losses equalled approx. US$ 361 million. Improved crop production was estimated at approx. US$232 million based on the increase in total area cropped and productivity due to the reduced waterlogging and soil salinity. Forest benefits included the value of tangible products that can be extracted from them and were estimated at approx. US$1,26 million. Their additional value of protecting the embankments through dissipation of the tidal forces was incorporated in the analysis through reduced O&M costs over the lifetime of the embankments. In total, the present value of benefits was estimated at approx. US$592 million versus costs of approx. US$243 million.

Box 2.8 World Bank support for climate resilience of coastal populations in Bangladesh
Source: World Bank, 2013

2.8 International commitments in support of natural capital investment

Asia's increasing wealth and urbanisation are mirrored by global trends. But 2015 may provide greater focus on natural capital in terms of the global policy framework. The list below highlights some of the key related agreements:

- Sustainable Development Goals and commitments to SDGs on ecosystems –may influence country priorities in favour of more natural capital investment,
- Climate mitigation and REDD+: Asia Pacific countries played a key role in the recently agreed Paris Climate Change agreement. The role of forests in climate mitigation has received growing attention with some countries showing particular interest such as Indonesia and Viet Nam. In some Asia Pacific countries, natural capital plays an important role in their Nationally Determined Contributions submitted for the Climate Change agreement.
- Biodiversity Convention and protected areas: Protected area commitments are growing across Asia Pacific
- Other international treaties – for example on illegal wildlife trade and RAMSAR wetland convention.

Specifically on terrestrial natural ecosystem and assets, Sustainable Development Goal 15 states: "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss". The targets also say: "By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally". In addition, there is a target to: "By 2020, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world. On biodiversity the target is to: "Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species". (UN, 2015). For marine ecosystems, Goal 14 states: "Conserve and sustainably use the oceans, seas and marine resources for sustainable development". The targets include: "By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information". (UN, 2015b).

- CITES (the **Convention on International Trade in Endangered Species** of Wild Fauna and Flora) is an international agreement between governments, currently numbering 183 Parties, supporting the legal and sustainable trade of wildlife and thus playing a crucial role in biodiversity conservation. According to a recent report by Nowell and Pervushina (2015), implementation of Resolution Conf. 12.5 on *Conservation of and trade in tigers and other Appendix-I Asian big cat species* has had significant progress in the conservation of Asian big cat species such as tigers and leopards that are currently threatened with extinction due to illegal trade. Below are some important developments that have taken place under the Resolution's focus areas (Nowell and Pervushina, 2015):

- **Legislation and regulation**: Higher penalties against illegal wildlife trade were adopted in 2013 by Bhutan, Japan, Russia and Viet Nam, with the last two countries classifying such actions under a criminal offense
- **National law enforcement**: Countries are employing innovative measures through anti-poaching squads in Thailand, online data-sharing networks, zero tolerance for online trading in China, multi-agency coordinating mechanisms in China, Lao, Nepal, Thailand and Viet Nam and high-level political support in Nepal and Viet Nam
- **International cooperation for conservation and enforcement**: 16 new bilateral and multilateral agreements for conservation and wildlife trade control have been signed or are being developed
- **Data gathering, availability and analysis**: in 2009 India established the innovative Tigernet, an online public database of tiger mortalities and illegal trade seizures, to which can contribute both wildlife officials and the public
- **Demand reduction, education and awareness**: Important initiatives are taking place under the Global Tiger Recovery Program, including a national strategy to reduce consumption of wildlife released by Viet Nam in 2013
- **Prevention of illegal trade from captive breeding facilities**: Pakistan developed comprehensive guidelines on the issue, and the TRACE Network launched TigerBase, a pilot project to support ASEAN countries in using DNA databases for law enforcement.

3 What natural capital to invest in?

This section will present a review of specific types of natural capital investments and an overview of potential investment areas, starting with support for the enabling context and followed by specific investments in each natural capital area. These sectors are:

- Agricultural natural capital: water, soil, grasslands and agrobiodiversity
- Sustainable forests and terrestrial protected areas
- Watersheds and freshwater natural capital
- Coastal and marine natural capital, including fisheries
- Urban natural capital
- Ecosystem based adaptation

3.1 A framework for natural capital investment

This section highlights the specific interventions that Asia Pacific governments and ADB staff can make to invest in natural capital. The investments include soils and agriculture; forests and terrestrial protected areas; watersheds and freshwater resources; coastal and marine resources and urban ecosystems. The final section will bring together how these investments relate to ecosystem based adaptation. The approach includes reviews of past success and innovation as well the opportunities for scaling up through national investment programmes.

This section presents the selected natural capital resources and ecosystems in terms of demand and supply and the interactions between “primary” natural capital and “secondary” natural capital alternatives (such as fertilizer, plantations and agroforestry, aquaculture and most urban ecosystems) (see Figure 3.1). More detailed description is presented in Table 3.1 and discussed in this section. While the framework outlined in Table 3.1 identifies different demand and supply interventions for “primary” and “secondary” natural capital, in practice the solution will be an integrated combination. A natural capital approach implies managing a resource/ecosystem as an asset that generates benefits beyond the private investor and towards society, for example linking to social protection for vulnerable groups (see Section 2). This means involving many stakeholders from the public and private sector, for example through integrated water resources management.

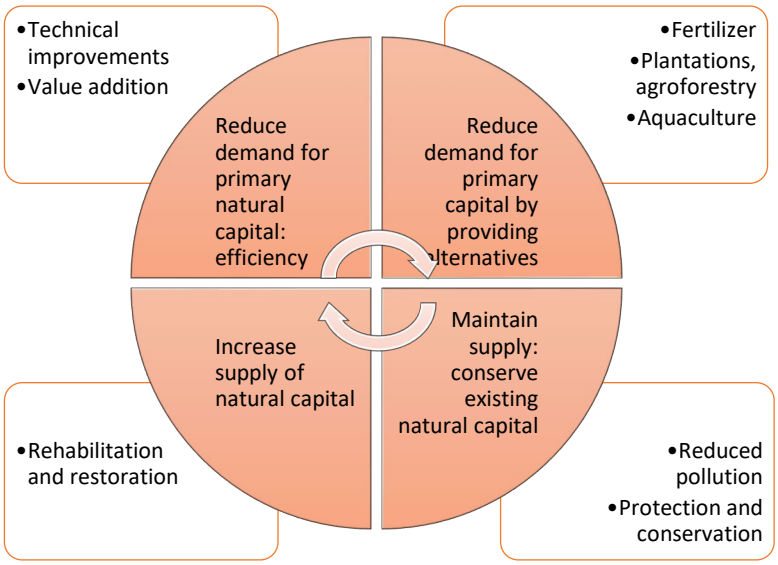


Figure 3.1 Framework for investments in natural capital: reducing demand and increasing supply
Source: Authors' own

Table 3.1 Framework for natural capital investments: reducing demand and increasing supply

Resource/ ecosystem	Crosscutting investments	Addressing demand		Addressing supply	
		Increase use efficiency	Promote alternatives	Maintain supply of existing wild natural capital	Increase supply of wild natural capital
Soils for agriculture	Tenure reforms	Agricultural intensification	Better fertilizers	Zero or reduced tillage	Soil terracing
Rangelands/ Grasslands	Tenure reforms	Animal productivity	Farm feeding of livestock	Maintain protected areas	Increased protected areas
Water for agriculture	Pricing and regulatory policies	Agricultural intensification, Higher value crops	Water from desalination	Groundwater protection	Groundwater recharge
Tropical forests	Reduced illegal logging, tenure rights	Sustainable forest management, Sawmill efficiency	Plantations/ Agroforestry	Maintain protected areas	Increased protected areas
Watersheds	Payment for Ecosystem services	Participatory management	Reforestation	Maintain protected area	Increased protected area
Aquatic	Monitoring and enforcement	Value addition eg fish processing	Aquaculture	Protection of fish spawning grounds	Increased marine protected areas
Coastal ecosystems	Participatory management	Higher value uses eg tourism	Artificial reefs	Reduced agricultural and urban impacts	Increased marine protected areas
Urban ecosystems	Awareness of ecosystem benefits over hard engineering	Not relevant	Constructed ecosystems/ green cities	Not relevant	Not relevant

3.2 Enabling context for investments

The following sections in this Chapter will help identify specific natural capital investments for each natural resource/ecosystem – leading to a menu of possible investment projects in particular geographical locations. However it is important not to overlook the more economy-wide, crosscutting and landscape level natural capital investments. This is for several reasons:

First, natural capital is often damaged by activities outside the particular resource. Forests are affected by agricultural and urban expansion, and other investments in roads. Marine ecosystem and fisheries are also affected by non-marine impacts from agricultural (particularly agricultural pollution and run-off) and from coastal urban and other shoreline investments which cause pollution and disturbance to ecosystems. So a narrow focus on a natural capital investment may miss out these economy-wide and crosscutting issues which lie at the root of natural capital loss.

Second, natural capital investments are often crucially dependent on softer aspects. The term "investment" may also emphasise particular physical and technical hardware, whilst giving less attention to "softer" institutional and policy reforms. For natural capital it may be this latter softer reforms that is just as important, or even more important, than technical hardware. For example Economy-wide and crosscutting investments at a national level for natural capital will require market and policy instruments (institutional and policy reforms, and economic instruments, regulations). For coastal and marine investments this would focus on policy and regulation for marine protected areas, pollution regulation and development control for tourism and aquaculture in particular.

	Resource/ sectoral Approach	Landscape Approach
Strengths	Generally quicker More targeted Easier to monitor	Easier to follow ecosystem boundaries Can cover damaging impacts beyond resource and identify trade-offs and synergies / opportunities across sectors Can gain more political visibility May be more institutionally sustainable in the longer term Aligns with SDG delivery
Weaknesses	Impacts may be limited May result in unforeseen negative trade-offs across over sectors	Generally slower Lack of immediate results Many stakeholders make decisions difficult May be more costly Only few examples of large scale successes

Table 3.2 Comparing resource specific/sectoral approach versus integrated/ landscape approaches
Source: authors own

Third, natural capital follows ecosystem and natural spatial boundaries often cuts across economic sectors and administrative boundaries (eg local government units or city boundaries) and so may require a "landscape approach." Thus to effectively manage an

ecosystem will require a more integrated, holistic approach – often using ecosystem boundaries instead of economic or administrative boundaries. This explain the current trend to move towards a “landscape management approach” which involve many types of natural capital in a national or regional context.

Finally, a landscape or integrated approach combines the requirements of ecosystem based planning with consultation with natural resource users. Table 3.2 compares an integrated approach with a sectoral approach. The issue is whether the strengths outweigh the weaknesses in a particular context. It may be that each approach is relevant for different contexts. Resource specific approaches are useful when there are immediate short term threats which need a quick response and where budgets and time may be constrained. An integrated approach may be more useful when a larger, more time-consuming and more expensive approach is possible that may have greater impacts and higher visibility leading to greater long run institutional and financial sustainability (Box 3.1 presents an example of a high profile ADB project in the Greater Mekong Subregion).

Greater Mekong Subregion. The Greater Mekong Subregion (GMS) is a natural economic area bound together by the Mekong River, covering 2.6 million square kilometers and home to more than 300 million people. With the launch of the program in 1992 through the support of ADB and other donors, the six countries- Cambodia, Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, Viet Nam, and People's Republic of China (PRC, specifically Yunnan Province and Guangxi Zhuang Autonomous Region) - agreed to enter into a regional collaboration on the environment and established the Greater Mekong Subregion Core Environment Program and Biodiversity Conservation Corridors Initiative. With the goal of a poverty-free and ecologically rich GMS, the countries are undertaking a range of activities to improve natural resource management, biodiversity conservation and climate resilience. Numerous other programs are also being implemented with support from various partners, contributing to a comprehensive approach to sustaining natural capital in the region.

Heart of Borneo (HoB). Covering about 22 million hectares, the Heart of Borneo, is one of the largest intact contiguous rainforest remaining in Southeast Asia extending into the territory of the countries of Brunei Darussalam, Indonesia and Malaysia. It is also one of the most biologically diverse habitats on Earth. Each year, an estimated 1 million cubic meters of timber is smuggled out of the area, leaving destroyed forests, threatened biodiversity, lost livelihood opportunities, and higher costs for forest rehabilitation. Conflicting laws and ambiguity over areas of responsibility for managing resources has left the region highly vulnerable. The HoB Initiative is a unique government-led and NGO-supported program that was initiated in 2007 by a joint declaration of the three governments. The aim of the program is to conserve the biodiversity of the Heart of Borneo for the benefit of the people who rely upon it through a network of protected areas, sustainable management of forests and other sustainable land uses.

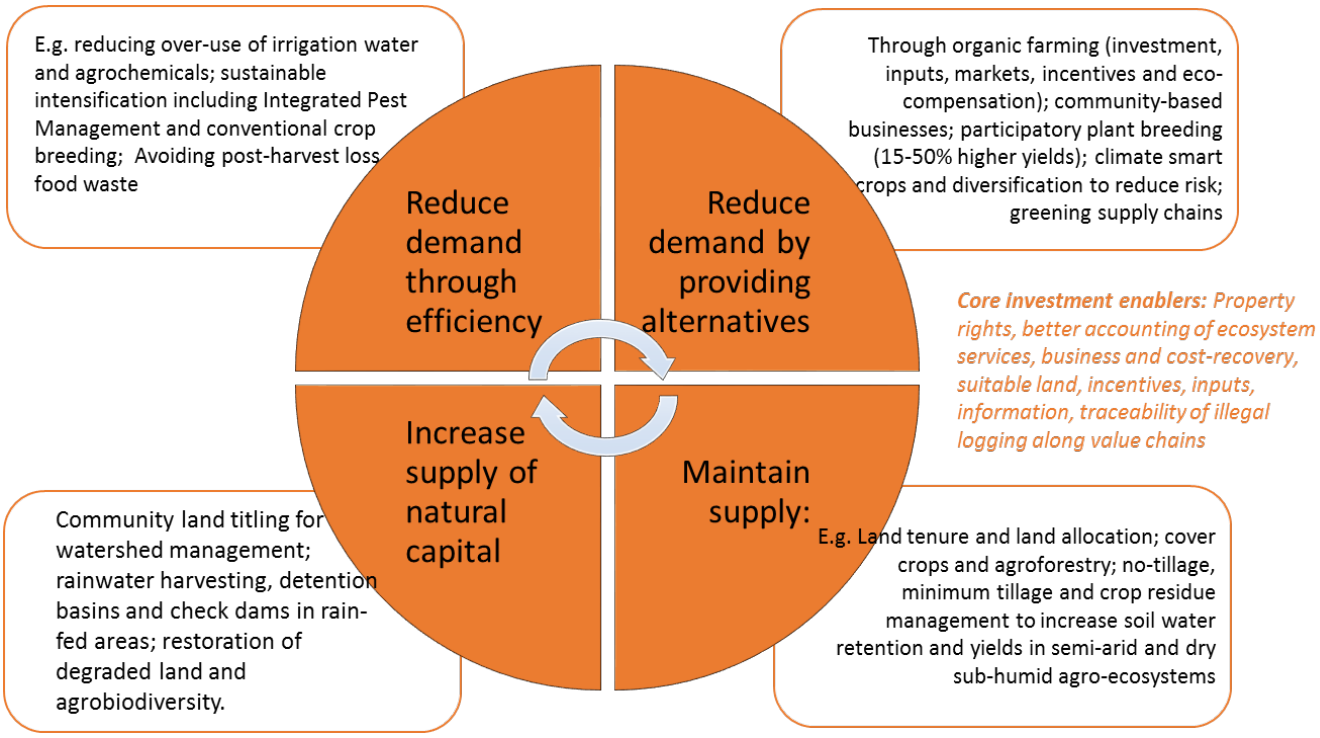
The Living Himalayas. Extending across India, Nepal, Bangladesh and Bhutan, the Living Himalayas is a part of the biologically rich Eastern Himalayan mountain range. The Eastern Himalayas are listed among the earth's recognized biodiversity hotspots, being the home of threatened species, including the Bengal tiger, Asian elephant, one-horned rhino, red panda and snow leopard. It is the source of fresh water for one billion people and feeds seven major rivers, including the Ganga, Indus, and Brahmaputra. Not only well known for its rich biodiversity, the Himalayas is also acknowledge for the diversity of culture and people. While the natural resources of the region are vital for the livelihoods of local people, mountain ecosystems are under severe threat from increasing human populations and haphazard infrastructure development. Climate change is accelerating the melting of glaciers, which will have major impacts on fresh water and energy security. To address these issues, the four countries organized the Climate Summit for a Living Himalayas 2011 in Bhutan where they adopted a "Framework of Cooperation" to build resilience to climate change in the Eastern Himalayas. The Framework outlines four main areas for focus and cooperation: 1) securing biodiversity and ensuring its sustainable use; 2) ensuring food security and securing livelihoods; 3) securing the natural freshwater systems of the Himalayas; and 4) ensuring energy security and enhancing alternate technologies. The summit and its outcomes have created a regional vision supported by civil society, the public and private sectors and development partners such as ADB, UNDP and WWF, to protect and sustainably develop the region's common resources for future prosperity. This cooperative effort promises to result in real progress in tackling climate change issues in the Eastern Himalayas, thereby securing the natural resources, ecosystem functions and livelihoods for millions of people throughout the region.

Box 3.1 ADB support for integrated natural capital approaches: Mekong, Borneo and Himalayas
Source: ADB and WWF

3.3 Investments for Agricultural Natural Capital

Investments should focus on increasing agricultural productivity while sustaining natural capital. This can include increasing efficiencies, providing alternatives, and securing existing natural resources - such as soil and water conservation. Many of these investments are highly complementary to agricultural infrastructure, for example improving irrigation water use efficiency, crop breeding for reduced water demand, and using organic fertilizer and biological pest control to prevent groundwater pollution (see figure 3.2).

Figure 3.2 ***What investments in agro-ecosystems?***



Source: Authors' own

Natural capital investments to safeguard soil and water resources is the focus of this section. Water is a necessary and usually the limiting factor for the most productive use of land. In a growing number of countries with arid climates the main constraint to agricultural growth is the availability of water rather than land. At the same time the use of land has major impacts on both the quality and quantity of water resources. In other words, decisions regarding the use and allocation of one resource impact directly or indirectly on the use and allocation of the other. To ensure sustainability, the need for an integrated approach to the use and management of land and water is increasingly recognized as imperative.

3.3.1 Core enablers: land rights and allocations

Secure land tenure is considered to be a precondition for sustainable land and water management. Land and water users are more likely to make sustainable investments in land and water management if they are confident that they will receive the benefits over time.

By contrast, where land and water rights are insecure, there will be a higher incentive to "mine" the resource for short term gain. The productive use of land and water is also influenced by the flexibility the land user has to change land use in response to market opportunities. Constraints on changing land use (other than for environmental reasons related to land suitability), such as those related to choice of forestry or agricultural tree crops, will likely result in sub-optimal land use. Land transactions can play an important role by allowing users who are most productive, but have limited access to land. Land rental markets are characterized by low transaction costs and are a flexible and versatile means of transferring land from less to more productive producers than sales. An inefficient land-use-rights market that does not accurately reflect market values restricts the ability of efficient farmers to take advantage of market opportunities to increase production, and of inefficient farmers to leave the sector.

Full security of land rights requires the rights to be clearly defined and defended by law, and that the land administration system can guarantee the rights allocated. The interface between land tenure rights and water rights and the relationship between these two resources is of equal significance. Land tenure rights and water rights are both types of legal rights and as such they are capable of being asserted in court against third parties including the state (FAO 2004[18]). Water rights are property rights since they confer on their holders the right to abstract or impound and use water in a natural source such as a river, stream, lake or aquifer, such rights are administrative rights. In contrast to land tenure regimes, under which the resource itself may privately owned, water in natural sources typically remains under public control (FAO 2004)

Land allocation to land users, especially households, has proceeded slowly in most regions despite government directives to accelerate the process. In regions where land allocation has been completed, deficiencies in the implementation of the land allocation process are evident. Often land allocation has been completed hastily without cadastral surveys, with inadequate resources and limited consultation with the recipients, especially households. In many cases the land allocation process and documentation has not fully complied with legal requirements. As a result security of tenure may be compromised and land disputes remain difficult to resolve.

Prevailing land allocation policy seek in many Asian countries to allocate land to existing users of land and as a result may deprive poor and landless households of the opportunity to receive a capital asset of land that could improve their socioeconomic situation. Even in places where there is a relatively high degree of legal literacy about land rights and clearly progressive land policies, people's access to and control over land resources are not automatically guaranteed, e.g. **Philippines** (FAO 2011b[19]), and individual freehold titles of land are in general rare (FAO 2011b).

[18] FAO 2004: Land and water – the rights interface ftp://ftp.fao.org/docrep/fao/007/y5692e/y5692e00.pdf
[19] FAO 2011b: HLPE (High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security): Land tenure and international investments in agriculture

Community land titling is part of many states' policy to recognize the land use systems of minority and local groups and constitute a important vehicle to build up management and financial capacity.. This method of land allocation has considerable potential to provide both positive social outcomes and good land stewardship especially for watershed protection. Community land titling has been applied in several regions as pilot programs to simplify and expedite the completion of land titling Experience to date has been mixed as there are reports of capture of benefits by local elites or limited effectiveness. There are also complexities in defining village boundaries and accommodating different cultural traditions. There is no uniform solution and a solely top-down approach is not appropriate; local consultations and facilitations are needed. However, existing pilot community land titling programmes confirm the willingness of community leaders to take responsibility for managing their own natural capital sometimes over several decades. Further effort is justified to develop community land titling processes.

3.3.2 Tacking demand by greening agricultural supply chains

Several initiatives have emerged to support the corporate agricultural sector improve their management of natural capital, engaging all stakeholders along supply chains on more responsible practices. One of the longest examples is the Roundtable on Sustainable Palm Oil, established in 2004 with the objective of promoting growth and use of sustainable oil palm products using creditable standards provides a platform for discussions across supply chains, including corporate sector (Unilever, Cadbury's, Nestle, Tesco), palm oil traders (Cargill, Archer Daniels Midland), and interested pressure groups (Greenpeace, WWF). In practice it has been difficult to deal with big issues, like the burning and draining of large tracts of peat swamp forest in Kalimantan, Indonesia; and the impact of conversion on biodiversity - as well as labour worker issues. Other roundtable initiatives for high value agro-commodities include the Roundtable for a Sustainable Cocoa Economy (RSCE, first meeting in 2007), the Roundtable on Sustainable Forests and the Roundtable on Sustainable Biomaterials and Biofuels.

3.3.3 Supply: Increase efficiencies in production

Soil and water management investments include addressing demand side issues such as boosting yields through crop protection and crop and animal breeding as well as reducing post-harvest losses and food waste, and supply side issues such as land and water management, including increasing pasture productivity. The role of agricultural technologies is intensively discussed in by IFPRI 2014[20] which screen many methods and list the 11 most potential or likely most successful investments (separately and in combination):

1. **Crop protection** — Methods of managing pests, diseases and weeds
2. **Drip irrigation** — Approaches that involve applying water directly around roots
3. **Drought tolerance** — Plant varieties that can process available moisture more readily and that are less vulnerable to water deficiency
4. **Heat tolerance** — Varieties that can withstand or thrive in higher temperatures

[20] International Food Policy Research Institute (IFPRI) 2014: Food security in a world of natural resource scarcity: The role of agricultural technologies. Washington, D.C.: http://dx.doi.org/10.2499/9780896298477

5. **Integrated soil fertility management** — New fertilizer and composting combinations
6. **Nitrogen use efficiency** — Plants that respond better to fertilizers
7. **No-till — Farming** that involves little or no soil disturbance and potentially the use of cover crops
8. **Organic agriculture**[21] — Cultivation that excludes manufactured fertilizers, growth enhances or genetically modified organisms (GMOs)
9. **Precision agriculture**[22] — GPS-assisted, machine to machine solutions that combine information collected by sensors with automated management.
10. **Sprinkler irrigation** — Water delivered through overhead nozzles
11. **Water harvesting**: Irrigation that uses earth dams, channels and other ways of directing water toward crops

3.3.4 Reducing demand for natural capital: avoiding post-harvest losses and food waste

Demand for soil and water can be reduced by avoiding post-harvest losses and food waste. Post-harvest losses before processing can be significant due to poor field storage facilities, lack of timing, weather impacts, fermentation, rodents, insects, diseases, etc. It is technically possible and theoretically easy to reduce losses of crops, wood, fruits, seed, and meat, very substantially. However, in practice it may turn out to be prohibitively expensive. Small, diversified farms will have difficulties affording expensive technologies accentuated by intensive management and monitoring, and punctual coordination with buyers. Losses can however be avoided by timely management, proper storage, and good planning. A wide range of post-harvest technologies can be adopted to improve losses throughout the process of pre-harvest, harvest, cooling, temporary storage, transport, handling and market distribution. Technologies applied depend on the type of loss experienced but intervention mitigations often fail due to cost of investments, maintenance, lack of electricity, water and other supplies. For example, lack of water for field storage can destroy crops while excessive amounts of water can be instrumental for fatal fungus, viral, and bacterial attacks. Some crops peak at the same time so markets cannot absorb them quickly enough and they may rot due to over-supply by producers.

Food waste also needlessly increases agricultural production and therefore demands on soils and water. About 24 percent of all calories currently produced for human consumption are lost or wasted. Food waste is less in Asia than in all other regions of the world but still significant, amounting to an estimated 414 Kcal/capita/day (2009 figures). The issue is also related to waste of input supplies for the production of commodities, e.g. loss of pesticides, water, fertilizer, etc. The implications of this amount of loss and waste are huge. In a recent paper by WRI (2013[23]) profiles a number of approaches for reducing it, and puts forth five recommendations to mitigate waste globally, regionally, and nationally.

[21] Trend in richer countries based on consumer's willingness to pay considerably more for such products
[22] Sophisticated, complex and intensive. Investment heavy. Most relevant in strong economies
[23] WRI 2013: Lipinski, B. *et al.* "Reducing Food Loss and Waste." Creating a Sustainable Food Future. DC: http://www.worldresourcesreport.org

3.3.5 Reducing demand for soil and water: agricultural intensification

The demand for soil and water capital and expansion into ecosystems such as forests can be reduced by agricultural "intensification" as a mean to improve yield. As Asia generally is densely populated and most potential and productive land is already under cultivation, extensification is not an obvious solution. Exceptions may be in scarcely populated areas in Central Asia where slopes, access, and limited rains allow for or even favour this. The need can be accentuated for rural areas in which younger generations tend to move to cities and the remaining, diminishing population have difficulties managing agriculture at steady or intensified levels.

Agricultural production in Asia is almost exclusively obtained through intensification (WRI 2013-3). In South Asia for example the crop yields/ha has increased 240% since 1961 while the cultivation area had only expanded approximately 15%. But there are many areas in Asia with limited opportunities for continued productivity increases as the gains from the green revolution have already been achieved and the curve of gains from continued investments starts to decline. That means in general that substantial investments are needed to secure continued productivity increases. In some poorer and remote regions intensification is still possible. For example Myanmar's Ministry of Agriculture found that use of artificial fertilizer use in Myanmar is still low by South East Asian standards and very low by world standards. Together with improved seed, fertilizer use and adoption of modern technology by farmers, agricultural productivity can be significantly raised (IFDC 2014: *Myanmar Fertilizer Policy Evaluation*[24]). The second challenge is intensified, and significantly more productive agriculture may pose additional treats on ecosystems and natural capital. Increased use of fertilizers and pesticides will pose risks for both soil and water natural capital.

The approaches to address this are crop protection and crop and animal breeding as well as effective pesticide and fertilizer use (see Table 3.3).

[24] https://ifdcorg.files.wordpress.com/2015/09/myanmar-fertilizer-policy-evaluation-9-17-14-kg-edits-4.pdf

Table 3.3 Strategies to address threats from agricultural intensification

Strategy	Description
Crop protection	For crops, one main challenge to increased productivity is pest control including managing insects, pathogens, and weeds. Proper crop protection includes use of pest-resistant cultivars and varieties, crop sequences and practices that maximize biological prevention of pests and diseases. Application of pest and disease forecasting techniques where available; determine interventions following consideration of all possible methods and their short- and long-term effects on farm productivity and environmental implications in order to minimize the use of agrochemicals including storage and use agrochemicals dosages, timings, and pre-harvest intervals. Integrated Pest Management (IPM) is an ecosystem approach to crop production and protection that combines different management regimes and practices to grow healthy crops and minimize the use of pesticides through hit avoidance (e.g. cultivation in areas where calamities cannot live/strike), preventive measures (e.g. better field management timing, use of seasonality, etc.) and biological control (e.g. introduction of pest/disease predators and eradicates). IPM methods are strongly favoured by FAO, but results globally have varied and IPM can be complicated. Drawbacks can include by introducing "aliens" into agro-ecosystems which – unintentionally – can become hosts or vectors of new and other pests and diseases. A stepwise approach, from lab to field experiments, from pilots to scaling up the use of the IPM application has to be applied as to ensure success.
Crop breeding	Breeding crops to produce more food is a core method of boosting yields and so can reduce pressure on soil and water and other natural capital. While farmers have been breeding crops since the dawn of agriculture, breeding by scientists became common only during the past century. Conventional crop breeding, involves sexually propagation of plants selected for desirable traits. Findings reveal that most of the gains in crop yields will depend on improving conventional breeding [25]. Genetic gains are linked to and depend on the best choice of material for the particular planting site and on proper management and cultivation. Soil treatment, plant care, and cultivation for genuine upbringings (with minimal or no crucial, negative side-effects) are preconditions for high yields and for utilisation of full potential of the plant genetic resources. Alternative propagation technologies can have a further additional yield effect through use of hybrids, clones, plantlets (from micro-propagation), grafts, cuttings and others. The challenge has been effective take-up especially in poorer, remote areas with limited infrastructure. Deployment depends on effective agricultural extension services, the initial costs for initial investments, awareness on their superiority, availability, and de facto yields at particular sites under particular circumstances. In addition agri-business and private operators may encourage or discourage propagation technologies based on commercial criteria and priorities.
Animal breeding	Increased productivity of livestock is a compound of higher off-take rates (shorter production cycles by, for example, faster fattening), and higher carcass weight and milk or egg yields. Higher carcass weights will play a more important role in beef and mutton production, while higher off-take rates (shorter production cycles) will be more important in pig and poultry meat production. Intensified breeding such as artificial insemination and embryo transfer ensure planned emergence of offspring and improve herd genetics[26]. Bred animals may convert feed more effectively to meat, milk, or fiber. Apart from better yields, an enhancement of the product quality and taste may be achieved. As these traits are of high heritability they stand a large potential for easier achievable results. Some practices vastly increase the number of offspring which may be produced by a small selection of the best quality parent animals. On the other, the approach will decreases genetic diversity, increasing risks and severity of certain disease outbreaks and may be prone to attacks by insects or being hit by other calamities

[25] WRI 2014: Searchinger, T. *et al.* 2014. "Crop Breeding: Renewing the Global Commitment." Installment 7: Creating a Sustainable Food Future http://www.worldresourcesreport.org.
[26] https://www.britannica.com/science/animal-husbandry

3.3.6 Investments to sustain agricultural water

Growing water scarcity and misuse of freshwater pose serious threats to natural capital. By far the largest demand for the world's water comes from agriculture. More than two-thirds of the water withdrawn from the earth's rivers, lakes and aquifers is used for irrigation[Error! Bookmark not defined.]. As competition, conflicts, shortages, waste, overuse and degradation of water resources grows, policy-makers look increasingly to agriculture as the system's safety valve.

The water resources need protection at source but also at user end, where cheap water causes lack of incentive for many users and farmers to economize the use. The solutions are definitely not only technical, but require water policy, pricing and institutional and regulatory reforms.

It is imperative for most countries to invest in water conservation and improving water-use efficiency. For agriculture, investments towards improved irrigation systems including groundwater and wastewater re-use require comprehensive investments, planning, management, and monitoring (see Table 3.4).

Table 3.4. Strategies for agricultural water efficiency

Strategy	Description
Crop-water relations, yield and water productivity	Water is often the limiting factor for yields in agriculture, forestry, horticulture and even aquaculture. Thus, land-winnings in genetic breeding, machinery, farm-management, technology development, fertilizer efficiency, etc., cannot be capitalized on if water is or remains the limiting factor. However, an intelligent approach may recognize early that water deficiency and water limitations will set the decisive yield limits. Thus, investments developing varieties and provenances of less water demanding plants may be a way forward, e.g. highland rice varieties. This will normally compromise crop yields but the advantages are high for climate adaptation to droughts and other climate extremes. This can be sought through development of plant varieties with lower water consumption from highly efficient plants (e.g. C4 photosynthesis) or of low evapotranspiration and of high sun and wind exposure tolerance.
Surface water irrigation	In the past, domestic spending for irrigation dominated agricultural budgets in countries throughout the world. For instance, in China, Indonesia and Pakistan, irrigation has absorbed more than half of agricultural investments. In India, about 30 percent of all public investment has gone into irrigation. The above sections have expressed concerns with the diminishing water for existing agricultural areas. The irony is that irrigated agriculture is expected to produce much more in the future while using less water than it uses today. Various innovative practices can gain an economic advantage while also reducing environmental burdens (IWMI 2007). Over-watering is probably the most significant cause of water loss in any irrigation system. No matter how well the system is designed, if more water is applied than can be beneficially used by the crop, efficiency will suffer. Thus, proper irrigation scheduling is important if high efficiencies are to be achieved – see below. Proper timing of the day (and night) to avoid excessive evaporation losses and proper timing in the crops lifespan and tailored amounts for different areas “within the area” as to avoid water losses in spots where less is needed. ***Irrigation water management: irrigation scheduling*** IRRIGATION METHOD — FIELD APPLICATION EFFICIENCY Surface irrigation — 60% Sprinkler irrigation — 75% Drip irrigation — 90%

Strategy	Description
	FAO, 1989, http://www.fao.org/docrep/t7202e/t7202e00.htm#Contents High degree of crop uniformity is crucial for yields and water efficiency. Irrigation systems can be designed to apply water with varying degrees of uniformity. A number of techniques can be used in the design of a system to increase its uniformity. For pressurized systems, these techniques include using larger pipe sizes to minimize pressure differences due to friction losses, using pressure regulators to minimize pressure differences due to elevation differentials, using close sprinkler spacing, or trickle emitters with low manufacturing variations. All such techniques will increase the cost of the system, and in general, the cost of the irrigation system goes up with the uniformity of application. But since higher uniformities mean higher irrigation efficiencies, there are some savings associated with the higher uniformity systems, notably savings in water and energy costs. Monoculture exhibits higher uniformity than mixed cropping and is thus more water efficient.
Groundwater management in agriculture	There is a continuous and unsustainable 'global boom' in groundwater use for irrigation in areas subject to extended dry seasons and/or regular droughts. In **India**, the groundwater-irrigated area has increased 500% since 1960. Irrigated agriculture is now the largest abstractor and consumer of groundwater, with >40% of all cultivated land under irrigation being fed by groundwater in South & East Asia[27]. The nations with the largest groundwater-use areas are India (39 million ha) and China (19 million ha). A study by GWP (2015), based on Siebert *et al*. (2010) show an alarming depletion of groundwater resources in South Asia (by 57%) and East Asia (by 34%), due to agricultural irrigation. Unconstrained use is causing serious aquifer depletion and environmental degradation, and cropping practices also exert a major influence on groundwater recharge and quality[27]. As it appears, it is likely just a matter of time before these groundwater resources are emptied. However there are a range of investments to reduce the problem including technical solutions of groundwater recharge, often incentivized by policy and economic reforms such as water metering and water pricing.
Salinity management and use of saline water in agriculture	Salinity is a major concern from irrigation. Many crops have varying levels of tolerance to increases in salinity. Therefore the value and the context at risk must be considered. Managing salinity involves striking a balance between the volume of water entering (recharge) and leaving (discharge) the groundwater system. The water table can be lowered by planting, regenerating and maintaining native vegetation and good ground cover in recharge, transmission and discharge zones. Groundwater can be recharged by pumping water from bores and redirecting it to other storages. Investments installing bores and interceptor drains in discharge areas can allow for water being used to irrigate adjacent areas. Installing sub-surface drainage systems can maximise cropping opportunities[28]. A number of options for managing salt-affected catchments are available. A relative inexpensive, common option is to 'fence and forget'—fencing the area from stock and spelling it while natural or introduced salt-tolerant vegetation becomes established, after which time the area may be suitable for limited or controlled grazing[29].
Crop water-management in rain-fed areas	Rainwater harvesting is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. It provides for additional or alternative water supply. Many sophisticated methods and technologies are developed, particularly in India and Israel. In general some of the methods are quite investment heavy. On the other hand lifespan of these efforts is considerable. Apart from using roofs for catchment, new approaches include e.g. *RainSaucer* "umbrellas" used for sustainable gardening and small

[27] Global Water Partnership (GWP), 2012: Groundwater Resources and Irrigated Agriculture– making a beneficial relation more sustainable

[28] Government of Queensland 2014: Preventing and managing salinity www.qld.gov.au/environment/land/soil/salinity/

[29] https://publications.qld.gov.au/storage/f/2013-12-19T06%3A11%3A43.252Z/salinity-management-handbook-ch13.pdf

<table>
<tr><th>Strategy</th><th>Description</th></tr>
<tr><td></td><td>plot farming[Error! Bookmark not defined.]. Also dew harvesting for crop cultivation and tree planting a re widespread in drier areas, particular Sri Lanka and India.

Construction of detention basins is the most known and common method. Software can improve such infrastructure to double its efficiency of rainwater harvesting without compromising the existing detention capacity ensuring water availability for later reuse (example of a commercial tool: Optimized Real-Time Control[30]). Apart from increasing water quality released and decreasing the volume of water released during combined sewer overflow events.

Check dams are dams constructed across streams to enhance the percolation of surface water in to the sub soil strata. This can be enhanced plenty fold by loosening the sub soil artificially by explosives. Thus local aquifers can be recharged quickly by using the available surface water fully for using in the dry season.</td></tr>
<tr><td>Wastewater and low-quality water use in agriculture</td><td>Estimates on wastewater use worldwide indicate that about 20 million hectares of agricultural land is irrigated with (treated and untreated) wastewater[31]. The use of urban wastewater for agricultural irrigation is a growing practice in semi-arid and arid countries at all levels of development, and in low-income countries where urban agriculture provides livelihood opportunities and food security, irrigation is the most prominent and the most rapidly expanding use of wastewater. Use of wastewater for agriculture conserves and expands available water supplies. Yet, if not fully planned, managed, or properly implemented, it is associated with a number of risks, for human health, but also agricultural and environmental hazards[31]. Apart from the irrigation effect, there is further a fertilizer effect of high N, K, and P contents. Less desirable impact is from occurrence of heavy metals and aluminum in the waste-water which can have negative, cumulative effects on plants, animals and humans. A pragmatic solution is to divide use into categories to best prevent unwanted uptake and re-occurrence in the living cycles eventually exposing consumers and the ecosystem:

Four categories of restricted irrigation from wastewater with increasing sensitivity, from left to right
<table>
<tr><th>A1

Not directly consumed</th><th>A2

Processed before consumption</th><th>B

Indirectly consumed</th><th>C

Directly consumed or exposed: parks, sports grounds</th></tr>
<tr><td>Wood, rubber, cotton, sisal, sunflower coconut</td><td>cereals, sugar, coffee, tea, cocoa, etc</td><td>fruit trees, fodder crops and pastures</td><td>Raw eaten vegetables, tubers, mushrooms, fish</td></tr>
</table>
Source: based on IWMI (2002)[32]

The degree of wastewater treatment required for crop irrigation depends on the nature of crops, local conditions, and regulatory requirements. Wastewater treatment cost studies show that marginal costs are very high at higher levels of treatment. However, these higher costs may sometimes be justifiable in view of the value of the crop, degree of water scarcity, and public concern. Cost minimization should remain an overriding objective of wastewater treatment plants in the absence of any binding constraints, such as environmental quality standards[32]. Apart from the added yields due to water and fertilizer there is a big gain from avoidance of wastewater into the waterways and thus a significant,</td></tr>
</table>

[30] https://en.wikipedia.org/wiki/Rainwater_harvesting
[31] World Bank 2010: Improving Wastewater Use in Agriculture: An Emerging Priority
[32] IWMI 2002: Wastewater use in agriculture: review of impacts and methodological issues in valuing impacts

Strategy	Description
	positive effect as the wastewater is better controlled when utilized and managed merely than discharged or being re-segregated under huge costs. World Bank (2010)[31] lists the following environmental advantages while observing some potential disadvantages as well (see above): • avoidance of surface water pollution which causes oxygen lack, eutrophication, and fish kills, • conservation or more rational use of freshwater resources in arid and semi-arid areas • reduced requirements for artificial fertilizers, with a concomitant reduction in energy expenditure and industrial pollution elsewhere; • soil conservation through humus build-up and prevention of land erosion; • desertification control and desert reclamation, through irrigation and fertilization of tree belts

3.3.7 Tackling agricultural soil and land management

Soil and land management covers a range of investments including changing agricultural cropping practices, physical investments and the careful application of chemical fertilizer.

Table 3.5. Strategies for agricultural soil and land management

Strategy	Description
Cropping practices	There are a variety of technical interventions for changing agricultural cropping practices to improve soil and land management on croplands (FAO 2010a[33]): • Introduction of ***Cover crops*** lead to higher yields due to decreased on-farm erosion and nutrient leaching, and reduced grain losses due to pest attacks • ***Crop rotations*** *and* ***intercropping*** ensure differential nutrient uptake and use – e.g. between crops, such as millet and sorghum and Nitrogen-fixing crops, such as groundnuts, beans and cowpeas – will enhance soil fertility, reduce reliance on chemical fertilizers, and enrich nutrient supply to subsequent crops leading to increased crop yields. • Increased crop yields after a ***fallow*** period have been widely reported. However, the magnitude of yield increment after each successive fallow is variable, and bare fallow may increase soil erosion risk. • Adopting ***organic fertilization*** (compost and animal manure) is widely found to have positive effects on the yields. • **Increasing** the proportion of ***nutrients*** retained in the soil – e.g. through mulching and limiting nutrient leaching – has in general positive effects on crop yields • ***Tillage systems*** – which adopt no-tillage, minimum tillage and crop residue management – provide opportunities for increasing soil water retention. Therefore, crop yields are often higher than under conventional tillage, especially in semi-arid and dry sub-humid agro-ecosystems. In other cases soil treatment is a precondition for higher yields and to allow root access to more nutrients. • ***Agroforestry*** refers to land use practices in which woody perennials are deliberately integrated with agricultural crops, varying from very simple and sparse to very complex and dense systems. It embraces a wide range of practices.
Physical structures for soil management	Physical structures, like cross-slope barriers provide a mix of extensive and intensive methods. Well known is soil treatment against contour lines, cross-sloping live fences, and physical terracing. Despite being extremely effective for water and soil retention, terrace

[33] FAO 2010a. Sustainable crop production intensification through an ecosystem approach and an enabling Environment…. www.fao.org/docrep/meeting/018/K8079E01.pdf.

	construction on steep slopes is now reducing, especially on the steepest slopes. This is because of the labour intensive requirements and hence costs and, in some places, increasingly stringent legislation regarding cultivation of unstable steep slopes. Bench terraces are inappropriate for the very steep slopes above 25-30 degrees, where construction costs become prohibitive because the area of terrace bed gained is very little compared with the work involved in developing high and closely spaced risers and the risk of mass wasting through landslides increases. It is not only the cost of construction that can be a constraint in bench terraces, but the essential and regular maintenance of terraces is time-consuming and expensive as well.[34]. The scope for terracing construction investments therefore lies at 10-25 degrees land slopes.
Chemical fertilizer use and soil management	The use of chemical fertilizer to replace loss soil fertility in Asia Pacific brings up many challenges. The benefits of chemical fertilizers are increased yields, but this can come at a high cost in terms of impacts on soil and water natural capital. Global cereal production has doubled in just 40 years after the green revolution (1960) mainly due to increased yields resulting from greater inputs of fertilizer, water and pesticides, new crop strains, and other technologies[35] While use of fertilizers may not guarantee sustainability or prevent some soil degradation there are methods to minimise, mitigate, rehabilitate, or even avoid negative impacts. Excessive use of fertilizer may have polluting effects on groundwater and the change of soil micro-life may create a dependency requiring continuation once started. There is also a reverse effect from nitrogen fixing crops and trees when applying artificial fertilizer. That implies it is a long-term choice whether to accept fertilizers or promote agroforestry or insert N-fixing crops to support to the main crop. Many chemical fertilizers are composed of acids like sulphuric acid and hydrochloric acid and these acids decrease the soil quality and acidity. The natural nitrogen fixing bacteria, rhizobium suffers from excessive usage of chemical bacteria. Fertilizer can also be damaging to water bodies due to eutrophication which is an overgrowth of aquatic vegetation and degradation of water quality due to extra nitrogen accumulation The advantages of chemical fertilizer use is that as soils vary in fertility, few can sustain high crop yields indefinitely without application of nutrients. For economic yields required in today's agriculture, nutrients have to be added to the soil as mineral fertilizers and/or organic manures. The new high-yielding crop varieties which supply so much of the region's food only perform well when they are provided with an adequate and timely supply of plant nutrients, generally supplied by chemical fertilizers. Fertilizer application will invariably increase due to expansion of farming to less fertile areas as a result of competing demand for land use Over-application of chemical fertilizer is a common problem in more developed Asian countries, where chemical fertilizer is relatively cheap. The cost of fertilizers is only a small part of total agricultural production costs. Farmers want to ensure good yields, and apply so much fertilizer that much of it is wasted. The problem is particularly acute with horticultural crops, which are high-value and produced very intensively in most of Asia. In tropical and sub-tropical climates, provided there is enough soil moisture, vegetable fields may bear as many as *ten successive crops a year*, all of which may receive heavy applications of fertilizer[Error! Bookmark not defined.]. Some countries in Asia are already close to the point where additional fertilizer brings no additional yield, or may even be past it. Japan, Korea and Taiwan are all estimated to be applying what is termed the theoretical maximum (theomax). In other countries, however, actual fertilizer application rates are low, and well below those recommended. Most countries with low fertilizer application rates import most or all of their fertilizer requirements. Indeed there are countries in Asia Pacific that have a problem of fertilizer shortages. The cost of fertilizer in such countries is generally high compared to the prices received by the farmer. Poor timing and poor application technology make this limited use of chemical fertilizer even less effective. A study of the nutrient balances for rice and

[34] ADB 2016: Sustainable Land Management in Asia: Introducing the Landscape Approach (unpublished)
[35] Nature 2002 Issue 418, pp. 671-677 www.nature.com/nature/journal/v418/n6898/full/nature01014.html

other major crops in selected Asian countries found a negative balance for major nutrients (N, P, K) in several countries, including Indonesia, Myanmar and Viet Nam. In Bangladesh and the Philippines, there was a positive balance for nitrogen but a negative one for other nutrients, while Thailand had a negative potassium balance. Negative balances, as with low overall fertilizer application rates, tended to be found in lower income countries with large and growing populations. A negative balance has serious implications of a long-term loss of productivity. Countries which are exporting rice and other crops without replacing the plant nutrients they contain are in effect exporting their soil fertility.

3.3.8 Investments in grasslands and pasturelands

Grassland and pasturelands are significant ecosystems in Central Asia, Mongolia and parts of PRC. Improved pasture management requires a combination of technical, policy and institutions aspects:

- At a technical level, improving vegetation structure (e.g. seeding fodder grasses or legumes with higher productivity and deeper roots) can lead to higher livestock yields due to greater availability of better quality forage with potential increased returns per unit of livestock. This can be complemented by infrastructural improvement – e.g. veterinary posts, livestock treatment stations (e.g. cattle dips[36], castration, and insemination structures), water detention dams, drinking posts, access roads, surveillance (towers, drones, cameras) and proximate slaughterhouses. However some infrastructure is counter-productive: settlements and fences, whether legal or illegal, tend to prevent herders, pastoralists, and livestock to access the most appropriate places at the right time of the year.
- Policy and institutional reforms include promoting effective collective decision-making as was done recently in **Kyrgystan** and has continued in **Mongolia**. This requires strong political support as pastoralists with the exception of Mongolia are minorities and so are fragmented and not collectively present to defend their land. Policy measures alone require significant follow up. The ADB has a number of projects which include pasture management as illustrated by the Mongolian project in Box 3.2.

3.3.9 Agrobiodiversity as natural capital

Agrobiodiversity can be protected by agricultural, horticultural, and forestry universities and research stations safeguarding these genetic varieties and provenances through in-situ, ex-situ, and circa situ conservations programmes establishing living museums or resource base (like breeding populations). However, it is costly, resource and land-demanding, populations may perish, and in most cases they may never be well needed. However, if a single strain face field difficulties it may quickly come to a verge of extinction or exclusion from being cultivated or bred, or raised (animal) any further. Then, the existence broader breeding or wild populations are invaluable. Establishment of gene banks[37] for long term storage for species conservations are another useful measure, but shows limitations to mainly

[36] Tank or trough with insecticide water to dip animals for killing or prevent livestock parasites
[37] Gene banks are collections of specimens and genetic material. Some banks reintroduce species to the ecosystem (e.g., via tree nurseries)

"orthodox species" while these which are "recalcitrant" may only be possible to conserve alive.

Box 3.2 Grassland management in Kyrgyzstan and Mongolia

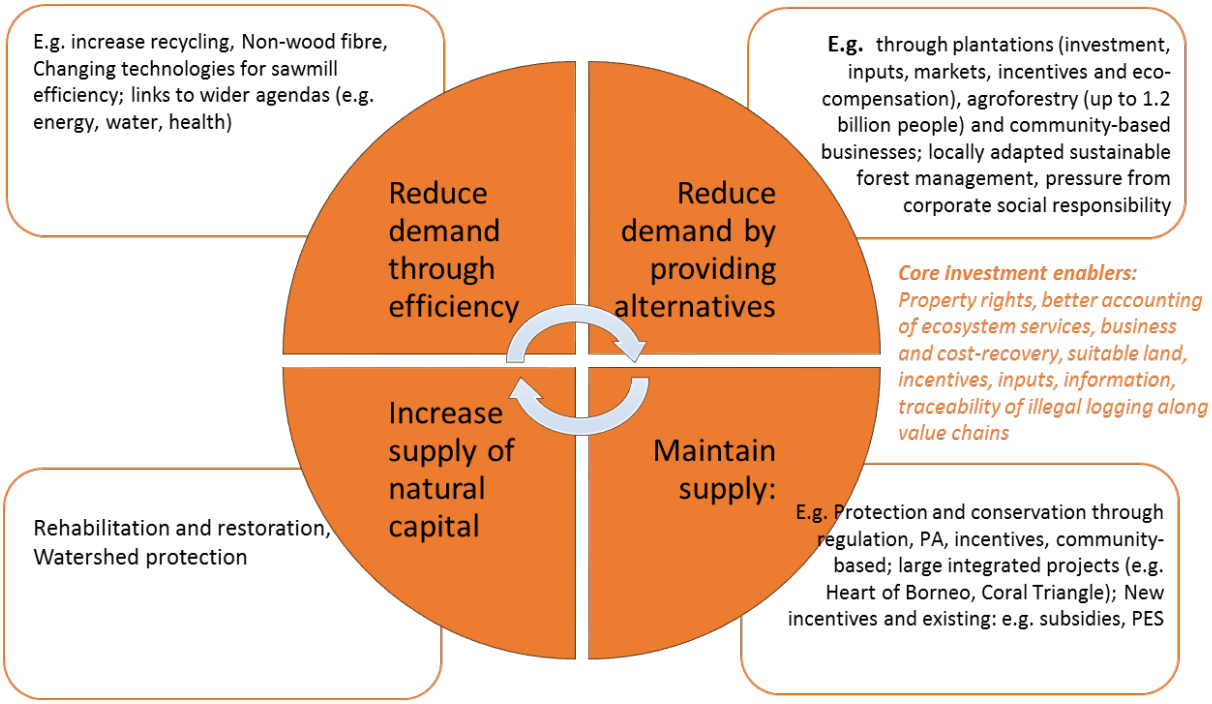
The upland grasslands and meadows are one of the most important natural resources in Kyrgyzstan, covering up to 85 % of agricultural areas. Most of the crop and livestock farmers there are faced with degradation due to overgrazing. To increase proper management on pasture land, regulations to avoid overgrazing were enforced by the government. Kyrgyz people gradually cease to be nomadic, yet their livestock continue to roam. The collapse of the Soviet Union in 1990 changed the situation radically. Independent Kyrgyzstan embarked on a major agrarian reform. Land, livestock, equipment and machinery that had belonged to Soviet collective farms and state farms were distributed among rural people. But new public, private and foreign investment in the agricultural sector did not come close to matching the injections of government funds during the Soviet years. Unused and unmaintained, roads, bridges and water pumps broke down and became unusable. Pastures close to towns and villages deteriorated due to overgrazing. In 2009, all pasture lands became categorised as a national treasure disallowing private ownership. Management authority for pastures were transferred to community organizations of herders. Pasture committees received basic training, with support from donor organizations, but with limited results.

Herding has been almost the sole land use of Mongolia for millennia and its pastures, although hard grazed, are still in reasonably good condition. Extensive, mobile grazing systems are therefore sustainable and will continue to be one of the main economic activity of the country. During the collective period, Mongolia maintained a modified system of mobile grazing, using hardy local breeds of livestock and without external sources of feed; its pastures have remained in good order in contrast to most of the neighbouring countries (Kyrgyzstan, Buryatya, parts of Northern China) that collectivized their livestock industry. Legal problems associated with grazing rights have been resolved, coupled with the organization of the herding population. Successes are due to removal of constraints requiring administrative decisions or actions like definition and granting of grazing rights, emphasizing winter camps and hay lands in the first instance and structure for the organization of the herding population.

3.4 Investing in sustainable forests and terrestrial protected areas

Investments in the forest sector can be approached in different ways, from specific forest management interventions at primary production points to interventions along the forest products supply chain and forest ecosystem services. The type of management also depends on the forest type (primary or old-growth, modified, semi-natural, and plantations - indigenous or exotic); or if it refers to agroforestry systems (traditional shifting cultivation and home gardens, mixed systems, alley cropping). Figure 3.3 presents a summary of the type of investments discussed in this section.

Figure 3.3 What investments in sustainable forests?



A natural capital approach to forestry implies managing it as an asset that generates benefits beyond the private investor and towards society (see previous section). This means involving traditional industries (industrial round wood for logs and pulp, paper, and fuelwood) in primary and secondary processing, community forest managers, tourism, energy, water, carbon trading and conservation groups. It will also require new institutions and instruments to improve benefit and cost sharing, ranging from right allocation to market-based incentives like price premiums and payments for ecosystem services.

The demand for wood product amounts to 3.4 billion m3 every year. According to the Living Forest Report[38], the amount of wood extracted from forests is expected to triple by 2050,

38 http://wwf.panda.org/about_our_earth/deforestation/forest_publications_news_and_reports/living_forests_report/

even after introduction of efficiency along production and consumption (WWF 2012). Any sustainable production model must reconcile the pressures from supply and demand, and involve the markets in the efforts to protect vulnerable forests from illegal logging, encroaching and conversion.

Table 3.6 presents a summary of potential options for investments in improved forest management from a natural capital perspective, considering both the private and public sectors. In this section we explore with more detail some of these strategies.

Forest type	Investment type	
	Private[1]	Public [2]
Primary (natural) forests	Improve efficiencies in management, Ecotourism development, private nature reserves, payments to landowners for watershed services	Creation of new protected areas; improve enforcement and management of protected areas, payments for forest conservation (PES), purchase of logging concessions
Natural modified forests	Reduced impact logging and other forest management improvements; Certification to sustainable forest management standards; Improve efficiencies in management,	Incentives for improved forest management; Support establishment of certification systems; control illegal logging;
Planted forests	Reforestation and afforestation for production; improve management and efficiency of planted forests	Incentives for reforestation/afforestation and to improve management; reforestation to protect ecological functions
Agroforestry (AF)	Extend the area with AF systems; improve management of AF systems	Incentives to landholders, incentives to improve management, technical assistance

Table 3.6 Investment options for various forest types
Notes. [1] Includes investments made by communities; [2] some of this also applies to private sector, often at a more limited scale than public programmes. Source: Grieg-gran and Bass (2011)

3.4.1 Crosscutting investment

A crucial point that will determine the commercial viability of any forest regime refers back to the institutions that affect their governance. Two key points need to be taken:

- **A need to deal with property rights.** Whether the investor is private, governmental, or community enterprise, a lack of an active and transparent land market for land use rights or land rental is an additional constraint to viable businesses. Forests are

often government property or the property of the investor (although in some parts of the Pacific and elsewhere forests are collectively owned). Legislative provision may be made to transfer government owned natural or plantation forest to land users. However, lack of specific policy and guidelines for the allocation of forest to business entities or households has stifled investment in, and potential benefit sharing from, both forest plantations and natural forest designated for production purposes. This includes clear concession rights, community and indigenous rights and tenure, open access resources. The wider ecosystem service approach now means new understanding with respect to ecosystem service rights: i.e. in terms of carbon offsets, or water regulation benefits. In many places there is significant overlap and contradictions between the creation of forest concessions on customary lands, the creation of protected areas, sharing revenues from commercial logging, and establishment of agro-industries and oil compensations.

- **A need to deal with illegal logging and improving traceability along supply chains**. Although this is a big problem across the world evidence shows that it can be tackled. New research shows that illegal logging has fallen in some countries, like Cameroon, Brazil and Indonesia. The strategies used include new trade regulations and initiatives (e.g. Forest Law Enforcement, Governance and Trade -FLEGT); and adding traceability along supply chains –including how agriculture commodities like palm oil, soy and beef affect forests. For example the Global Forest and Trade Network (GFTN) promotes the engagement of conservation groups like WWF with companies that are committed to sourcing their wood and paper products from responsibly -managed forests.

3.4.2 Improving efficiencies in industrial wood processes along value chains

Technology, changing patterns in consumer demand and stricter regulations can foster efficiencies in the wood industry. Some of these improvements include (WWF, 2012):

- **Increased recycling**, using material other than virgin wood fibre for the production of swan wood, panels and papers. The main sources are recovered paper, non-wood products and collection of waste wood products (demolition waste, used furniture, etc). For the paper industry for example, 53% of fibre came from paper recovery (China imported 50% of its recovered paper) and 47% from virgin sources including non-wood sources (bamboo, agricultural residuals, etc – used extensively in India. South Korea reached a 90% recovered rate in 2009.
- **Changing technologies** that improve efficiency, maximising the production per m3 of wood, including engineered wood products made from fast-growing and less expensive species, and the use of by-products from production processes in composites and pulp.
- **Increased sawmills efficiency**, which at the moment operate at 50% efficiency on average. This can take place by using waste (sawdust and off-cuts) in further processing, use of better logging and log grading systems, infrastructure and sawing technology.
- **Increased efficiency in pulp and paper mills**, with new processing technologies that allow the extraction of more cellulose fibres from a given volume of wood, attention

to mineral additives in paper and re-engineered packaging that is thinner, lighter and stronger.

- **Use of non-wood fibre,** such as other plant-based materials for example bamboo fibre and furniture made from rattan. The relative environmental impacts of these plant fibres will be affected by the management systems by which they are grown, sourced and processed.
- **Increased links to wider agendas, like energy or water security.** In **Mongolia**[39] for example the government estimates that nationwide around 16 million cubic meter dead wood (slashed and salvaged timber) need to be sustainably cleared out of the forest to reduce fuel loads. Dead wood poses a challenge for forest management and forest fires have a high climate change impact. Dead wood, on the other side, can be used as source for livelihood by communities, such as raw material for production of wood furniture, or as an alternative fuel to decrease the use of coal.

3.4.3 Sustainable forest management and timber extraction

Sustainable Forest Management (SFM) promotes the management of forests according to the principles of sustainable development, keeping a balance between ecological, economic and socio-cultural principles. In the practice, SFM is more the exception than the rule. ITTO's member countries in 2005 only had 7 per cent of their production forests sustainably managed (25 million), only 27% of the 353 million hectares of production forests had management plans, and only 3% were certified.

The trend however is changing, as better guidance is developed that allows the wood industry to supply more wood products with less impact on forests. New information emerges, designed to specific areas (e.g. temperate, tropical) on the elements of good management practice – for example designed to reduce the adverse environmental impacts associated with tree felling, yarding and hauling, as well as how to improve profitability and sustainability in the forestry sector (Breukink et al. 2015)

There is detailed guidance on the economic, social/cultural, economic and environmental dimensions of Reduced Impact Logging and Sustainable Forest Management as well as specific regional criteria (for example that applies to the International Tropical Timber Organization (ITTO) members).

Certification schemes -such as the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC) - are used to provide an indication of best practice, opening niche markets and the potential to obtain price premiums. The integration of new harvesting technology, new models for planation forestry, extension of best-practice models, and technology advances (such as new pulping methods and engineered wood) can be used as catalysts for engaging the forest industry.

According to the Living Forest WWF report, it is not clear whether it is better to log natural forest more intensively in smaller area, or do light logging across larger areas. Local laws and

[39] This is an ADB project in Mongolia: Sustainable Forest Management to Improve Livelihood of Local Communities. http://www.adb.org/projects/48061-002/main#project-pds

restrictions, and a robust land planning will in many cases dictate what is possible to do in the practice, and what affects the commercial viability of natural forests, as well as what happens to these areas once they have been logged.

For example, serious commitments to ecologically restore heavily logged forests, and to respect the creation of "set-aside" areas that help maintain the long-term productivity of the forests for other ecosystem functions. In **Borneo** and **India** for example WWF is working with communities to return degraded forests to a more natural stage, which is resulting in improved water quality, soil stabilisation and access to NTFP that had been lost by the degradation of the forest. Other strategies also involve the use of payments for ecosystem services (PES and/or REDD+) and active approaches promote markets for lesser-known timber species. This can help increase the economic attractiveness of sustainable forest management. On the other hand, it may make illegal logging more attractive in areas where governance is weak –for example with unclear property rights.

3.4.4 Improving supply of primary forestry: investing in better forestry plantations

Plantations will be required to meet the increased demand for wood, and reduce pressure on natural forests. Investments in industrial-scale planted forests have grown in recent years and are included into investment portfolios for various reasons (e.g. diversification, risk mitigation, attractive returns), which increases the interest from investors interested in assessing not only the outcome, but also sustainability and responsibility of the investment (Brotto et al. 2016). Planted forests can take different forms, ranging from productive/high-yield plantations to reforestation that also promoted ecological restoration of ecosystems (for example the Eco-compensation programme in PRC, or Greening the Nation programme in the Philippines – see section 5).

Rate of returns will vary accordingly. The scope for viable production forestry is determined firstly by product need and market opportunity. Given high transport costs of wood products, proximity to markets is an important factor determining viability. Other considerations are availability of land, soil fertility, capital available for investing, technical and market knowledge, and access to suitable planting material –i.e. seedlings of good quality.

New technologies and innovations such as drones and geo-mapping techniques advance the viability of forestry operations, and a combination of ecotourism and community-based enterprises adds value to forests located in remote areas. At the same time, large-scale forest operators, like paper manufacturers, are increasingly pressured to develop more sustainable value chains, for example through the recently announced Natural Capital Protocol, a voluntary framework that helps business operations understand their linkages to their natural capital (Natural Capital Coalition 2016)

While market opportunities for forest products are increasing through government and private investment in the wood processing sector (e.g. in Indochina), limited access to suitable land is a constraint to potential investors in forest plantations. Land allocated for potential forestry investment is frequently "bare" land which is often severely degraded and

subject to other uses. Further, severely marginalised lands may prove too harsh, risky, or even impossible for cultivation, afforestation or reforestation.

In **Viet Nam**, only slow utilization of marginal/degraded land takes place upon allocation to forestry. This is partly due to the limited access to investment capital by users (households and state enterprises) as well as lack of relevant technical knowledge and management skills. Poor households may also have short term food security needs that take priority over long term intensive investments like quality products agriculture, agroforestry, and forestry. Other factors such as limited market access, lack of feeder roads, often constitutes local constraint to invest in heavy, bulky products.

Viability of commercial plantations will be affected by access to markets, both to obtain the inputs (seedlings, access to credits, use of appropriate repayment in line with timber growth) and to sell forest products.

3.4.5 Improving assisted supply of forestry: promoting agroforestry for smallholders and communities

Agroforestry is a very important activity for smallholder and indigenous communities. According to Grieg-gran and Bass (2011) global estimates range from 500 million to 1.2 billion people. Agroforestry systems include traditional shifting cultivation and home gardens, mixed systems of different tree strata (e.g. fruit trees, banana/papaya/lemon, and spices), contour hedgerows (e.g. as used in Eastern Visayas in the Philippines), fertilizer tree fallows and rotational woodlots (used widely in Africa).

The woody perennial plants applied in agroforestry interact with the soils and crops to create an agro-ecological system that enhance and enable the ecosystem to increase overall crop productivity. Especially home gardens are one of the agroforestry practises widespread in SE-Asia and the Pacific.

The costs and rates of return of AF systems will depend on the location, species and management types. Most of the results show positive benefits in the medium to longer term, once the trees are established. Grieg-gran and Bass provide examples from Sumatra, where households with diversified AF systems depend less on gathering products from protected areas than farmers cultivating wetland rice, and in the US trees planted as wind breaks increase crop yields significantly. However, there are high initial investment costs in the early years (seedlings, technical knowhow and support, and the space lost to agricultural production). This constitutes a major obstacle to adoption, and financing strategies to incentivise agroforestry systems need to be researched, such as payments for ecosystem services –e.g. linked to watershed services and/or carbon markets, as well as the provision of technical support and access to markets.

3.4.6 Increasing 'natural' forestry supply: investing in protected areas

Protected areas are important set-aside areas that can provide multiple benefits (see Section 2). But the main challenge is in financing. The investment required to establish and care for protected can be large, and include the cost of the land (or legal fees needed to expropriate), administrative costs of demarcating, management and enforcement. There will also be major social and economic opportunity costs from removing large tracts of land

from agricultural and other uses, and there may be other costs such as human wildlife damage on local people. Protected areas in private property (i.e. enforced set-aside areas) have an opportunity cost in terms of forgone timber income for the landowner, and timber royalties for the government. As discussed in Section 2, many of these PA do not have adequate funding to ensure their appropriate management.

Many protected areas are seeking to diversify the stream of revenues they receive. In some cases ecotourism may be a possibility, or agreements with downstream water users (e.g. hydroelectricity projects) in exchange for watershed protection services. Studies elsewhere of the benefits of protecting for biodiversity and recreational tourism show for example that the costs to local communities is exceeded by the global and national benefits from tourism. In theory, a compensation strategy could be designed to share in these benefits with the communities. In practice this rarely happens. This however may not be an option for many of the remote protected areas in Asia. However the growing access of protected area to transport links and tourism may provide new revenues, but this needs careful management to ensure this is done sustainably. Meanwhile the core budget for these protected areas will remain in the hands of the government.

3.5 Investments in watersheds and freshwater

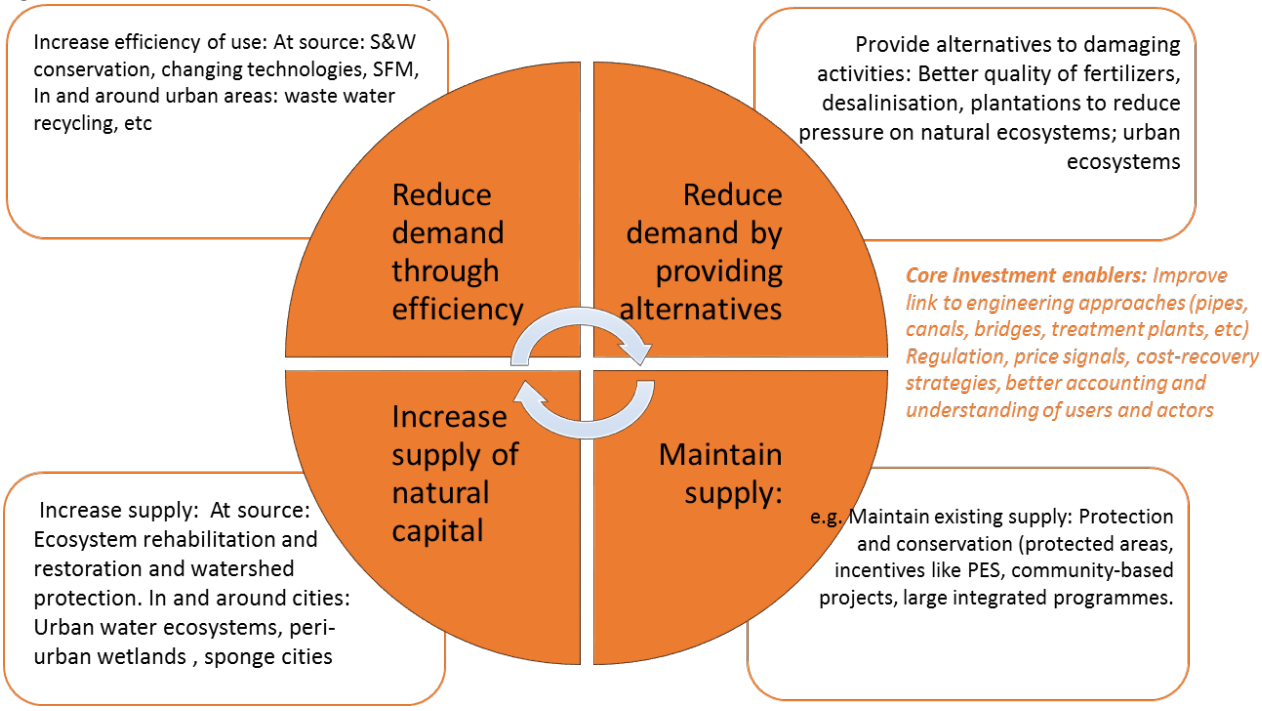
Natural capital activities use the natural functions of ecosystems to complement – or even replace, in some cases - infrastructure investments. The type of investments focus on activities that affect water quality, quantity and regulation from ecosystems at the source (e.g. supply at catchment level), to reduce demand (working with multiple users) and to treat water flows back again to the ecosystems after use (waste efficiency). These investments in ecosystem management should be designed and implemented in combination with existing and planned infrastructure (e.g. pipes, canals, dams), regulation, price signals and engagement with multiple actors across basins (e.g. Mekong River Commission addressing transboundary water).

Some examples of investments in ecosystems for supply and demand include:

- Investments that affect supply of water: directing resources to maintaining the existing supply of natural ecosystems (protected areas, incentives for private and community land management, integrated water management programmes), and also rehabilitate and restore important ecosystems.
- Investments that affect demand of water: increasing efficiency of water use through soil and water conservation, changing technologies, etc, and providing alternatives to damaging activities (e.g. better quality of fertilizers for agriculture, salinization, etc).

Agricultural water management is a priority investment: for example higher-value crops, surface-water irrigation efficiency and groundwater management, as well as soil conservation (see previous section on Agricultural investments). As cities grow they become important players in water management. Investments in urban wetlands, parks, gardens and green spaces can significantly reduce peak flows and allow drainage systems to cope better during storms. These ‘sponge city’ approach has been adopted in China, and shows considerable scope for using natural capital to improve urban hydrology management. Sometimes, prevention is better than introducing costly remedies, and investments should also go to secure and expand protected areas across Asia.

Figure 3.4 What investments in water ecosystems?



Key actors: Government, regulators, Agriculture (rain-fed, irrigation; Industry (washing, diluting, cooling etc); Households; Industry/energy; Others: (emergency management (floods), health, environment protection agencies), protected areas and/or landowners (for ecosystem management), farmer groups,

3.5.1 Investments at the source: watershed management

There are many watershed management projects implemented in South and South East Asia. Yet a lot of them are project-based with little continuity in the long-term or over larger tracks. An integrated watershed management approach (IWM) seeks to re-address these issues, involving a wider governance systems to secure the long-term the benefits from watershed management.

There is a trend in the region to unify watershed programmes to achieve scale. In **India** for example the Department of Land Resources amalgamated three separate watershed programmes (Integrated Wastelands Development Programme, Drought Prone Areas Programme, and Desert Development Programme) into a large Integrated Watershed Management Programme which operates as a cluster since 2009-2010.

In a nutshell, Integrated Watershed Management (IWM) is the process of managing human activities and natural resources in a watershed. A watershed as a reference unit allows to incorporate upstream/downstream linkages, both biophysical and economic.

By affecting the composition of the biota and the way it is managed upstream, it is possible to improve downstream water services, such as river flows, groundwater recharge, and reductions in soil sediments deposited in reservoirs, riverbed and canals downstream. The economic costs and benefits will vary depending on who is affected, as well as the geographic extent. Advances in economic valuation help to measure these values and understand their distribution, and are important to support negotiation of the necessary institutional arrangements.

The type and impact of activities depends on the level of watershed taken as management planning unit. A micro watershed focuses in relatively small areas along specific rivers, and it is an appropriate unit to address specific local issues. It can struggle however to achieve scale, and may require large investments to develop specific institutional arrangements. A macro-watershed comprises the watersheds of several tributaries of a main river. The impacts can be larger, but it can be more challenging as it involves multiple administrative units for the preparation of management plans across the region. District and sub-district coordination is necessary in the planning and implementation of activities.

Many watersheds in Asia are transboundary, requiring the coordination of multiple governments. In Lao PDR for example (see Table 3.7) there are several type of watersheds identified, involving different administrative levels. Activities need to be design in terms of manageable watershed planning units, which promote and support activities carried out by local communities, institutions and villages (VDCs).

Level	Indicative area	Administrative area	Key agencies
Mekong River	International	Transboundary	Governments of Mekong riparian countries, Mekong River Commission
	National	Whole country	Government of Lao PDR Water Resources; Coordinating Committee Lao National; Mekong Committee Ministry of Agriculture and Forestry
River basin to large watershed	More than 1600 km2	Province	Provincial governments; Provincial agriculture and forest services (PAFS)
Watershed	100 to 1600 km2	District	District governments; District agricultural and forestry offices (DAFO)
Micro-watershed	Less than 100 km2	Village	Village development committees (VDCs)

Table 3.7 Watershed levels in Lao PDR
Source: Pravongviengkham *et al.,* (2003)

3.5.2 Coordination across multiple actors

Watershed management is moving beyond implementing specific activities and looking more into managing resources that benefit local people and provide downstream benefits. Top-down approaches promoted by governments can achieve larger scales but often struggle to reach farmers effectively.

Participatory (and bottom-up) approaches in watershed programmes in Asia can help increase the likelihood of success, especially when involving local communities. The participatory approach adopted In Nepal has contributed to strengthening of local level

institutions, and indirectly to multiplier effects across the communities for example in terms of improved livelihoods, women empowerment and social mobilization (Tiwari et al. 2008).

The Asian region in general has been undergoing different decentralisation processes across the region, which can foster devolution to improve local management of resources in rural areas and cities (Miller and Bunnell 2016). In practice, however, decentralisation has taken different shapes, from those that keep resources under the control of local government bureaucracies to those that actively engage and empower local groups and not just the elites.

But IWM can be an onerous process: detailed watershed plans for large watersheds involving multiple stakeholders are more likely to be justified when accompanying large infrastructure investments (existing or new). These plans must be also be realistic and in line with resources and technical capacity available.

Poor planning and coordination can result in failure – for example a lack of control over water extractions will most likely negate the added benefits from S&W conservation, damaging the reputation of watershed management. A recent water crisis in India, for example, has been blamed on the State's poor management of their watershed programmes (Prabhu May 7, 2016).

Box 3.3 shows an example of an ADB-supported integrated watershed management project in Cambodia.

Box 3.3 ADB and integrated watershed management in Cambodia
Source: ADB Case study: Case Study: GMS-FBP Collaborative Management for Watershed and Ecosystem Service Protection and Rehabilitation in the Cardamom Mountains, Upper Prek Thnot River

ADB is supporting an effort to address severe problems with land and environmental degradation in Cambodia, which are causing high levels of water and food insecurity. The project is focuses on the Prek Thnot watershed, whose main river spans over 280 km with a drainage area of 5050 km2. Continuous deforestation and land degradation have affected soil and water quality. With a mix of integrated management of landscape mosaics and mixed agricultural and forest ecosystems, the project seeks to restore and maintain forest cover and restore the watershed stability functions. The $13.3 million project activities span over 36 months and have been partly financed by national government and a mix of ADB/GEF partnership.

Components	Expected Outputs
Improved on-farm soil and water management practices in middle to upper watershed areas	1. Good practice Sustainable Land and Water Management interventions piloted with 2,720 households in agricultural production areas. 2. Pilot demonstration of site-stable agroforestry in three Upper Basin districts. 3. Conservation and sustainable integrated watershed and farming models and guidelines applied to 25,000 economic land concession hectares.
Integrated agroforest and forest ecosystem restoration on Prek Thnot watershed prioritized steep slope areas	4. Pilot demonstration of improved forest canopy and vegetative cover in three districts on steep sloping public lands. 5. 1,000 ha. of forestland under assisted natural regeneration
Improved stakeholder capacities for watershed management and monitoring	6. Collaborative watershed management authority established for Kampong Speu Province 7. Mechanisms established for increased stakeholder participation in watershed rehabilitation and management (e.g. involving local stakeholder groups including community watershed committees, farmer groups, businesses) 8. Guidelines, training and tools for assessing landscape level ecosystem stablility, resilience and maintenance of regulating services developed. 9. Draft Landuse Law and other regulatory instruments supporting SLM and UNCCD implementation submitted for approval to CAM Govt. and linked to output 3. 10. Development of improved methods for multi-scale assessment and monitoring of land degradation trends, and for impact monitoring of GEF investment in SLM.

3.5.3 Integrated water resources management (IWRM)

Integrated water resources management (IWRM) is a practical approach that takes a watershed approach to basins of large rivers and national and international level. It looks beyond sectoral water extractions and pricing, and more into the linked management of land, water and other resources –such as forests and fisheries that affect the economic uses of water. This is of particular importance to some areas like Central Asia, that depend heavily on irrigation and hydropower, and competition over resources is leading to increasing conflict of water (GWP 2014)

IWRM then focuses on three objectives, achieved through various instruments and processes (UNEP 2010): 1) promoting efficiency in water use, 2) equity in allocation of water across social and economic groups, and 3) addressing environmental sustainability protecting the base of water resources and associated ecosystems. Useful experiences emerge from countries where the concept is applied, for example designing IWRM roadmaps integrated to existing national agendas. Lessons show that local ownership is key for the design of successful strategies and the definition of rights to water, as well as improve local logistics and implementation. Sharing of information is even more important for transboundary activities and programmes.

The scale of water insecurity across the world demands responses that address competing demands from sectors (agriculture, industry, domestic, energy) with the risks of unpredictable and endangered supply.

3.5.4 Improving management efficiencies

These issues have already been addressed in the section on agricultural water, but here we look more broadly at freshwater resources from a demand and supply point of view. In terms of demand for fresh water to improve water use efficiency:

a) **Sustainable cost-recovery**, which includes better pricing systems revising taxes, tariffs and transfers for water supply and sanitation (the "3Ts" for strategic financial planning). This includes having the scope to revise and improve the cost-effectiveness of expenditures on water and the financial arrangements necessary for efficient system performance. For example, the introduction of sustainable cost-recovery targets i.e. for operation and maintenance (O&M) and investments in urban water supply, or cost-recovery for rural water supply through a combination of financial sources that include user charges, public budgets and ODA.
b) **Improving the understanding on who wins and who loses.** For example, strategies that improve local ecosystems will have direct positive benefits on poorer populations depending directly on unpiped water for drinking, subsistence agriculture and their livestock. Uncontrolled water extractions and increased point and non-point pollution leave these groups at risk (Peña 2011).
c) **Raising public and institutional awareness** and changing attitudes to water, including better information about the water plans. Newer accounting tools such as the SEEA Water Accounts promoted by the United Nations are increasing our knowledge of how water feeds into the economy, adding value to the various sectors

of the economy and generating wealth across the country (see for example water accounts in Southern Palawan in the Philippines[40]).

In terms of improving supply for freshwater including for ecosystem purposes:

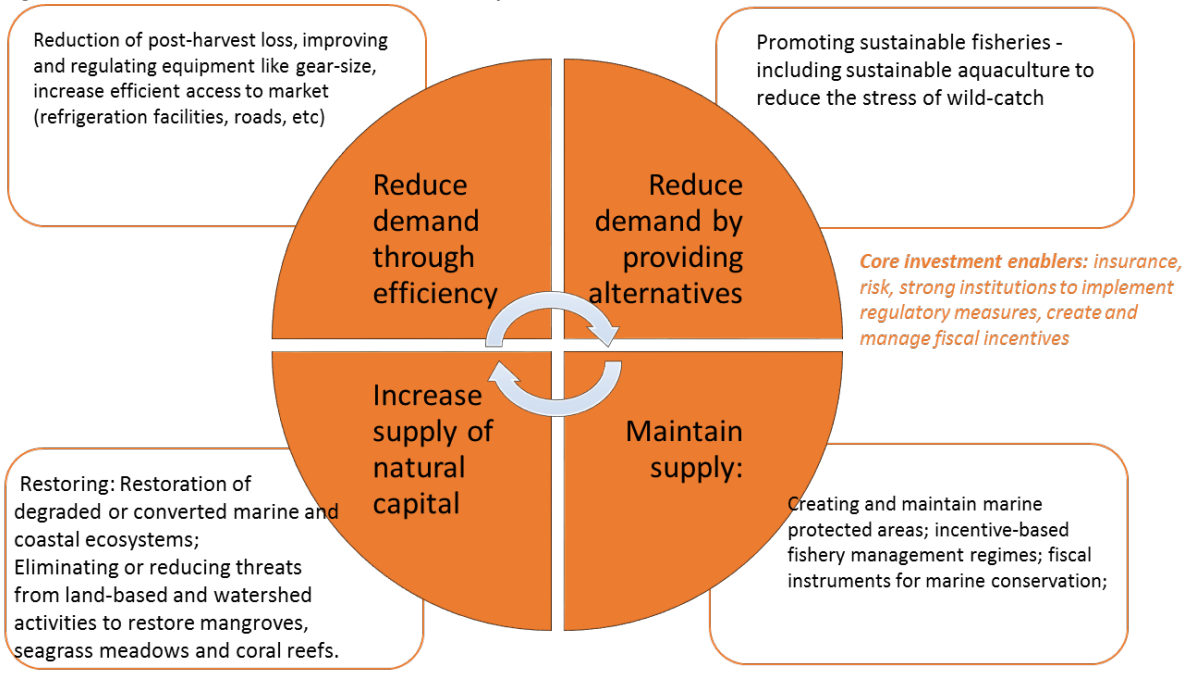
d) **Modern/upgraded infrastructure**, for example the more traditional approaches of updating pipes and building dams and irrigation canals.
e) **Updated water application methods**. For example irrigation systems for crops that take better care of flooding, seepage and evaporation. This includes technologies that take into account the type of crops –including changing to other economically viable alternative crops, the soil-reclamation conditions and the type of minerals/fertilizers necessary. Better irrigation methods can also reduce the amount of water extracted from rivers and allow more ecological flows to other ecosystems- including the sea. An example of this is the IWRM "bottom-up" approach in the Fergana valley in Central Asia (GWP 2014)

[40] This is an example of ecosystem accounts prepared for Southern Palawan in The Philippines, following the SEEA framework: https://www.wavespartnership.org/sites/waves/files/kc/WAVES%20Snapshot%20Southern%20Palawan.pdf

3.6 Investments in coastal and marine natural capital including fisheries

Resilient marine and coastal ecosystems can be achieved by several major investments. These include tackling demand and supply through introducing efficiencies, promotion of more sustainable harvest methods, protection and maintenance of marine protected areas and a stronger focus on land-water interactions.

Figure 3.5 What investments in marine natural capital?



3.6.1 Managing coastal ecosystems

Across the Asia Pacific region there is considerable scope and need for investment in coastal and marine natural capital. As discussed before marine and coastal systems provide a range of important and vital ecosystem services including coastal protection, fish production, biodiversity conservation, recreation and other economic and cultural values (MEA 2005). The ability of coastal marine systems to continue to provide these services are also being degraded and compromised by a range of human induced pressures, such as, marine pollution, habitat loss resulting from urbanisation and the expansion of mariculture, as well as the long-term effects of ocean acidification and sea level as a result of increasing anthropogenic greenhouse gases and climate change.

In general, there are three main priorities for the investment in marine and coastal natural capital across the Asia Pacific. These include investment in natural systems for coastal protection, investment in natural capital for the maintenance of ecological processes, particularly how this influences marine fish stocks and food security and investment in natural capital for the protection and conservation of biodiversity. These three priority areas are not mutually exclusive and ideally investment should be able to achieve multiple benefits if not all three of these priorities.

To achieve these priorities, investment in natural capital in marine and coastal ecosystems should be targeted at three strategies. Firstly, investment in terrestrial based natural capital such as green infrastructure in urban areas to improve water quality and reduce land-based pollution and stressors of coastal ecosystems. Secondly, prioritising the protection of existing natural areas that provide ecosystem services and natural coastal defences. Finally, targeted restoration or enhancement of existing degraded coastal marine ecosystems with a priority for those areas that provide coastal protection for high-value assets such as urban areas and improvement in ecosystem services.

Box 3.4 outlines how ADB is supporting the six-country Coral Triangle Initiative, protecting an area which is the richest centre of marine life and coral reef diversity on the planet.

3.6.2 Marine protected areas

Marine protected areas are urgently needed to sustain fisheries and protect coastal ecosystems. Currently Asia Pacific has 7.9% of territorial waters protected, compared with 9.2% globally and 7.2% for Africa. The Pacific sub region has 12.7% of its waters protected, South and South-West Asia only 2.2% of their marine areas, South-East Asia and East and North-East Asia subregion stand respectively at 4.8 and 3.4% (UNESCAP, 2014). As with terrestrial protected areas, a challenge is sustainable finance as well as effective monitoring and enforcement. These can be addressed by community participation and charging visitors to use the parks. Where fishers are initially displaced, education and awareness are needed to demonstrate the value of the protected area.

3.6.3 Sustainable aquaculture

Asia is by far the largest producer of aquaculture with 10 of the world's top 15 producers within this region and is responsible for 88% of global volume by weight. During the period of 2000 to 2012 the FAO (2015) reports Aquaculture production grew by 8.2% per annum within Asia (excluding China the world's largest producer). In Asia, since 2008 farmed fish production has exceeded wild catch (freshwater and marine), reaching 54 per cent of total fish production in 2012 China is by far the largest producer in the world (61.7%) but the vast bulk is produced form inland aquaculture. Indonesia on the other hand has a larger reliance on finfish from mariculture which largely depends on the development of ponds in coastal and brackish water and has the fourth largest shrimp production in the world (FAO 2015). The rapid growth in mariculture is not restricted to Indonesia and has been widespread across SE Asia. Bostock *et al.,* (2010) report that during the period 2000 to 2007 Viet Nam had a growth rate in aquaculture production of 30.1%.

Currently sustainable aquaculture is controversial particularly when it comes to large commercial operations. However many countries in Asia Pacific, such as Bangladesh depend heavily on small scale aquaculture for food security and incomes.

Box 3.4 ADB Support for the Coral Triangle Initiative
Source: ADB

The Coral Triangle Initiative (CTI) was originally a six-country program—Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands, and Timor-Leste—to protect and sustainably manage an area often referred to as "the Amazon of the Seas". The Coral Triangle is the planet's richest center of marine life and coral reef diversity holding more than 75% of the world's known corals, over 3,000 species of fish, and the greatest extent of mangrove forests on earth; supports the livelihoods of over 120 million coastal people; and provides more than $3 billion in annual foreign exchange income from fisheries exports and coastal tourism revenues.

Cognizant of the prime importance of saving the Coral Triangle from the threats of overfishing, pollution, and climate change, the six Coral Triangle countries endorsed in 2009 the Coral Triangle Initiative on Coral Reefs, Fisheries and Food Security (CTI-CFF) that lays out a plan of action to preserve and manage marine resources. Key areas of focus include managing priority seascapes and networks of marine protected areas, applying ecosystem based approaches to fisheries management, addressing climate change, and protecting threatened species. For example, In Indonesia ADB is supporting a community-based coral reef rehabilitation and management system project (COREMAP) that is mobilizing local people to help protect, rehabilitate, and manage mangroves and coral reefs. In the province of Palawan in the Philippines similar projects such as the Philippines Integrated Costal Resources Management Project, are helping establish fish sanctuaries aimed at reversing the trend of marine resource depletion and dwindling fish catch resulting from unregulated fishing, destruction of mangroves, and dynamite and cyanide fishing.

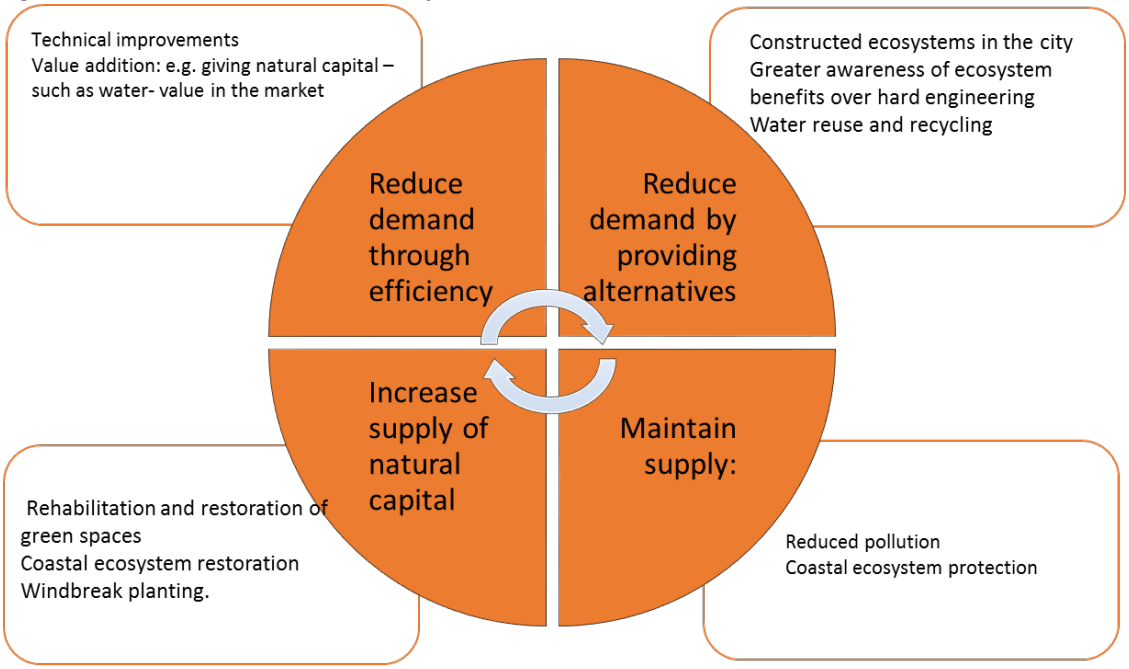
Recently, ADB included Fiji and Vanuatu to the existing Pacific Island nations in the Coral Triangle Initiative (Papua New Guinea, the Solomon Islands, Timor Leste) to form a similar and linked grouping knows as the Pacific Coral Triangle due to the five countries' common environmental concerns in regard to climate change and biodiversity conservation. This program is looking at a range of Ecosystem based Adaptation programs such as ridge to reef approaches and ecosystem based coastal fisheries management in the Solomon Islands and watershed rehabilitation, and community based marine management in the Ra province of Fiji.

ADB serves as an active partner and lead for mobilizing the considerable resources needed to support these programs. At the end of 2010, more than $300 million in new financial resources had been mobilized, with financial and technical support provided by ADB, the Global Environment Facility (GEF), the governments of Australia and the United States, the United Nations Development Programme (UNDP), and the Food and Agriculture Organization (FAO) of the UN. Several international environmental nongovernment organizations (NGOs), including Conservation International, The International Union for the Conservation of Nature (IUCN), The Nature Conservancy, and the World Wide Fund for Nature (WWF), are also providing active support through their own resources; and bilateral and multilateral partners are funding selected projects.

3.7 Investments in urban natural capital

Natural capital investments within cities are often referred to as 'green' infrastructure, because they can substitute for engineering solutions. There are six broad areas where investment in natural capital in urban areas can be beneficial. The investments can be grouped according to ways to reduce the demand for provisioning services from natural capital, and ways to increase supply (see Figure 3.6).

Figure 3.6 What investments in urban ecosystems?



3.7.1 Green infrastructure

Even though cities are the most intensive form of human land use, the people within these cities still require the environmental services that are provided by natural capital. Many of the services such as the provision of food, clean water and air will by necessity be provided by systems outside the urban boundary. Nevertheless, there are number of services or uses of natural capital within cities that can reduce the impacts of cities on other systems, protect people from natural disasters or improve the quality of life the urban residents.

Natural capital investment within cities is often referred to as "green" infrastructure as many of the uses of natural capital in cities are often substitutes for engineering or hard infrastructure solutions. Green infrastructure can be considered as a hybrid between natural green spaces and modified built systems. Natural systems include forests and wetlands were modified built systems incorporate concepts such as green roofs or green walls that together can contribute to ecosystem resilience and human benefits through ecosystem services (Naumann et al., 2011; Pauleit et al., 2011). Although green infrastructure cannot be considered as a replacement for natural areas it is regarded as beneficial to biodiversity as it can provide habitats for many species and therefore help protect terrestrial and aquatic ecosystems (Andersson *et al.,* 2014). Green infrastructure has also been indicated as

promising approach for reducing the adverse effects of climate change in urban areas, for example, by balancing water flows to alleviate flooding, providing thermal comfort by shading vegetation, and supporting coping capacities by providing people with opportunities to grow food for themselves (e.g. Krasny and Tidball, 2009; Cameron et al., 2012; Farrugia et al., 2013).

In general, there are five broad areas where investment in natural capital with in the urban boundary can be beneficial.

- Use of trees and green infrastructure for temperature regulation and reduction in particulate pollution
- using green infrastructure for stormwater management and to improve downsteam water quality.
- incorporating natural areas into a city for Urban amenity (scenic protection and recreation opportunities and improving wildlife habitat)

in coastal cities natural based defences against storm surge and wave induced coastal erosion Green infrastructure to reduce heat island effect and reduce pollution. Thewell-known urban heat island effect can mean that urban areas can be significantly warmer than the surrounding countryside (discussed in Section 2). Warmer temperatures due to the urban heat island effect can also lead to increased ozone production (Gray & Finster, 2000) and increased energy use for air-conditioning and refrigeration and thus increased greenhouse gas emissions.

Strategic use of trees and other vegetation or “green roofs” or “green walls” can ameliorate a significant component of this increased temperature within cities. The reduction in heat retention of green surfaces in comparison to concrete or other man-made surfaces and the shade from urban street trees can reduce the urban temperature by up 5 - 7° and in some estimates high as 10°C (Armson *et al.,* 2012). The effect of green roofs and walls on energy consumption is also highly related to local climate. The hotter and drier climate the greater the benefit from green roofs and walls. Energy savings of 32% in relatively cooler climates and up to 100% in hot dry climates were recorded by Alexandri and Jones's (2008)

The type, structure and spatial distribution of the green cover can significantly influence the amount of cooling afforded by the vegetation. For example, even though grass cover and green wall structures reduce thermal transmission and increase evaporative cooling they do not provide the shading properties of trees. Adams and Smith 2014 demonstrated that tree cover is more effective than low grasses or other herbaceous surfaces in reducing the temperature of urban surfaces. They demonstrated that the surface temperature reduction afforded by a 10% increase in tree cover was almost double the cooling effect of grass cover alone.

3.7.2 Investments in stormwater management

Historically, urban stormwater management was only concerned with collecting and distributing stormwater to minimize flooding (Tilley and Brown 1998). This focus had led to widespread degradation and pollution of waterways adjacent to or downstream of urbanised areas. Traditionally, these conventional approaches have failed to address the

increases of storm run-off volume and peak flows caused by urbanisation. This run-off in turn has overburdened wastewater treatment works and has carried pollutants such as trash, bacteria and heavy metals into the downstream receiving waters (Liu *et al.,* 2014). Incorporation of natural capital by the use of vegetated areas and wetlands in urban environments can provide significant benefits in terms of stormwater flow management and water quality improvement.

Vegetation and plant litter intercept rainfall and reduce the erosivity of rainfall on soils. Groundcover and litter also increase surface friction thus slowing overland flow as well is intercepting soil particles that may be moved by storm by water flow. The roots of plants and the incorporation of organic material from litter fall increase soil porosity and permeability meaning a significant component of the rainfall is held within the soil profile and released more slowly than impervious surfaces such as concrete. The evapotranspiration of vegetation, especially larger plants such as trees, can significantly reduce soil moisture between rain events increasing the capacity of soils to hold more water before they become saturated. Many larger woody species such as trees have deep root systems which increase soil shear stress resisting shallow soil movement. Wetland systems also play a significant role in altering the water cycle. Wetlands, in particular floodplain wetlands, reduce floods promote groundwater recharge and regulate river flows (Bullock and Acreman, 2003).

Incorporation of green infrastructure into the urban fabric to maximise hydrological and water quality benefits requires careful selection of the appropriate form of green infrastructure and the placement within the landscape (Ellis 2012). Ideally green infrastructure for stormwater management should incorporate a range of technologies including:

- incorporating green roofs and walls into buildings,
- incorporation of green open space,
- planting of a new urban tree canopy into existing areas,
- bioswales and
- constructed wetlands.

Many green infrastructure formats require relatively large surface areas and are therefore often difficult to retrofit into existing urban systems. Green roofs on the other hand provide considerable potential for mitigating against the effects of stormwater run-off in urban areas as they can be incorporated into the existing built infrastructure and increase infiltration on-site. Green roofs store water during rainfall events assisting in delaying run-off until after the peak rainfall and returning some of the precipitation in the form of evapotranspiration (Mentens *et al.,* 2006). Green roofs can reduce annual total building run-off by as much as 60 to 79% (Köhler *et al.,* 2002) and a 10% coverage of green roofs within an urban environment could reduce overall regional run-off by 2.7% (Mentens *et al.,* 2006). Where space is available increasing the area of parks and permeable pavements can have dramatic impacts on urban hydrology. In the highly flood prone urbanised Como Lake catchment, incorporation of green areas and permeable pavements have reduced

stormwater run-off by up to hundred percent during normal years and up to 88% during years of high precipitation (Capitol Region Watershed District, 2012).

Tree planting into existing urban environments increases the rainfall interception, increases evapotranspiration and can increase water infiltration and groundwater recharge within urban areas. Bartens et. al. 2008 found that planting of trees in formerly compacted urban environments increased infiltration rates by an average of 153%, which both reduced surface flows and increased groundwater recharge.

Not all green infrastructure technologies will be possible in all situations as space within existing urban environments are often limited. In existing cities there is still considerable scope for incorporating green roofs and the planting of urban trees to maximise on site retention and improve soil infiltration. However, wherever possible in new or expanding urban developments multiple green infrastructure technologies should be incorporated as part of an integrated stormwater management system. No single green infrastructure technology will be adequate in dealing with the issues of urbanisation and stormwater management nor can green infrastructure be a total replacement for other more traditional hard infrastructure stormwater management techniques.

In the United States of America the incorporation of multiple green infrastructure technologies and stormwater management is often referred to as low impact development (LID) and in Europe and Australia is referred to as Water Sensitive Urban Design (WSUD) and in China the concept of improving water retention within the city is often referred to as the sponge city concept (see Box 3.5). In the US, a recent study that compared low-impact developments against traditional developments (Hood *et al.,* 2007) found the run-off from traditional development was 1100% greater than that from LID. The study indicated that LID resulted in lower peak discharge, discharge volume and increasing lag times compared with traditional residential development.

In Asia a modelling study looking at incorporating the benefits of multiple green infrastructure into Beijing (Lui et. al. 2014) illustrated that green infrastructure could make a considerable contribution to urban flooding control. However, they also indicated that using only a single green infrastructure approach was not capable of effectively reducing both the run-off volume and significantly reducing peak flow. They found that if they incorporated a range of green infrastructure technologies then stormwater run-off of the 1 to 2 year recurrence intervals were completely eliminated. Peak flows and storm run-off were reduced by 94.2% and 85.6% for the five year recurrence flood events. For the 10 year recurrence flood events peak flow was reduced by 97.1% and run-off was reduced by 93.1% significantly reducing the risk of flood to the population of Beijing.

Box 3.5 ADB support for China's Sponge City programme

A good example of integrating natural capital and green infrastructure into an urban environment is China's *Sponge City Program.* In 2013 poor water management and inadequate drainage systems that was a legacy of decades of rapid urbanization led to widespread flooding of more than 230 cities across China. This incident led to a rethink in China and in 2014 the sponge city initiative was launched. The Chinese Government's 13th Five-Year Plan (2016–20) followed and further highlighted water conservation as its first priority in the nation's built infrastructure network. It emphasised that water resource management including water ecology remediation and water environment protection will be the most important element of infrastructure construction.

The concept of sponge city refers to cities that instead of having lots of hard impermeable surfaces that shed water and can make flooding worse the city is designed to act like a sponge (see Figure 4.6). The urban area are planned and constructed to soak up almost every raindrop and capture that water for reuse. The concept of a sponge city is quite similar to the United States' Low Impact Development (LID), the United Kingdom's Sustainable Drainage Systems (SuDS) and Australia's Water Sensitive Urban Design (WSUD). Instead of funnelling rainwater away, a sponge city retains it for use within its own boundaries via the use of urban greenspaces, green roofs, bioswales and incorporation of permeable surfaces and wetland retention ponds. The recycled water can be used to recharge depleted aquifers, water gardens and irrigate farms. When properly treated, the recycled water can replace drinking water, flush toilets or clean homes.

Over the next three years, ADB is assisting regional governments in China to implement the program across the first 16 pilot sponge cities. In those cities they will develop ponds, filtration pools and wetlands; and build permeable roads and public spaces that enable storm water to be absorbed and reused. Ultimately, the plan is to manage 60 per cent of rainwater that falls in these cities. The aim is that by 2020, more than 20 per cent of urban areas will meet sponge city objectives and requirements, with a long term aim of raising that to more than 80 per cent by 2030.

3.7.3 Urban natural capital for amenity

Incorporating green infrastructure for temperature regulation, air-quality management and water quality improvement all will have significant impacts on the urban amenity of cities across the Asia Pacific. For example, studies have shown the use of green spaces to alleviate the effects of thermal stress and the number of people that use urban green spaces increases rapidly with increases in temperature (Thorsson *et al.,* 2007).

Incorporation of green infrastructure into urban environments can have significant impacts on urban amenity which in turn are linked to improvements in health outcomes for the residents. In developed nations there are a range of studies that indicate access to urban green spaces is associated with higher physical activity levels and a lower likelihood of being obese or overweight (Coombes *et al.,* 2010). Green urban infrastructure tends to encourage more active and healthier forms of recreation such as walking and cycling and Mass et al

2009 demonstrated that the annual prevalence rate of 15 of the 24 disease clusters was lower in living environments with more green space within a 1 km radius.

Access or the desire to access green space is often considered an issue only of relevance in developed countries or for the rising middle-class in the developing world. Nevertheless, a study in small provincial cities in South Africa found that irrespective of socio-economic background 50% of the respondents considered the number and condition of publicly available green open space within their suburbs as inadequate and wanted greater access to green open space (Shackleton and Blair 2013). Of these respondents most visited green open spaces at least three times a month and considered them to be places important for recreation and relaxation. The value placed by the residents on green open space was such that 50% of those surveyed were willing to volunteer time and 20% willing to pay the maintenance of public open spaces. The World Health Organisation (WHO) recommends that a minimum of 9 m^2 of green space per person is required (WHO 2002) and the UN Habitat Global Observatories Unit recommends at least 15 to 20% of the urban area be allocated to green open space in cities (UN Habitat 2013) in all cities.

In high density urban environments participation in the community management of green space through activities such as community gardening, park management or watershed restoration can improve the feeling social responsibility and interaction (Krasny and Tidball, 2009). Opportunities for socialising in green space has also been recorded as being particularly important for more vulnerable societal groups such as the elderly, those in poor health or those with young children that attend have limited access to social networks (Kaźmierczak, 2013).

In a review of the evidence relating to the impact of green space or natural areas on human health Frumkin (2003) reported that there was evidence that interaction with nature had multiple individual and societal health benefits. He reported that views of nature or natural elements speed recovery among post-operative patients, that contact with nature has been associated with fewer sick call visits amongst prisoners in prison populations, lower blood pressure and less anxiety and decrease mortality among senior citizens and that nature contact enhances emotional, cognitive and values related development in children especially during middle childhood and early adolescents. Contact with nature has also been credited with reducing stress and enhancing work performance.

3.8 Combined investments for ecosystem-based adaptation (EBA)

The management, conservation and restoration of natural capital can help people and communities adapt to climate change in a process known as ecosystem-based adaptation. (MEA, 2005; Munang et al., 2013). EBA can be more cost effective as well as more flexible than other types of climate adaptation. Ecosystem-based adaptation responses can also offer more flexibility in response to a changing climate. For example, mangrove forests and tidal salt saltmarsh both have an ability to trap sediment and keep pace with rising sea levels (Kirwan & Megonigal 2013, Kirwan *et al.,* 2016). Likewise natural ecosystems within catchment areas can adjust to climatic conditions maintaining their role in reducing soil erosion and improving downstream water quality. Hard engineering responses on the other hand either need to be overdesigned to cope with future sea level rise or will need to be replaced or modified as the climatic conditions change.

Nevertheless, there are limitations to the use of ecosystem-based adaptation approaches. In general, ecosystem-based approaches will by necessity require a larger spatial footprint - that is they will require more land or sea space than a purpose-built, designed engineering structures. There are times when the extreme nature of the threat or the high value of the asset means that a hard engineering approach may be the only one possible. For example, channelisation of stormwater drains in intensely developed urban areas may be the only solution where space is limited and flooding from upstream sources likely. Ecosystem-based adaptation responses may also have a longer lead time before they become fully functional. For example, the effect of tree planting on urban cooling may take a number of years to reach its full potential. Finally, ecosystem approaches do not necessarily have the clear-cut design parameters required or available for engineering structures and there may be a high degree of uncertainty in relation to their performance.

Therefore, adopting an Ecosystem based adaptation (EbA) approach does not replace the need for other adaptation strategies such as infrastructure development, planning controls or regulatory reform but should be considered as part of an overall adaptation strategy to help people and communities adapt to the negative effects of climate change. When deciding on appropriate adaptation response for a particular situation or location consideration should be given to all possible forms of adaptation. In many cases the most appropriate response may include the incorporation of policy and knowledge base products as well as a combination of hard infrastructure and nature-based solutions. For example, in a study on adaptation responses to increased storm risk for Lami town in Fiji the most effective strategy in terms of economic benefit and performance was to utilise a combination of nature-based catchment management solutions and hard engineering approaches in key downstream high value areas (Rao *et al.,* 2012). Likewise, Jones *et al.,* (2012) report that incorporating a range of ecosystem based approaches aimed at restoring natural flow regimes and reconnecting floodplain wetlands in the Yangtze River catchment has meant the regional hydrological system is better able to cope with current climate variability and is considered more resilient in the face of increased climate variability projected in the future. This approach has also had additional benefits through increasing the incomes of local communities by allowing farmers to diversify their livelihoods (Schuyt 2005).

There will be cases however where nature-based solutions or ecosystem based adaptation is either more cost effective than a hard engineering solutions or is the only viable alternative for the community. In some instances, an ecosystem based approach may be the only logical or available solution to the community. For example, the small coral atoll island Taro, is the provincial capital of Choiseul Province in the Solomon Islands. Rising sea levels and coastal erosion are major problems for this very small coastal community. The construction of seawalls and dykes are simply beyond the physical and economic resources available in this poor region. The islands best option, for the short to medium term, are improving the health of the fringing coral reefs through a combination of marine protected areas and runoff control and the restoration of coastal vegetation on the windward side of the island (Piper and Smith, 2015).

As a general principle, it is recommended to consider the linkages of ecosystem based approaches in relation to the local communities affected. In particular ecosystem approaches have an important role to play in the protection of communities from natural hazards, enhancement of water security, maintenance of food security and the potential for diversification of income especially for the rural poor.

Ecosystem based adaptation is not restricted to the management and restoration of large natural areas or the creation of national parks. Incorporation of natural based solutions through ecosystem based adaptation can be accommodated at a range of scales and used across a range of sectors, from even the most intensive human land uses in the urban zone (discussed in previous sections). Other sectors include water shed management, coastal zone management, transport and infrastructure, and smallholder agriculture and forestry.

3.8.1 Landscape, Watershed Management and Water Security

Rising temperatures and altered precipitation regimes as a result of climate change will have significant impacts on watershed hydrology. Ecosystem-based adaptation approaches are very important role to play at the landscape or catchment scale. The type of ecosystem based approaches can be adopted at this scale vary from protection of existing natural forest and wetland habitats, to maximising the characteristics that affect hydrological flows. Generally, forests can reduce overall hydrological yields (through higher evapotranspiration) but this needs to be balanced against the propensity of forests to improve water quality and minimise soil erosion and sedimentation of streams. Targeted approaches for restoration can be effective. For example, targeting key parts of the landscape for reforestation and vegetation management to increase ground cover, and maintaining vegetation on steep slopes and in key parts of the landscape such as drainage lines and riparian zones significantly reduces sediment loads into streams.

Using forest as part of EbA provide other co-benefits and products such as timber, fuel and some food products. Additional cultural and tourism benefits can accrue from forested catchments including recreation.

Approach	Description
Protection and restoration of forests and natural vegetation in catchments	Although forests in certain catchments may actually reduce total water yield due to their higher rate of evapotranspiration. At larger regional scales there is a recent evidence to indicate that Forests play a significant role in increasing regional precipitation (Ellison et al 2012). Modelling studies show tropical deforestation leads to warmer and drier conditions at the regional scale and widespread deforestation in South East Asia could lead to an average drying of 132mm per year. (Lawrence and Vandecar 2015).
Evapotranspiration management	All vegetated surfaces –including forests- recycle rainwater through evapotranspiration (a biotic pump). Water consumed by vegetation is released back into the atmosphere, increasing local moisture content. Studies using satellite remote-sensing data of tropical precipitation and vegetation indicate that air masses passing over extensive vegetation produce at least twice as much rain as air masses passing over little vegetation (Spracklen et al., 2012). A recent proposal is to use the "biotic pump" attributes of forests to increase regional precipitation and water security in a region where climate change threatens water security Layton and Ellison 2016). The proposal, named "*Induced precipitation recycling (IPR)*" initiates these processes by irrigating afforested land using locally available surplus water to increase regional atmospheric water and thus precipitation.
Flow regulation and groundwater recharge	Research in tropical landscapes indicates that intermediate tree canopy densities can help groundwater recharge. This can have a positive effect in enhancing dry season flows and water security. The benefit is obtained by balancing the increased benefits of soil infiltration obtained through roots and soil organic matter against the impacts of increased evapotranspiration found in trees (Ilstedt et al 2016). Forests in particular improve soil quality and increase the storage of organic carbon in the soil. This allows the forest soils to absorb and store more water during rain events and then releasing it more slowly over time thereby evening out the flow of water in streams (Krishnaswamy et al 2013).
Water quality	Natural forests, and well managed plantations, can improve water quality by providing soil cover and reducing sediment yields.
Restoring wetlands and wetland function in the landscape	Wetlands are significant in the hydrological cycle and floodplain wetlands in particular play a key role in flood regulation and incorporation of wetlands into a catchment can reduce flood problems downstream (Bullock and Akerman 2003)

Table 3.8 Landscape and watershed management in EbA

3.8.2 Coastal and Marine Environments

The major climate change risks in the Coastal and near shore marine environments are sea level rise, storm surge and altered storm frequency on low lying coastal communities as well as the impact of ocean acidification on the productivity of marine systems. The major climate change risks and vulnerabilities and the EbA approaches that can be utilised are presented in table 3.9.

Approach	Description
Coastal protection through protection and restoration of coastal ecosystems	These investments can provide important coastal and near shore marine defence values. Coral reefs contribute to coastal protection by reducing wave energy, and through reef building and reef erosion cycles provide sediments critical for island building and sand replenishment (Perry et al 2015) Salt marshes and mangroves contribute to coastal protection by reducing wave energy, increasing sedimentation, and/or reducing erosion and movement of sediments (Shepard et al., 2011). Mangroves, sea grass and salt marsh have ability to trap sediments not only improving water quality but also leading to land building through vertical accretion of sediments that may keep pace with sea level rise. (Kirwan &Megonigal 2013)
Food security through improving health of key ecosystems such as mangroves, seagrass beds, coral reefs and saltmarshes.	This will have significant impacts on fish biomass and related food security. This will be particularly important for poor coastal communities within Southeast Asia as well is within the Pacific region. A key component of increasing the health of the systems will be the incorporation of a system of marine protected areas. Well managed Marine Protected Areas are known to increase fish biomass and can lead to increased fish catch in adjoining areas (Lorenzo et al 2016 Journal of nature). For example, Prior to the declaration of a marine reserve in Goukamma in Southern Africa the catch of per unit of effort for the commercial sea bream species Roman had been declining. After one year the catch was above pre declaration levels and by Ten years after declaration had doubled. In other regions without a marine protected area the catch per unit of effort has continued to decline (Kerwith et al 2013)
Investing in marine protected areas to stop degradation from ocean acidification	Key activities will be declaration of marine protected areas and Improvement of marine ecosystem management by reduction of additional stressors from land band pollution improve marine system health.

Table 3.9 Coastal and marine investments in EbA

3.8.3 Transport and infrastructure sectors

The major risk to transport infrastructure sectors from climate change are the potential intensification of the hydrological cycle resulting in more frequent and intense storm events. This is then linked to increased risks of slope instability, soil erosion and sedimentation of transport drainage infrastructures. The type of ecosystem-based adaptation approaches that can be adopted for this sector are presented in Table 3.10.

Approach	Description
Green Infrastructure in transport construction	For example, taking a "whole of slope" view of using and managing vegetation to increase infiltration and reduce run off in areas higher in the catchment than the transport infrastructure.
Slope stabilisation	Incorporation of green infrastructure into a slope stabilisation program can reduce soil erosion as well is minimise shallow to mid-level and slip and landslide. Root cohesion plays a significant role in stabilising natural hillslopes. In a recent study in Korea the impact of tree roots were equivalent to an increase of soil cohesion of 3.8Kpa (Lee and Kim 2016). Nevertheless there are limitations in the use of green or bioengineering approaches. In general, green infrastructure has major benefits in limiting slope erosion and shallow mass movement but it not suitable as a tool for deep landslides and in areas of high instability.
Protecting infrastructure from coastal erosion and storm surges	In coastal areas, judicious use of ecosystem-based adaptation approaches to reduce coastal erosion and storm surge such as protecting and replanting mangroves and saltmarsh.

Table 3.10 Transport and infrastructure investments in EbA

3.8.4 Agriculture and food security

Smallholder farmers are particularly vulnerable to climate change. Changes in temperature, rainfall and the frequency or intensity of extreme weather events directly affect crop and animal productivity. This in turn can significantly affect their household's food security and well-being

The use of ecosystem-based management practices in agricultural systems and landscapes can help smallholder farmers adapt to climate change by providing both on farm and landscape level benefits (Lavorel et al., 2015). Ealier in this chapter we presented in depth description of agricultural investments in natural capital. This section links these investments to ecosystem-based adaptation (see Table 3.11)

Approach	Description
On-farm management of genetic biodiversity	The diversification of crop varieties or inclusion of wild relatives can ensure a broader source of crop resistance-capacity to uncertain occurrence and effects of extreme weather events (Ratnadass et al., 2012).
Planting of windbreaks and agroforestry systems	These help reduce the evapotranspiration effect of extreme radiation and/or wind, or the energetic force of extreme rainfall and strong winds on soil structure. In Indonesia one study showed that cacao systems that were shaded by trees were more resilient to drought because the shade offered by trees and the water uptake in general studies showned that trees and agroforestry systems have the potential to improve soil fertility, soil moisture and microclimate in agriculture and can therefore make crop production more resilient to climate variability (Schwendenmann et al., 2010 and Pramova et al., 2012)
Water and nutrient cycling	As discussed in the previous sections, catchment practices can include those that use biodiversity and ecological processes to help regulate water and nutrient cycling.
Biological diversity as pest control	The inclusion of natural vegetation on farm to increase the diversity of biological controls for crop pest and disease outbreaks related to extreme weather events Jackson et al. (2007) and Jaramillo et al. (2013).

Table 3.11 EbA for food security
Source: adapted from Vignola, *et al.,* 2015 and Section 3.3.

4 How to finance investment in natural capital?

This section reviews how to finance investment in natural capital from three main sources:

- domestic public funding including subsidy reforms, taxation, natural capital funds, payment by ecosystem users, public work schemes and national and local government financing
- international public funding including traditional development aid from bilateral donors and International organisations and climate finance, including REDD+
- private sector funding – both domestic and international

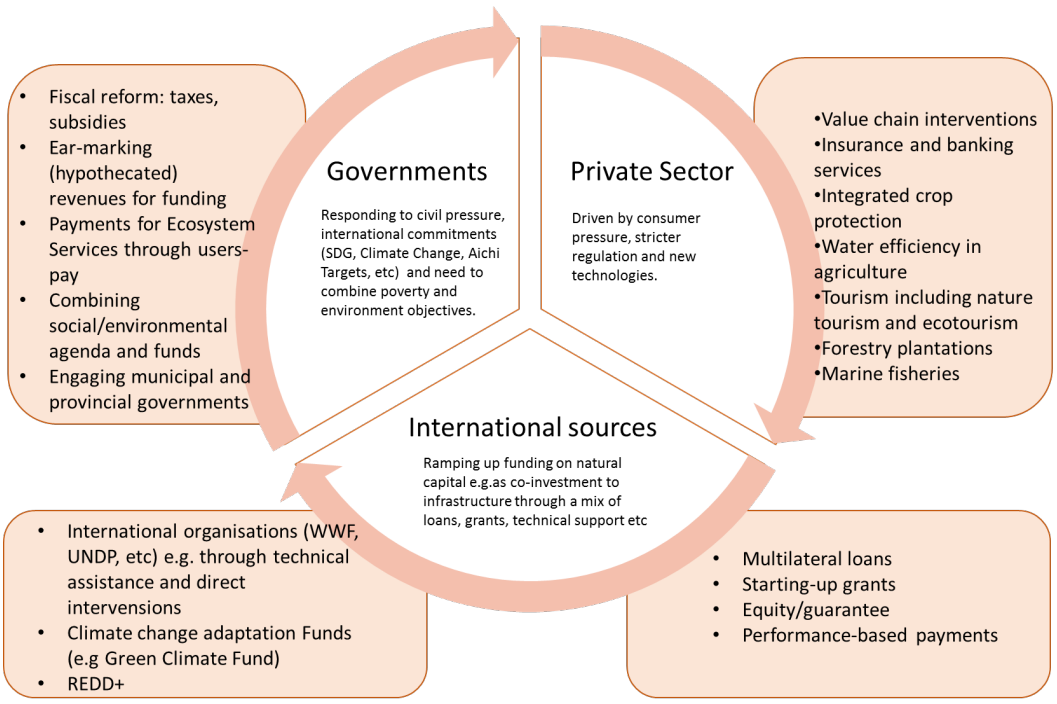


Figure 4.1 How to finance investments in natural capital?

4.1 Domestic public finance for natural capital

Domestic public source are likely to be the main sources of funding for natural capital investments. Public finance is instrumental to promote a greener economy that incorporates ecosystem services. Governments can intervene through redesign of market signals – specifically through a tax and fiscal reform that addresses price distortions and reduces free-riding on natural resources and ecosystem services traditionally considered "free". The funds provided by environmental fiscal reform can be used to leverage private and international funds, increasing profitability in favour of sustainable, long-term projects.

4.1.1 Subsidy reforms to eliminate perverse incentives damaging natural capital

Some of the perverse incentives and subsidies that harm natural capital and environmentally-friendly activities include:

- Subsidies to already under-priced natural resources. For example the provision of water and energy at low subsidised prices, can lead to excessive consumption and often waste.
- Subsidies to inputs of production, often can lead to over use, for example energy subsidies can lead to over use of groundwater, subsidies to fertilizers or pesticides in agriculture can leads to overuse and externalities and subsidies to bottom trawl fleets can have a major negative impact on the habitat of fish species.
- Sometimes lax collection of natural resource taxes can act as an implicit subsidy, such as uncollected forestry taxes, increasing deforestation (see e.g. Box 4.1).
- There are other forms of perverse incentives beyond subsidies. For example, requirements to remove forests as precondition to receive land tenure or titles, or laws that threaten "idle" lands with higher taxes.

The elimination of these harmful subsidies can increase efficiency – and free up considerable funds which could be used to address environmental and social needs.

Box 4.1 Indonesia: forestry taxation reforms due to billions of lost revenues per year

Sources: (KPK, 2015; Jong, 2016)

The government of **Indonesia** will be revamping its system of non-tax state revenue (PNBP) collection in its forestry sector, meaning the various royalties, levies and fees it collects from commercial timber production within its Forest Estate. The planned changes are the result of a recent report by its Corruption Eradication Commission (KPK), which for the 2003-2014 period estimated state losses of about US$ 67.1 to 90.3 billion, or between US$ 5.5 to 7.5 billion per year. These losses are mostly from vast unreported timber activity estimated at about 80% of total production, as well as from the under-collection of revenues from reported production. In its report the KPK identifies several factors behind this: widespread corruption leading to false information and weak law enforcement, inadequate data collection and distribution systems, as well as low royalty rates that capture only a small fraction of the total economic rent meant to be used for the public interest.

To address these issues, the government will be implementing a series of reforms on a gradual basis, starting with 12 provinces identified for their high losses and revenue potential. Key planned actions include conducting comprehensive audits, identifying corrupt agro-forestry companies, updating the online revenue system to be connected with the Finance Ministry responsible for collection, and building greater inter-institutional coordination among the various ministries and government agencies involved. Other measures suggested by the report but not yet commented on by the government include updating the forest inventory using satellite technology and reviewing the structure and rates of fees to achieve greater efficiency and fairness. Successful reforms would also mean significant additional financing for Indonesia's national Reforestation Fund, financed by PNBP collection and currently valued at about US$ 5.8 billion.

4.1.2 Environmental taxes to incentivise sustainable natural capital

Governments in Asia and the Pacific can develop system of natural resource taxes for forestry, fisheries and water (such as aquifers) which provide incentives for more sustainable extraction and effective tax collection and monitoring schemes to enforce. There is a range of different instruments for this, including:

- taxes on the level of extraction (linked either to physical units by volume, or to economic units by value)
- taxes on profits
- taxes on exports
- state participation in the industry (eg partial state ownership)
- auctions of concessions or the extracted produce

These instruments are often combined (OECD, 2012) as they have different advantages and disadvantages. While in theory some instruments are better for reducing incentives for over-extraction (e. taxes on the volume of extraction) these can be costly to administer as they also provide incentives for tax evasion, so simpler taxes on more easily collected data such as traded exports and/or audited profits may be preferred.

Sustainable tourism is a rapidly growing industry and an especially important one for many countries rich in natural capital, particularly coastal resources and forests. In the Maldives and Bhutan tourism taxes provide a large share of government revenues (see Box 4.2). Fishery taxes are a way for coastal countries to raise revenues and can be used to reduce fishing effort and to invest in fishery management (see e.g. Box 4.3). For natural capital that act as inputs to the production process particularly water, taxes need to be carefully managed to avoid social impacts and political opposition (see Box 4.4 for water pricing in PRC).

In the Maldives for example, revenues from the Goods and Services Tax (GST) contributed 39% of total government revenues in 2014, with two-thirds of total GST revenue about. US$198 million attributed to the tourism sector. Tourist GST revenues were 23.5% higher than 2013 and 5.5% more than projections as a result of a boost in tourist arrivals. Also, revenues from the Tourism Land Rent (charged on resorts by area) contributed another US$75.8 million or 10.1% of total revenues, an amount 8.2% higher than the previous year. Tourist arrivals in 2015 grew by 2.4%, reaching a total of 1.2 million, while receipts from international tourism in 2014 totalled US$2.64 billion. With its 'Visit Maldives Year 2016' campaign, the government is aiming to increase tourist arrivals in 2016 to 1.5 million.

In another example, the Royal Government of Bhutan has seen large benefits from its High Value-Low Impact (HVLI) policy that sets a fixed daily tariff of US$250 for any foreign tourist wanting to visit the country, thereby limiting tourist inflow within the country's environmental and cultural capacity, while securing a substantial source of government revenues. The number of foreign tourists have increased from 1896 in 1985 to 134,000 in 2014, a year where international tourism revenue reached an all-time high of US$ 125 million or 15.7% of the country's GDP. The government's latest five-year plan titled *Bhutan Tourism Strategy and Development Plans 2013-2018* envisions further growth of its sustainable tourism industry, targeting the arrival of 200,000 tourists.

Box 4.2 Revenues from sustainable tourism in Maldives and Bhutan
Sources: (Gross National Happiness Commission, 2012; Singha, 2012; Maldives Inland Revenue Authority, 2015; World Bank, 2016; Naish, 2016a; Naish, 2016b)

Box 4.3 Fishery taxes in the Pacific
Source: IMF (2014)

Fishery taxes for the rich tuna fishery of the Pacific are governed by the 1982 Nauru Agreement among eight Pacific island countries. This agreement seeks to increase the bargaining power of license-issuing countries and regional control to stop illegal fishing by foreign fleets. Nauru Agreement members moved to a minimum fee for fishing per vessel day which was set at a minimum amount of US$6,000 effective in January 2014. Initial data suggest that overall fishing license fee revenue almost quadrupled, from about US$60 million in 2010 to US$230 million in 2012, with the biggest gains in Kiribati and Tuvalu. However the ratio of revenue to the value of the catch is still too low because tuna prices have been rising.

Box 4.4 Water pricing in China
Sources: (PwC, 2016; Wang, 2016; Xinhua News Agency, 2016)

Following crude oil, natural gas, coal and rare earth minerals, water is the next target of a comprehensive reform in China that is replacing resource fees with taxes that are more efficient, less burdensome, better enforced and aligned with China's steps towards a green economy. The water tax is being piloted in Hebei, a province suffering from severe water scarcity and over-extraction that has led water availability per capita in the area to be only 1/7th of the national standard. The reform will be accompanied by a comprehensive elimination of numerous previous charges and fees in order to avoid double taxation and minimize the additional burden on industry. Indeed, experience from similar reforms in the taxation of the coal industry in 2014 suggests that the total burden on some companies has actually been decreased.

The tax itself will be levied on an ad valorem basis that allows for greater flexibility and responsiveness to market signals than the volume-based method used before. The rates will differ based on area and industry, for example agriculture will be given tax-exempt quotas and groundwater extraction will be charged higher in water-scarce areas. The burden on domestic use by households and normal use by businesses will not be increased. These measures are meant to encourage water conservation without stifling agricultural and industrial development. Moreover, in an important move towards decentralization, it will be the local governments' responsibility to determine their own reform plan, including their own tax rates within an allowed range. This is expected to greatly increase their autonomy, as well as their motivation to better understand their local conditions and needs. Most importantly, the tax revenue will now be collected and kept by the local governments, providing them with a large fiscal revenue stream that they can use at their discretion. Following the piloting in Hebei, the water tax is expected to be applied nationwide in the near future, while plans are being made for similar taxes to be expanded to forests, pasture and tidal zones.

4.1.3 Public expenditure on natural capital: natural capital funds

As well as pricing and taxation, governments can specifically target expenditures on natural capital management. Often these expenditures are financed through natural resource related taxation. There are arguments for and against setting aside a share of revenues collected for sustainable natural resource management. Such dedicated (or "hypothecated") funds can be justified to ensure a sufficient proportion of natural resource taxes are spent on management and to ensure economic benefit streams from ENR are maintained and preferably increased. Generally, Ministries of Finance prefer not to reserve or hypothecate revenues for a particular purpose. But for natural capital management, natural resource revenues can provide a vital source of revenue. This is often the case with forest funds which have been set up in a number of Asia counties as demonstrated in Table 4.1. These forestry and conservation funds have demonstrated a number of successes as illustrated by the Bhutan Trust Fund for Conservation in Box 4.5.

Box 4.5 Financing natural capital: Bhutan Trust Fund for Environmental Conservation
Sources: Dorji, 2013; BTFEC, 2015

The Bhutan Trust Fund for Environmental Conservation (BTFEC) is the world's first conservation trust fund, established in 1992 as a collaborative venture between the Royal Government of Bhutan, UNDP, and WWF. With a strong focus on biodiversity conservation and capacity building, it has awarded more than US$15 million in grants for projects in research and development, awareness and education, climate change adaptation strategies, green sector projects, rural/community projects and integrated water source management. Between 1993-98, its endowment fund managed to receive about US$21 million in donor funding, with important contributions from GEF (US$10 million), WWF-US (US$1 million) and the governments of Norway, Switzerland, the Netherland, Denmark, Finland and Bhutan (totalling about. US$10 million). Since establishment, the fund has managed to more than double its value to US$52 million, with 7% average annual return rate generating about US$1.7 million in annual revenues.

Its environmental impact has been significant with the establishment of 10 Protected Areas covering 19,617 km2, more than half the country's total area. Through BTFEC, more than US$9 million have been spent in capacity building for effective park management, 189 field staff have been recruited, 24 post-graduate specialist degrees have been trained, and more than 389 scientific courses have been facilitated. According to its 2015-2010 Strategy Plan, BTFEC will be focusing on three objectives: i) addressing a few systemic and urgent conservation issues currently affecting Bhutan around human-wildlife conflicts, waste management and prevention, sustainable forest management, biodiversity conservation and improvement of rural livelihoods, ii) supporting populations most affected by loss of natural resources and biodiversity through sustainable conservation and capacity building programs, and iii) collaborating with other civic, governmental and private institutions to maximize impact. To fund these activities, a new fundraising strategy is currently being developed as part of the 2013-18 GEF-World Bank project titled 'Sustainable Financing for Bio-diversity Conservation and Natural Resource Management'.

Table 4.1 National forest funds in Asia-Pacific

Country	Name of fund & indicative value	Description
Bhutan	Bhutan Trust Fund for Environmental Conservation	Established in 1992. The main focus is on the conservation of forests, flora, fauna, wildlife, diverse ecosystems and biodiversity. The endowment fund is the most important asset of the fund and has been successful at more than doubling its original amount. The Trust Fund manages approx. US$48.63 million and generates US$1.7 million per year.
India	Compensatory Afforestation Fund (US$ 5 billion)	Constituted based on the order of the Supreme Court of India dated 5 May 2006 and operationalized in 2009. Follows a specialized financing mechanism based on the "polluter pays" principle designed to levy those who use forests. Funds collected are used to mitigate losses by investing in afforestation, reforestation and conservation
Indonesia	Reforestation Fund (US$ 5,8 billion)	Established in 1989, the fund obtains its income from royalties charged on timber harvested from natural forests. It is spent on reforestation, plantation development in non-productive forests, and the rehabilitation of other lands.
	Fund for REDD+ in Indonesia (FREDDI) (in progress) (US$4 billion expected)	Designed as a funding instrument of REDD+ Agency that is responsible for managing, channelling, and mobilizing REDD+ funds in support of the REDD+ National Strategy. It is a fund of funds, meaning that it invests in other funds that can be special-purpose vehicles or collective investment agreements. FREDDI is expected to mobilize up to US $20 billion by 2020
Lao People's Democratic Republic	Forest and Forest Resource Development Fund	Established in 2005 with income of US $1 916 932 in 2012–13. Receives income from national budget and other sources. Funds may be spent on a broad range of forest activities, including public education
Malaysia	Forest development funds	Individual funds created in each state. They receive income from various sources and spend on state forest management and administration
Nepal	User group funds	Participants in community forest programmes keep funds that receive income from forest activities, donations and government, which is to be spent on forest management and community development
Philippines	Special Deposit Revolving Fund	Receives income from forest-related fees, which is spent on various forestry projects
	Tropical Forest Conservation Fund (US$ 8.2 million)	Established in 2002 and became active in 2005. It aims to conserve, maintain or restore tropical forests. It has supported watershed management plans and institutionalized multi-stakeholder management arrangements through public–private partnerships to promote community enterprises and advance their livelihood opportunities.
Solomon Islands	Plans to create a Protected Area Trust Fund	The proposal to establish the Protected Area Trust Fund is being pursued though a Global Environment Facility project
Sri Lanka	Forest Department Fund	A specialized fund devoted to law-enforcement activities, such as paying rewards and compensating forest officers injured in the line of duty.
Vanuatu	Biodiversity Conservation Trust Fund (inactive)	Difficulties experienced in getting the fund off the ground and operating. There is now another proposal to establish a local conservation trust fund though a Global Environment Facility project
Viet Nam	Forest Regeneration Fund	Receives income from a fee charged on all harvests, which is spent on planting new forests, restoring damaged forests and managing and protecting existing forests
	Forest Protection and Development Fund	This fund was established in 2008, mobilizing social resources to sustainably manage and protect the country's forests while assisting small and medium-sized forest landowners and community-based forestry. Partly financed by fees on hydroelectric companies for the environmental services provided by upstream forests. Its value in 2012 was US $55 million

Source: (Adapted from Matta, 2015; Syahrani, 2013; ICCTF, 2016)

4.1.4 Financing through ecosystem users: payments for ecosystem services

Payments for ecosystem services (PES) promote a user-pay principle, where the beneficiaries of an ecosystem pay for its protection. It also provides a system to reward the providers of these ecosystem services, through cash or in-kind transfers, or a combination of both. There are a number of examples from are slowly being applied to Asia Pacific. These include smaller scale schemes such as where protected area visitors pay entrance fees, such as diver entrance fees to a marine reserve in **Fiji** (see Box 4.6).

There is also the example of **Viet Nam** which had developed a national system of payment for ecosystem services (see Box 4.7). However, while PES makes sense from a theoretical point of view in identifying natural capital beneficiaries to pay for ecosystem services, the practice has been more challenging. Despite many attempts, PES remains difficult to implement with high transaction costs of setting up effective payment systems and large schemes such as Viet Nam remain the exception. Latin America is the region with the most advanced national and regional PES programmes.

4.1.5 Public works and poverty-reduction financing for natural capital

A number of countries in Asia Pacific are also combining public works schemes, poverty reduction programmes with natural capital improvements. In Asia Pacific such schemes include:

- India's Mahatma Gandhi Rural Employment Guarantee Scheme (see Box 2.4 in Chapter 2)
- Philippines Greening the Nation Scheme and
- PRC's Sloping Land Conversion Programme (see Box 4.8)

The advantage of funding natural capital improvements from poverty reduction and public works schemes is that these tend to be better funded with more political support than pure natural capital conservation schemes. The challenge is that combining both poverty and environmental objectives may be difficult. The poverty targeting may be weak, while on the environmental side, environmental expertise may be lacking leading to limited environmental outcomes. Many of the land, water and forestry investments in some public works schemes have been of limited quality, with for example trees planted at the wrong time and in the wrong place so many of them do not survive (Porras *et al.,* 2016). The solution is to promote better collaboration between the Ministries responsible for social welfare and rural development with the environmental agencies.

Box 4.6 Sustainable financing for conservation and community benefits in Fiji
Source: (Coral Reef Alliance, 2014)

The Namena Marine Reserve (NMR), a biodiversity and diving hotspot in Fiji, is a successful example of a sustainably financed marine protected area improving livelihoods. It was established in 1997 when Kubulau, the local community, concerned about their food security due to the overfishing taking place in the area, declared a five-year ban on commercial fishing. This ban however meant a significant loss of community income previously collected from fishing licences.

In 2003, the Coral Reef Alliance (CORAL), a non-governmental organization with established relationships with the Kubulau, worked with the community to inaugurate a dive tag program by which every visitor wanting to dive in the area would have to pay a fee to get a dive tag. This user fee system was modelled after the Bonaire Marine Park in the Caribbean and was initially set at FJ$20 after extensive consultations with tourism operators and the community. It has now been increased to FJ$30, selling approx. 1,000-1,200 tags per year, and providing an important source of revenue for both the reserve and the people. The fee system is fully transparent, with the funds being used to finance the reserve's management along with various community development projects such as scholarships for Kubulau students. According to a survey done in the area in 2015, the tourists are happy to pay when they know they are contributing to a worthy cause such as conservation, local community development and education. Annual stakeholder meetings are held to ensure the participation, ownership and satisfaction of the local communities and tourism operators involved.

Box 4.7 Viet Nam: securing forestry financing from payments for ecosystem services
Sources: (VNFF, 2014; Trung, 2015)

In 2010, Viet Nam became the first country in Asia to institutionalize a nationwide policy on Payments for Forest Environmental Services (PFES), whereby the users of certain forest ecosystem services have to compensate the agents responsible for supplying them. This policy is meant to tackle the multiple objectives of increasing the country's extent and quality of forests, boosting the forestry sector's contribution to the national economy while reducing forestry-related budgetary burdens, and improving rural livelihoods. The services accounted for include soil and water regulation, carbon sequestration, hydrological services for coastal fisheries and aquaculture, as well as landscape protection and biodiversity conservation. Users of these services are water supply companies, hydropower plants, industrial producers and tourism companies, while service providers are considered the individuals, households and communities in possession of forested land titles. Implemented by Viet Nam's Ministry of Agriculture and Rural Development, user-specific payments are channelled to the Viet Nam Forest Protection and Development Fund (VNFF). The capital is then distributed by the VNFF to various central and provincial forestry funds that have been set up to act as administrative and financial intermediaries for signing contracts, collecting and distributing payments.

Up to now, the PFES has been largely successful in achieving its goals as evidenced by its significant environmental, economic and social impact. Since 2008, forested area in Viet Nam has increased from 12.8 to 13.5 million ha, out of which 3-5 million ha/year are protected with support from the FES budget. More than US$ 213 million has been generated through approx. 400 contracts signed with hydropower plants, water suppliers and tourism facilities. With annual revenues between US$ 50-6- million, FES payments have provided additional capital investment for the forestry sector, accounting for about 25% of the sector's total capital. Finally, employment opportunities have been created for 348,715 households, improving their annual income by an average of US$90/year. These amounts are currently being revised to reflect the real value of the ecosystem services.

Box 4.8 Sloping Lands Conversion Programme in PRC
Source: Extracted from Porras et al (2016)

The Sloping Land Conversion Program (SLCP, also known as "Grain for Green") is the largest ecological restoration project in PRC and PES initiative in the developing world, with a total current investment of more than US$69 billion (Liu and Lan, 2015). It was launched together with the Natural Forest Protection Program (NFPP) as a response to the severe drought of the Yellow River region in 1997 and the widespread flood of the Yangtze River in 1998. The initial objective of the programme was to reduce soil and water erosion by the targeting and conversion of 14.67 million ha of marginal farmland to forest or grassland. In 2005 "poverty alleviation" was added as an additional objective to the SLCP, to be achieved through livelihood diversification and increases in rural household incomes.

Its innovative character lies not only in its scale – targeting 25 provinces that cover about 82% of PRC's total land area – but also in its institutional design. Its hybrid form of governance combines a top-down approach with decentralization at the provincial and local government levels and voluntary participation at the household level. In practice, it works by compensating farmers for the provision and improvement of ecosystem services that they facilitate by retiring part of their land from cultivation and restoring it to either forest or grassland. In that way, it is an eco-compensation project that is distinctively different from the country's traditional command-and-control instruments of environmental governance (Jin and Wenjuan, 2010).

The program is run by the central government through the State Forestry Administration (SFA), with its finances managed by the Ministry of Finance. After deciding on country- and provincial-level reforestation tasks, the SFA distributes the retirement quotas to provincial governments who then allocate them to the counties, townships and, finally, to the participating households. By signing liability agreements, the local governments are held responsible for meeting the targets set by the SFA. Accordingly, their responsibilities include allocating the quotas, targeting the enrolled areas, determining the participants, distributing payments, providing technical support and monitoring the program's achievements.

Between 2002 and 2012, total investment for the SLCP amounted to 438.5 billion CNY or about $69 billion, including the grain subsidy, seed fund, maintenance fees, and various special funds, of which 326.2 billion (approx. $52 billion) constituted direct payments, benefitting 32 million households in 25 provinces[41] (Liu and Lan, 2015).

By 2012, the Programme had achieved the afforestation of 9.7 million ha of cropland to forest and grassland (Song *et al.*, 2014). As a result of the cropland retirement and increases in vegetation cover, research shows that the SLCP has been effective in reducing soil erosion and water runoff, evident in decreased sediment concentrations and sediment discharges into the two rivers (Zhou *et al.*, 2009). According to observations made by the Sichuan Agricultural University, silt run-off from converted lands is 22-24% less than from comparable farming lands in Tianquan County (Changjin and Chen, 2005). At the same time, the Program has largely contributed to carbon sequestration and thus climate change mitigation, with carbon concentrations having greatly increased both above and below ground, with some estimates claiming that in its first 10 years of implementation the Program managed to sequester from 222 to 468 million tons of carbon (Moberg and Persson, 2011; Song *et al.*, 2014).

[41] Amounts in US$ are estimated using the 2012 average CNY exchange rate of 1 US$ = 6.3125 CNY.

4.1.6 Public financing: local and municipal government finances for natural capital

Another important source of revenues for natural capital investment are local government revenues and expenditures. Most urban natural capital investment for ecosystem based adaptation and other purposes are financed by municipal governments. In PRC, Central Document No.1 of 2011 by the State Council requiring governments at all levels to invest 10% of revenues from property transfers into water conservancy projects. India has recently reformed its payments to local governments by central government to incentivise sustainable forestry as set out in Box 4.9.

In February 2015 the Parliament of India passed a series of ground-breaking tax reforms that include the channelling of about US$6 billion/year of tax revenues as incentives for forest conservation. The reform which increases the total amount of tax revenues allocated to the country's 29 state governments from US$60 to US$80 billion per year, also changes the way these funds are distributed. In what is called the 'horizontal devolution formula', previously based on the states' 'population', 'area' and 'income', is now added 'forest cover', meaning that the states' share of tax revenue will depend on how much of their forest area they are conserving. Progress will be monitored against data from India's 2013 Forest Survey and will affect the states' share of tax revenues with a 7.5% weight. This is important news for a number of reasons. First, US$6 billion is a significant sum that surpasses any other country's results-based finance for forest conservation. Translated into approximately US$120 per hectare per year, it compares favourably with average per hectare potential agricultural income and thus provides a strong incentive against clearing the land. Second, it is expected that these reforms will greatly contribute to the county's efforts in climate change mitigation, taking into account that its forests currently offset about 15% of its other sectors GHG emissions. Third, both the simplicity of 'forest cover' as an indicator, and the size of the funding it is tied to, are expected to grasp the interest of politicians and reinforce the role of forest conservation in the country's political dialogue. Finally, it serves as a valuable example of how countries can use smart fiscal reforms to strengthen their natural capital financing.

Box 4.9 Tax reforms in India reward local governments for forest conservation
Source: (Busch, 2015)

4.2 International public finances for natural capital investment

International public aid flows measured as Official development assistance (ODA) remains critical for some countries with special needs, such as least developed countries, landlocked developing countries and small island developing states. ODA is now declining worldwide and particularly in Asia Pacific.

The provision of ODA is also changing. First generation multilateral banks and bilateral donors may soon form a shrinking share of development finance. Their poverty, environment and climate objectives and safeguards may be less influential, while middle-income country aid, businesses, national development banks and institutions in the BRICS — Brazil, Russia, India, China and South Africa — step up with their own poverty and environment provisions. This architecture is now supplemented by — and sometimes confused by — climate finance.

Climate finance is complex, fragmented, and can be challenging to access by poor countries. The Paris Agreement calls for simplifying it, and some hope that the Green Climate Fund might become a streamlining vehicle. The convergence of official development assistance and climate finance may reduce rather than amplify options for poorer countries, with a trend for using official development assistance to finance climate mitigation in middle-income countries and declining aid for Least Developed Countries (Steele, 2015). The post-2015 agreements present an opportunity to break down siloes between climate and development finance, in particular given the commonality of some principles, including country ownership, transparency and partnership (Shine and Campillo, 2016).

4.2.1 Experience of natural capital development assistance

Many developing banks and international organisations have been financing for natural capital and biodiversity for many years and now seeking to ramp up this funding. Here were look at the experience of three institutions the World Bank, the United Nations Development Programme and the European Investment Bank, which has recently introduced a Natural Capital Investment Facility (see Table 4.2).

Table 4.2 Development assistance for natural capital investments

Institution	Strategy
The World Bank	An examination of World Bank projects completed between 1998 and 2006 found that conservation projects with development objectives such as poverty reduction and private sector development were as successful as projects focusing solely on development, contradicting common apprehensions regarding compatibility between those goals. In addition, conservation projects were found to be more successful when combined with market mechanisms and sustainable financing (Kareiva *et al.*, 2008). In its 2014 report titled *Investing in Natural Capital for Eradicating Extreme Poverty and Boosting Shared Prosperity*, the World Bank (WB) lays out its investment action plan for the sustainable use and conservation of biodiversity based on three decades of experience and the Bank's strategic objectives for the future. The WB has been at the forefront of biodiversity investments, comprising 60% of global biodiversity-related funding since the 1980s (including GEF co-financing), with a portfolio of 245 projects in 74 countries and more than US$1 billion in direct biodiversity commitments over the FY04-13 period. Reflecting on this considerable store of experience, the report offers a number of valuable observations. First, lack of explicit strategic directions in biodiversity investments provided for a diverse, resilient and demand-driven portfolio that expanded the WB's breadth of knowledge and expertise. However, portfolio fragmentation resulted in higher transaction costs and a lower focus on development impact. A clearer set of objectives, better monitoring of outcomes, and greater community engagement should help better understand biodiversity projects' impact on poverty alleviation. Second, integration of effective environmental safeguards provides for major opportunities and synergies in the wider portfolio, especially in infrastructure projects. Third, biodiversity partnerships are vital sources of knowledge and technical support and the WB should strengthen its presence and participation in them. To maximize impact, WB investments will focus on four strategic areas: 1. **Addressing policy failures and perverse economic incentives** through i) tools such as natural capital accounting, ii) financing instruments and Development Policy Operations (DPOs), and iii) partnerships such as WAVES and Net Positive Impact 2. **Improving environmental governance and public sector capacity** through i) institutional strengthening, ii) clarification of roles and responsibilities iii) greater coordination with the private sector and civil society, iv) securing land tenure and access to resources for local communities and indigenous peoples, and v) building capacity for environmental crime prevention 3. Investing in cost-effective natural infrastructure that substitutes or complements hard infrastructure, (such as watersheds and hydropower generation facilities), in climate-smart

Institution	Strategy
	agriculture, protected areas, and nature-based tourism that engages both public and private sectors 4. Generating financial flows through innovations in finance mechanisms (PES schemes, conservation trust funds, carbon finance with biodiversity co-benefits) and deeper engagement with the private sector, especially in relation to financial products and natural capital-related risks Source: (World Bank, 2014)
UNDP's ecosystems and biodiversity programmes	The United Nations Development Programme (UNDP) has been playing a fundamental role in natural capital financing with a portfolio of 512 biodiversity and ecosystems projects around 146 countries, US$1.5 billion in GEF funding and US$3.5 billion in co-financing. Its Ecosystems and Biodiversity Programme has helped establish more than 2,000 protected areas that cover 272 million hectares, and promoted ecosystem-based approaches to climate-change mitigation or adaptation in 71 countries. In its *Biodiversity and Ecosystems Global Framework 2012-2020*, the UNDP (2012) recognizes the need to scale up action and focus on innovative financial mechanisms for natural capital investments. Accordingly, UNDP has launched its three Signature Programmes with the overarching aim to "maintain and enhance the goods and services provided by biodiversity and ecosystems in order to secure livelihoods, food, water and health, enhance resilience, conserve threatened species and their habitats, and increase carbon storage and sequestration". • **Signature Programme 1** - "Integrating biodiversity and ecosystem management into development planning and production sector activities to safeguard biodiversity and maintain ecosystem services that sustain human wellbeing" • Covering multiple sectors such as fisheries, agriculture and forestry, it will promote the adoption of more sustainable production practices that come with significant social co-benefits such as job creation in nature-based tourism or producers' access to premium-markets. • **Signature Programme 2** - "Unlocking the potential of protected areas, including indigenous and community conserved areas, to conserve biodiversity while contributing towards sustainable development" • This work will focus on finding sustainable financing schemes for both terrestrial and marine protected areas to ensure the areas' effective management and secure livelihood improvements for the vulnerable groups that depend on them. Secure land tenure, rights to resource use and co-management for the local communities will be emphasized. • **Signature Programme 3** - "Managing and rehabilitating ecosystems for adaptation to and mitigation of climate change" Includes the design and implementation of ecosystem-based adaption, the expansion and connectivity of protected areas, the conservation and rehabilitation of natural ecosystems, as well as capacity building and technical support for countries to tap into new sources of financing for the conservation of ecosystems that serve as important carbon sinks.
European Investment Bank's Natural Capital Financial Facility	The Natural Capital Financial Facility (NCFF) is a new financial instrument by the European Investment Bank (EIB) and the European Commission that will, over a 2014-17 pilot period, provide a total of €125 million in natural capital (NC) financing and €10 million in capacity building. The NCFF will explore different financing options in its aim to demonstrate the potentially high returns from natural capital investments and build the case for more NC investments from the private sector. The NCFF will fund four categories of projects: i) projects involving payment for ecosystem services (PES) schemes, ii) green infrastructure projects, iii) projects developing biodiversity offsets, and iv) projects related to pro-biodiversity and adaptation businesses. To receive funding, a project must be located in the EU-28 and promote either the conservation and sustainable management of ecosystems or the application of climate-adaptation approaches. Moreover, it will have to demonstrate financial sustainability meaning that overall benefits, including economic ones, must exceed total costs. Each NCFF investment, either direct or indirect through intermediaries, will be between €5 to €15 million, financing up to 75% of total project costs, and targeting both the public and private sectors. (EIB, 2014 & 2016).

4.2.2 Reducing emissions from deforestation and forest degradation (REDD+)

One form of external finance linked to natural capital is reducing emissions from deforestation and forest degradation (REDD+). This is an international process by which developed and developing countries have committed to reducing emissions from deforestation and forest degradation, conserving and sustainably managing forests, and enhancing carbon stocks (REDD+). Developing countries receive a financial investment – through a transfer from developed countries – to manage their natural resources. Conditionality takes place at local level, using field inventories and satellite data. Countries have to prove their emissions reductions by implementing Measuring and Monitoring Systems compliant with the Measuring, Reporting and Verification (MRV) concept agreed upon by the UNFCCC. In Asia Pacific, Indonesia is the country with the most advanced REDD+ programme as set out in Box 4.10.

Box 4.10 REDD+ financing in Indonesia

Sources: UNORCID (2015); REDD Desk (2016)

Progressive in REDD+ and with ambitious emissions reduction targets of 26% by 2019, Indonesia has managed to mobilize about US$ 4.4 billion in REDD+ financing. Of this, about US$ 3 billion is in the form of concessional loans, and US$ 1.4 billion in grants and technical assistance. Bilateral assistance accounts for US$ 3.5 billion, and multilateral for US$ 0.9 billion. Important funders include the governments of Norway, Australia and Germany, UN-REDD, the WB, KfW, Agence Française de Développement, GEF and CI, among others. The biggest contribution came from the Government of Norway which in 2010 pledged up to US$ 1 billion in the form of performance-based payments with the requirement that Indonesia sets up a functional national mechanism of contributions for verified emissions reduction (VER) by 2017. In 2013 Indonesia established BP REDD+, the first national REDD+ agency in the world, which has been working on an innovative financing scheme called the Financing REDD+ in Indonesia (FREDDI). FREDDI will have to raise at least US$8 billion until 2020 and will be responsible for managing, channelling, and mobilizing REDD+ funds in support of the REDD+ National Strategy. It is designed as a fund of funds, meaning that it will invest in other funds that can be special-purpose vehicles (grants and performance-based payments) or collective investment agreements, including funding through investments, loans and carbon markets. As a strategic investment fund rather than a passive disbursement mechanism, FREDDI is expected to maximize impact and ensure long-term sustainable environmental financing.

4.3 Private sector financing – domestic and international

While the bulk of finance for sustainable natural capital comes from the government, there is evidence that the private sector can be included – including both domestic and international players. Key actors include private companies, fund managers and private foundations and the banking sector. According to a study by NatureVest and EKO (2014), private investments in integrated ecosystem management more than doubled between the periods of 2004-2008 (US$893 million) and 2009-2013 (US$1923 million).

4.3.1 Private companies and natural capital

Private companies are already heavily involved in natural capital (see also Chapter 3 on green value chains in agriculture). This includes private companies involved:

- Integrated crop protection

- Water use efficiency in agriculture
- Tourism including nature tourism and ecotourism
- Forestry plantations
- Marine fisheries – both caught fisheries and aquaculture

While many companies have a mixed record in relation to sustainable natural capital, there are growing examples of attempts to invest in natural capital conservation. Boxes 4.11, 4.12 and 4.13 illustrate some examples from fisheries, forestry and tourism.

In 2010 private equity investor The Carlyle Group made an investment of US$190 million into the China Fishery Group (CFG), thus acquiring holding of 13.62% in the company. Carlyle saw significant growth potential in the Asian fishing industry but also serious supply-chain risks for many of its businesses due to their unsustainable practices and lack of long-term vision. After extensive research and expert consultations, it chose to invest in CFG due to the company's strong marine sustainability ethos. For example, CFG does not harvest tuna, many species of which are currently being overfished and threatened with extinction. The additional capital together with Carlyle's technical expertise gave CFG the opportunity to take steps towards a more secure future and access to premium markets. A Corporate Social Responsibility Committee of the Board of Directors was created, responsible for developing CFG' sustainability policy and strategic plan for the future. The company renewed its efforts to acquire the Marine Stewardship Council (MSC) certification for its key fishing sites, a costly process that was already underway yet expedited with the additional funds available. Finally, plans were laid out to assess the biomass of its South Pacific fisheries through acoustic sounding expeditions, information that will guide CFG's fisheries management and be available in the company's sustainability reports.

As public concern about the sustainability of marine products rises, more and more companies are turning to certification standards in order to appease stakeholders and consumers, and gain access to premium markets. On example is Regal Springs, the largest vertically integrated tilapia producer in the world, and a market leader in sustainable aquaculture. In 2012 Regal Springs' tilapia farms in Indonesia were the first to receive Aquaculture Stewardship Council (ASC) certification for both their farm operations as well as their chain of custody. The ASC logo informs the consumer that the fish have been responsibly farmed and with the minimum possible adverse impact on society and the environment. Thus certification also acts as a strategic marketing tool, and companies are investing in it to differentiate their products and cater to changing consumer preferences. Since launched in 2012, ASC certification has been approved for 6289 products in 58 countries and demand is steadily growing.

Box 4.11 Private companies taking on sustainable fisheries in Asia
Source: Blinch, McCarron and Yewdall (2011).

In December 2015 New Forests, a timberland investment fund with over AUD 2.5 billion in assets, invested about US$40 million in a joint venture partnership with Indonesian firm Sampoerna Agro to grow its sustainable rubber plantation in Ketapang, West Kalimantan province, from 9,000 to more than 30,0000 hectares. The investment was financed by the New Forests' Tropical Asia Forest Fund (TAFF) which is worth US$170 million and supported by European funds, development banks, and European and American funds of funds. TAFF, focusing on the development of Southeast Asia's sustainable plantation forest industry, also manages a 34,000-hectare conservation investment in Sabah, Malaysia and is looking into similar investments in Viet Nam.

The West Kalimantan province, where the estate is located, has suffered severe environmental degradation from pulp and paper businesses and fire outbreaks, yet some forest cover has remained. This investment, among the first of this character in large-scale, sustainable forestry in Indonesia, represents an important step for commercial, environmental and social performance in the sector. Through an integrated landscape approach, it will conserve all remaining forest cover and 20% of the estate as 'high conservation value forest'. Apart from rubber production, it will set aside areas for community forestry and peatland rehabilitation. It will adhere to recognized standards such as the Forest Stewardship Council and the International Finance Corporation's environmental and social performance standards. More importantly, success in this venture is expected to send the signals for further private sector capital in sustainable forestry investments in the region.

Box 4.12 Investing in sustainable forest plantations in Indonesia
New Forests (2015) and Environmental Finance (2016).

With tourism being the biggest industry in Maldives and bringing significant revenues for the nation, private investments in ecotourism are growing. Through an US$8 million investment backed by names such as ABB and Siemens, the Champaa Brothers made the Gasfinolhu Island Resort in Maldives the first 100% solar-powered resort in the world. They have also taken additional measures to minimize environmental impact such as a centralised system that uses chilled water for air-conditioning, and a zero waste management system planned for the near future. This way, its environmentally-sensitive guests can enjoy their luxury vacations with a smaller carbon footprint. The investment is supposed to recover its cost within six to seven years, whereas without it about US$1.5 million would annually be spent on fuel.

In 2007 Hotel Investment Conference Asia Pacific (HICAP) launched the HICAP Sustainable Hotel Awards to be given to the region's hotel operators and developers who are leading the industry's path to sustainability. The prestigious award illustrates impressive innovations in energy, water and waste management, accompanied by significant contributions to wildlife and cultural conservation in the area. An important aspect and motivation behind these investments is their business case or profitability and as a report by WWF, Horwath HTL & HICAP (2010) examining three years of HICAP award nominees shows, there are important synergies between environmental and financial performance in the hospitality industry. An example comes from the Evason Phuket resort in Thailand which, when redesigning its buildings dating back to 1972, installed state-of-the-art technology to maximize its resource efficiency and thus minimize its negative impact. The investments quickly recovered their costs, bringing about significant annual cost-savings and higher revenues in the long-term.

Box 4.13 Asia's private tourist operators incorporate natural capital
Sources: WWF, Horwath HTL & HICAP, 2010; HICAP, 2016, Trade Arabia, 2016; Corporal (2016).

4.3.2 Impact investments in natural capital

The private sector plays a key role by engaging in activities such as technology, capacity building, and various types of impact investment (e.g. sustainable investing, ethical investing, and mission investing).

Impact investment -designed to make a positive measurable impact on social or environmental issues, are mainly promoted in middle-income developing countries where donors are phasing out their participation through non-conditional grants. Impact investments also foster the emergence of a larger capital pool, which might improve financial scalability of programmes and complement climate change mitigation and adaptation strategies by promoting the adoption of sustainable practices. The early-stages of impact investment are characterised by high risk compared to similar investments in other sectors, which will reduce as the local regulation and market structures are developed to be more compatible with a sustainable model. Investment instruments initially rely on venture philanthropy, ground-making equity, grants and donations and seed funding – to eventually move towards market instruments such as equity, bonds and options and securitized cash flows (CS et al. 2014).

Conservation impact investments are viable in sectors such as forestry, agriculture and sustainable land-use, carbon offsets, fisheries and marine conservation, aquaculture, wetlands, and freshwater. The forestry and ecosystem services asset class are particularly of interest, as they show a low correlation with the debt and equity markets and responses to macroeconomic conditions –an important consideration in the continuing low-interest rate environment, volatile equity and debt market. Technological transfer towards greener activities has remained the focus of the private sector, as well as participation in research and development in conjunction with publicly funded research, etc. Most R&D in green technologies is relatively low in Asia Pacific and remains an opportunity for engagement (United Nations 2012). Capacity building requires bilateral, regional and international cooperation, and should focus policies and programmes to build up required capacities at different levels.

The Athelia Climate Fund is an example of European environmental impact investment fund created in 2011, aiming to finance global sustainable land use and ecosystem service projects in developing countries in Latin America, Africa, and Southeast Asia. Together with Credit Suisse, the Fund created the Nature Conservation Notes, directed at HNWIs and quasi-public institutions that want to invest in conservation projects while receiving target market-rate returns. These investors come mainly from European and Asian countries and were selected by Credit Suisse, being qualified by the bank as wealthy investors. The Fund's projects seek to generate conservation impact, as well as, environmental assets, such as carbon credits and certified commodities, which can be sold at premium prices and, thus, produce financial returns for the investors. Currently, the Althelia Climate Fund has raised over US$105 million and is targeting a total fund size of US$ 204 million. Its first project started in 2014 in the Taita Hills, in southeastern Kenya. Income is expected to be generated through REDD+ credits certified by VCS. In Peru, where the Nature Conservation Notes have

committed US$ 7 1 million to protect 570,000 hectares of natural forest and 4,000 hectares of degraded land around parks.

4.3.3 Financial systems and natural capital

Financial system play a vital role in providing early warning systems to investments. The UNEP *Inquiry into the Design of a Sustainable Financial System*[42] for example provides in-depth information on mobilisation of financing for the transition to a sustainable, low-carbon economy. Institutions, like central banks, financial regulators, finance ministries and other government departments play key roles making the rules that affect investments. Other institutions, including market-based standard setters such as stock exchanges and credit rating agencies, help design the standards to implement and monitor investments. International organizations and platforms provide financial market development and oversight remits.

Investments in sustainable natural capital should be linked to financial systems for at least four reasons:

1) Managing risk: for example banks –and increasingly the private sector, are required to incorporate environmental and social factors into due diligence. People's Bank of China has, for example, used its balance sheet to make equity investments in China's policy-directed investment vehicles.

2) Promoting innovation and stimulate missing markets for example linked to ecosystem services. Examples include standards and incentives in "embryonic areas", such as 'green bonds', carbon offsets, etc. In India for example, a core financial policy in India is the Priority Sector Lending (PSL) requirement for banks to allocate 40% of lending to key sectors such as agriculture and small and medium-sized enterprises.

3) Strengthening resilience – taking into account costs of natural hazards affecting for example investments in agriculture and forestry e.g. linked to pension schemes.

4) Ensuring policy coherence with wider government policies, for example tuning to sectoral policies such as China and anti-pollution drive, and the Green Financial System which affects information flows, legal frameworks, fiscal incentives and institutional design. Coherence also includes working with vulnerable groups in social protection. For example, risk-pricing and supporting vulnerable groups (such as small and medium enterprises) and critical social groups (notably low-income households) being unable to gain access to regular financing.

Recent studies by Trucost (see Box 4.14 for example) show that the financial sector is underestimating the natural capital costs it is exposed to, and how the impact of [currently unpriced] decline on ecosystem services that affect their productivity can also affect financial market values. This includes, for example, banks and pension funds in Brazil through financing of activities such as cattle ranching, agriculture, fishing, and food and beverages (Carreira et al. 2015). A similar study in India reveals that banks and investors are

[42] http://web.unep.org/inquiry

exposed to financial risks from loans they provide to businesses with natural capital intensive sectors such as agriculture and power generation, as well as industries including food processing and iron and steel manufacturing. Government policy mandating loans to agriculture increases this exposure (Harvey et al. 2015).

These risks include: a) the increase in compliance costs as stricter regulations come into play, b) risks from droughts and resource shortages which disrupt supply chains, c) reputational damage from unsustainable business operations; and d) shifts in consumer preferences towards greener products, e.g. renewable energy and resource efficiency.

The impact on the banking sector is not negligible (Trucost PLC 2013, Harvey et al. 2015). Indian banks are financing business sectors with a total natural capital cost of INR 90,496 billion, equivalent to 2.9 times the credit provided to those sectors. If these natural capital costs were internalized by borrowers, it would impact their ability to repay loans significantly.

- Financial institutions should acquire more detailed data on sector exposure to natural capital risks as a priority. Banks and investors should use natural capital valuation to quantify and manage the natural capital risks they face through corporate loans and equity investments, and integrate natural capital costs in their decision-making processes and encourage investments into resource efficiency. They can use their influence with companies to encourage improved disclosure of environmental performance data.
- Banks should provide training in natural capital valuation to enable employees to quantify exposure to natural capital risks. Risk managers, credit analysts and other key staff should be given the skills to move beyond a qualitative understanding of environmental and social issues towards quantification and analysis of natural capital risks.
- Sector-specific natural capital considerations should be included in credit analysis. Banks should try to identify the most significant operational and supply chain impacts of a sector, so that they can develop appropriate assessments and incorporate these into financial analysis.
- Long-term timeframes present significant opportunities for product innovation. The impacts of climate change are expected to become more severe in future. Banks can become more resilient by incorporating environmental factors into long-term loan decisions. They can also finance projects that have a net environmental benefit such as renewable energy, sustainable farming, and industrial resource efficiency. Indian banks can use this study to assess whether the natural capital costs generated by a sector are from direct operations or its supply chain.
- Financial institutions should work with the Indian government and other stakeholders to develop a national green accounting framework. India was the first country in the world to commit to developing green national accounts, and work is underway to deliver this ambition. Banks, investors, companies, governments, economists and environmentalists need to work together to successfully develop and implement this framework.

Box 4.14 Recommendations on natural capital for financial institutions: lessons from India
Source: Harvey *et al.,* (2015).

5 Discussion: challenges and opportunities

This section identifies challenges with natural capital ecosystem investments and how they can be addressed. It focuses on market failure, government failure and capacity and managerial failure.

5.1 Market failure: market signals that undermine natural capital

Natural capital is undervalued by the market and thereby suffers from what economists call "market failure". Market failure can take several forms as set out below:

- *Public goods*: This includes the fact that many natural resources are public goods (e.g clean water and clean air) and so their use is what economists call "non-excludable" and "non-rival" so there is no incentive for them to be provided by the private sector.
- *Externality*: Much natural capital damage is "external" to the price mechanism and is not costed and accounted for by the perpetrator (e.g pollution of a river). These damage costs negatively impact society through pollution.
- *High discount rates*: The fact that markets only take account of current consumers with preferences for consumption in the present (high discount rates) rather than the future means that there is a lack of inter-generational equity. This particularly affects natural capital whose loss may be irreversible (eg loss of species) or very slow (time for soils or underground aquifers to regenerate) and so future generations, who will benefit from natural capital, are not present to ensure effective management occurs. This can be seen in the way that farmers will mine soils or cut down trees for present consumption.
- Missing tenure and property rights: Many natural capital assets, such as fisheries and waterbodies have weak or limited property rights so there is "open access" leading to overuse of the resource.

Market failures can be addressed by some form of government intervention. For example the government can introduce regulations or environmental taxation and pricing to overcome the externality or ensure that enough natural capital is provided to support future generations. The challenge is that where the state takes on a greater role it can also be subject to government and management "failure".

5.2 Governance, regulatory and economic disincentives

State management and control of natural capital may be as problematic as lack of an effective market. In some cases this may be due to state inefficiency. Examples include poorly managed state timber companies or poorly planted timber plantations. In other cases, the State may be subject to political influence which allows natural capital to be legally and illegally extracted, often with involvement of political elites. Thus the State may provide subsidies for natural capital destruction for political objectives or to promote perceived short term growth objectives.

Governance and regulatory failure can be addressed by range of political, economic and legal reforms. Some of these aspects have been discussed in detail in the "core enablers" sections of What to Invest, in Chapter 3.

- Anti-corruption and enforcement drive in selected countries (eg to reduce illegal forestry),
- Increased community participation (eg community forestry and fisheries in many countries),
- Greater transparency and public pressure (eg public information and right to information legislation) and
- Use of third party monitors and regulators (eg certification schemes and legislation, civil society watchdogs).

5.3 Capacity and management challenges

There may also be ways in which the state (or other actors such as a multilateral development bank) may face challenges in managing natural capital or in designing natural capital loans. The primary reason will be a lack of financial and human capacity to properly manage natural capital, as well as the inherent management challenges in natural capital projects.

Many government have weak and disempowered ministries in charge of natural capital with a vicious cycle of under-resourcing leading to further limited capacity and limited implementation. This can be addressed by making natural capital agencies self-financing so that they have an incentive to improve performance and increase their funding base. Thus some agencies responsible for forestry, fisheries, parks and wildlife may be able to retain their own user-fees and reinvest them to sustain the natural resource base.

This requires a supportive Ministry of Finance and Ministry of Economic planning who appreciate the economic and social benefits provided by investment in sustainable natural capital. This can be achieved by undertaking economic analysis to make the case. This can be achieved both by micro level analysis and by macro level such as natural capital accounting.

Natural capital are often spatially difficult to manage as they cut across economic sectors (agriculture, industry, urban etc) and political and administrative boundaries such as local government or city boundaries. Thus watersheds cut across administrative boundaries and are impacted by different sectors including agriculture and infrastructure. The same applies to forests or marine resources. The disconnect of this natural capital with economic and political sectors means that they may have no clear institutional home within government and so may be viewed as a lower priority.

This can be addressed by Institutional reforms such as the creation of a Ministry of Natural Resources which brings together relevant natural resource departments. Still the key activities that affect natural capital may lie outside these department's control, such as agricultural or urban activities impacting on coastal resources or agricultural expansion impacting forests. Even when there are a limited number of Ministries, management may

be complex. For example management of protected areas in Viet Nam is split between the Ministry of Agriculture, the Ministry of Natural Resources and local governments leading to conflicting objectives (GEF, 2015).

The spatial challenge of natural capital cutting across different administrative boundaries requires an integrated spatial approach for natural capital. Examples include integrated water resource management, integrated watershed management and integrated coastal resource management. More recently there has been move towards an even broader spatial approach with a "landscape" approach. This is reviewed further in section 4 which will show that while these integrated and landscape spatial approaches have some advantages, they can also have disadvantages and the procs and cons needs to be carefully considered.

Natural capital projects may also bring management challenges with the high transaction costs of multiple small projects, often with community involvement. This can be addressed by decentralisation and community management programme often linked to public works programmes as with the Sloping Land Conversion project in China, the Rural Employment Guarantee project in India and the Greening the Nation project in the Philippines which are explored more in section 5.

A final management challenge with natural capital projects may be the high monitoring and enforcement costs. Examples include monitoring and enforcement of forestry, wildlife and coastal fisheries to ensure compliance and to prevent illegality and crime. Often this may be made difficult or even dangerous due to political factors. These challenges can be overcome by appropriate funding for monitoring and enforcement often with those caught contributing to the costs such as offshore fishing fleets that contribute to fishing inspection or wildlife fines being used for further enforcement. A share of the fines can also be used for those at the front line of enforcement such as wildlife rangers taking on poachers to provide an incentive for this otherwise low paid and dangerous work.

6 Conclusions

Why invest? Whether on a farm, a megacity or a reef, the lives of Asia Pacific's people are linked to the goods and services provided by nature. These ecosystems provide economic wealth, jobs and revenues. They complement physical infrastructure. They particularly benefit the most vulnerable women and men. But this natural capital is under pressure and investment in sustainable management is urgent to ensure these benefits continue in the future. The reasons to invest in natural capital are:

1) Natural capital provides many critical benefits to people, through the goods and services they provide and as complement to infrastructure.
2) Natural capital is an important source of wealth, accounting for significant proportion of GDP, exports, and government revenues.
3) The social returns are high, in terms of jobs, incomes and ways out of poverty through small-scale enterprises. Ecosystem-based adaptation reduces the climate risks for millions of poor and vulnerable people across Asia Pacific.
4) Economic rates of return, at national and project level can be significant, and the cost of preventing degradation is lower than the cost of inaction.
5) The urgency of action to protect, rehabilitate and sustainably manage natural capital increases as the natural base is rapidly lost.
6) There are solutions to the challenges of natural capital investment: This involves targeted investments as well as institutional and market reforms.

How to finance? Natural capital investments have high economic returns, but this needs to translate into finance, especially if loans are to be repaid. Finance is increasing for natural capital from national and international public and private sources. PRC is leading the way and other countries and companies will follow as Asia Pacific develops and its natural capital base becomes scarcer and more valuable. The main messages from our analysis of financing sources are:

1) Asia Pacific countries are reforming fiscal systems- including taxes and subsidies-to raises funds for natural capital investment. This includes forestry taxes in Indonesia, fishery taxes in the Pacific and water taxes in PRC.
2) These fiscal reforms provide a "virtuous circle" of finance and incentives to invest in more sustainable finance, through forestry funds and conservation funds. These forest funds exist in many countries including India, Indonesia, Lao PDR, Philippines and Viet Nam.
3) Private finance – both national and international – is playing a growing role. The private sector is already a key player in agricultural technology, tourism, forestry and fisheries. These companies are starting to finance more sustainable investments, but much more could be done. Consumer pressure, stricter regulations and new technology encourage this finance.

4) International public finance is important, particularly for climate, but will shift to more loan finance over time. The international community has been funding natural capital for some time. This will grow particularly with respect to climate finance. But with tight budgets, donors will prefer more loan finance.
5) Financial system play a vital role in providing early warning systems to investments. Regulating institutions, like central banks, financial regulators, finance ministries and other government departments play key roles making the rules that affect investments. Other financial bodies and market-based standard setters such as stock exchanges and credit rating agencies help design the standards to implement and monitor investments. International organizations and platforms provide financial market development and oversight remits.
6) PRC's national and provincial government and companies are leaders in financing natural capital, but other countries will follow. PRCs finance of natural capital is driven by the demand from a more educated, more concerned population where natural capital is also under threat. These conditions are likely to develop in the rest of Asia Pacific.

References

Abdullah, A.N., Kumar, P., 2014. The influence of roadside vegetation barriers on airborne nanoparticles and pedestrians exposure under varying wind conditions. *Atmospheric Environment*, Volume 90, June 2014, Pages 113-124, ISSN 1352-2310, http://dx.doi.org/10.1016/j.atmosenv.2014.03.040 (www.sciencedirect.com/science/article/pii/S1352231014002258).

Adams, M.P. and Smith, P.L., 2014. A systematic approach to model the influence of the type and density of vegetation cover on urban heat using remote sensing. *Landscape and Urban Planning*, 132, pp.47-54.

ADB Urban Operational Plan 2012-2020.

ADB Case study: GMS-FBP Collaborative Management for Watershed and Ecosystem Service Protection and Rehabilitation in the Cardamom Mountains, Upper Prek Thnot River.

ADB. *Water for All Policy* and *Water Operational Plan 2011–2020.*

ADB ref TO BE ADDED LATER

ADB. 2009. *Energy Policy.*

ADB. 2012. *Climate Risk and Adaptation in the Electric Power Sector* in 2012.

ADB. 2013. *Guidelines for Climate Proofing Investment in the Energy Sector* in 2013.

ADB. 2005. Financial Management and Analysis of Projects. Asian Development Bank Manila.

ADB. 2008. Strategy 2020: The Long-term Strategic Framework of the Asian Development Bank 2008-2020. Available from www.adb.org/sites/default/files/institutional-document/32121/strategy2020-print.pdf (www.adb.org/about/our-work).

ADB. 2011. Energy for all: Viet Nam's sucess in increasing access to energy through rural electricification. Asian Development Bank, Mandaluyong City, Philippines.

ADB. 2011b. Guidelines for climate proofing investment in the transport sector: road infrastructure projects. See: www.adb.org/documents/guidelines-climate-proofing-investment-transport-sector-road-infrastructure-projects

ADB. 2013. ADB's Support for Achieving the Millennium Development Goals. Thematic Evaluation Study. Available from www.adb.org/sites/default/files/evaluation-document/36005/files/tes-mdg.pdf

ADB. 2013. Environment Operational Directions 2013-2020: Promoting Transitions to Green Growth in Asia and the Pacific. www.adb.org/sites/default/files/institutional-document/33869/environment-operational-directions-2013-2020.pdf

ADB. 2013. Operational Manual. Bank Policies. Available from www.adb.org/sites/default/files/page/30786/files/oma1.pdf

ADB. 2014. Midterm Review of Strategy 2020: Meeting the Challenges of a Transforming Asia and Pacific. Available from www.adb.org/sites/default/files/institutional-document/34149/files/midterm-review-strategy-2020-r-paper.pdf

ADB. 2014. Midterm Review of Strategy 2020: Meeting the Challenges of a Transforming Asia and Pacific. Available from www.adb.org/sites/default/files/institutional-document/34149/files/midterm-review-strategy-2020-r-paper.pdf

ADB. 2015. Key Indicators for Asia and the Pacific. 46th Edition. www.adb.org/sites/default/files/publication/175162/ki2015.pdf

ADB. 2015. Annual Report. Scaling up to Meet New Development Challenges. Available from www.adb.org/sites/default/files/institutional-document/182852/adb-annual-report-2015.pdf

ADB. 2016a. Asian Development Outlook 2016: Asia's potential growth. Asian Development Bank, Manila.

ADB. 2016b. Asian Water Development Outlook 2016: strenthening water security in Asia and the Pacific, Manila.

ADB. 2015c. Operational Plan for Agriculture and Natural Resources: Promoting Sustainable Food Security in Asia and the Pacific in 2015–2020. See: www.adb.org/documents/operational-plan-agriculture-and-natural-resources-2015-2020

Adhikari, B., 2005. Poverty, property rights, and collective action: understanding the distributive
aspects of common property resource management. *Environment and Development Economics* 10, 7–31.

Agarwal, C., Tiwari, S., Borgoyary, M., Acharya, A., Morrison, E., 2007. Fair deals for watershed services in India. Natural Resource Issues No. 10. International Institute for Environment and Development, London, UK.

Albert, 2013.

Albert, J.A, Warren-Rhodes, K., Schwarz, A.J. and Duke. N.D., 2012. Mangrove ecosystem services and payments for blue carbon in Solomon Islands, The World Fish Center, Solomon Islands. AAS-2012-06.

Alexandri, E. and Jones, P., 2008. Temperature decreases in an urban canyon due to green walls and green roofs in diverse climates. *Building and Environment*, 43(4), pp.480-493.

Alexandratos, N. and Bruinsma, J., 2012. World agriculture towards 2030/2050. The 2012 revision. Food and Agriculture Organization of the United Nations.

Alongi, D.M., 2002. Present state and future of the world's mangrove forests. *Environmental conservation*, 29(03), pp.331-349.

Alongi, D., 2009. The energetics of mangrove forests. Springer Science & Business Media.

Andam, K.S., Ferraro, P.J., Sims, K.R.E., Healy, A. and Holland, M.B., 2010. Protected areas reduced poverty in Costa Rica and Thailand, *Proceedings of the National Academy of Sciences of the United States of America*, Vol. 107 No. 22, pp. 9996–10001.

Andersson, E., Barthel, S., Borgström, S., Colding, J., Elmqvist, T., Folke, C. and Gren, Å., 2014. Reconnecting cities to the biosphere: Stewardship of green infrastructure and urban ecosystem services. *Ambio*, 43(4), pp.445-453.

Angel *et al.,* (2011)

Armson, D., Stringer, P. and Ennos, A.R., 2012. The effect of tree shade and grass on surface and globe temperatures in an urban area. *Urban Forestry & Urban Greening*, 11(3), pp.245-255.

ASC in numbers – August 2016. 2016. Aquaculture Stewardship Council (ASC). Available at: www.asc-aqua.org/index.cfm?act=tekst.item&iid=2&iids=306&lng=1 [accessed 2 September 2016].

Aw-Hassan, A., Korol, V., Nishanov, N., Djanibekov, U., Dubovyk,O. and Mirzabaev, A., 2016. Economics of Land Degradation and Improvement in Uzbekistan in: *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*. Eds: Nkonya, E., Mirzabaev, A. and von Braun, J., Springer International Publishing, Cham, Switzerland. http://dx.doi.org/10.1007/978-3-319-19168-3

Baig, S.P., Rizvi, A., Josella, M. and Palanca-Tan, R., 2015. Cost and Benefits of Ecosystem Based Adaptation: The Case of the Philippines. IUCN, Gland, Switzerland.

Barbier *et al.*, 2008.

Bartens, J., Day, S.D., Harris, J.R., Dove, J.E. and Wynn, T.M., 2008. Can urban tree roots improve infiltration through compacted subsoils for stormwater management? *Journal of Environmental Quality*, 37(6), pp.2048-2057.

Bekturganov, Z., Tussupova, K., Berndtsson, R., Sharapatova, N., Aryngazin, K. and Zhanasova, M., 2016. Water related health problems in Central Asia—A review. *Water* 8.

Bellard *et al.*, 2012.

Upadhyay, B., 2005. Women and natural resource management: Illustrations from India and Nepal. *Natural Resources Forum* 29, pp. 224–232, checked on 8/24/2016.

Blinch, J., McCarron, B., and Yewdall, K., 2011. *The Future of Fish in Asia*. Responsible Research. Available at: www.sustainalytics.com/sites/default/files/the_future_of_fish_in_asia-issues_for_responsible_investors_0.pdf [accessed 2 September 2016].

Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., Little, D., Ross, L., Handisyde, N., Gatward, I. and Corner, R., 2010. Aquaculture: global status and trends. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 365(1554), pp.2897-2912.

Braimoh and Huang, 2014.

Brauer, M., Freedman, G., Frostad, J., van Donkelaar, A., Martin, R.V., Dentener, F., van Dingenen, R., Estep, K., Amini, H., Apte, J.S., Balakrishnan, K., Barregard, L., Broday, D., Feigin, V., Ghosh, S., Hopke, P.K., Knibbs, L.D., Kokubo, Y., Liu, Y., Ma, S., Morawska, L., Sangrador, J.L.T., Shaddick, G., Anderson, H.R., Vos, T., Forouzanfar, M.H., Burnett, R.T. and Cohen, A., 2016. Ambient Air Pollution Exposure Estimation for the Global Burden of Disease 2013. *Environmental Science & Technology* 50:79-88.

Breukink, G., Levin, J. and Mo, K., 2015. Profitability and Sustainability in Responsible Forestry: economic impacts of FSC certification on forest operators. WWF, Foundation Lombard Odier, Swedish International Development Cooperation Agency, Form Valuations.

Brook *et al.*, 2008.

Brotto, L., Pettenella, D., Cerutti, P., and Pirard, R., 2016. Planted forests in emerging economies. Best practices for sustainable and responsible investments. CIFOR, Bogor, Indonesia.

BTFEC, 2015.
Bullock, A. and Acreman, M., 2003. The role of wetlands in the hydrological cycle. Hydrology and *Earth System Sciences Discussions*, 7(3), pp.358-389.
Busch, J., 2015. India's Big Climate Move. [Blog] *Views from the Center*. Available at: www.cgdev.org/blog/indias-big-climate-move [accessed 3 September 2016].
Calder, I., 2005. The Blue Revolution: land use and integrated water resources management. Earthscan Publications Ltd, London, UK.
Cameron, R.W., Blanuša, T., Taylor, J.E., Salisbury, A., Halstead, A.J., Henricot, B. and Thompson, K., 2012. The domestic garden–Its contribution to urban green infrastructure. *Urban Forestry & Urban Greening*, 11(2), pp.129-137.
Cao, S., 2008. Why large-scale afforestation efforts in China have failed to solve the desertification problem. *Environmental Science and Technology* 42:1826-1831.
Capital Region Watershed District, 2012. BMP performance and cost-benefit analysis: Arlington Pascal project 2007-2010. Cited in Demuzere, M., Orru, K., Heidrich, O., Olazabal, E., Geneletti, D., Orru, H., Bhave, A.G., Mittal, N., Feliu, E. and Faehnle, M., 2014. Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. *Journal of environmental management*, 146, pp.107-115.
Carreira, D., Re-em, A., and Tarin, M., 2015. Natural capital risk exposure of the financial sector in Brazil. Trucost, BMZ, GIZ, CEBDS, World Business Council for Sustainable Development (WBCSD).
Chakma, G.K., Carino, J., Lasimbang, A., Trakansuphakon, P., Franthing, T., Truong, L.T., Pinto, F., 2010. Traditional Livelihoods and Indigenous Peoples. Thailand: Asia Indigenous Peoples Pact (AIPP) Foundation. Available online at www.iwgia.org/publications/search-pubs?publication_id=663 [checked on 8/25/2016].
Changjin and Chen, 2005.
Chen *et al*., 2015.
CHINA SoE, 2014.
Christensen, V., Coll, M., Piroddi, C., Steenbeek, J., Buszowski, J. and Pauly, D., 2014. A century of fish biomass decline in the ocean. *Marine ecology progress series*, 512, pp.155-166.
Chung, K.F., Zhang, J. and Zhong, N., 2011. Outdoor air pollution and respiratory health in Asia. *Respirology* October 16:1023-1026.
Coase, R.H., 1960. The Problem of Social Cost. *Journal of Law and Economics* 3:1-44.
Collier, 2006.
Coombes, E., Jones, A.P. and Hillsdon, M., 2010. The relationship of physical activity and overweight to objectively measured green space accessibility and use. *Social science & medicine*, 70(6), pp.816-822.
Coral Reef Alliance, 2014. Namena Marine Reserve User Fee Manual: Procedures and guidelines for the design, production, distribution, and sale of dive tags supporting the sustainable management of Fiji's Namena Marine Reserve. Available at: http://coral.org/wordpress/wp-content/uploads/2014/02/Namena-Marine-Reserve-Dive-Tag-Manual-FINAL.pdf [accessed 6 September 2016].

Corporal, J., 2016. Maldives has the world's first solar-powered resort. *The Holiday Place*. [online] Available at: http://holidayplace.co.uk/news/details/115835/maldives-has-the-worlds-first-solar-powered-resort [accessed 2 September 2016].

Costello and Ward, 2006.

CS, WWF, and McKinsey, 2014. Conservation Finance: Moving beyond donor funding toward an investor-driven approach. Credit Suisse, WWF, McKinsey&Company.

Cunniff, S. and Schwartz, A., 2015. Performance of natural infrastructure and nature-based measures as coastal risk reduction features. Environmental Defense Fund, September.

Danone-Fund-for-Nature, 2010. Achieving carbon offsets through mangroves and other wetlands. In: Davidson, N. (Ed.), Expert workshop meeting. Danone Group/IUCN/Ramsar Convention Secretariat, Gland, Switzerland, p. 87 pp.

de Abreu-Harbich, L.V., Labaki, L.C. and Matzarakis, A., 2015. Effect of tree planting design and tree species on human thermal comfort in the tropics. *Landscape and Urban Planning*, 138, pp.99-109.

Das, N, 2011. Women's dependence on forest and participation in forestry. A case study of joint forest management programme in West Bengal. *Journal of Forest Economics* 17 (1), pp. 67–89. DOI: 10.1016/j.jfe.2010.09.003.

Davis, 2005.

Deng, X. and Li, Z., 2016 Economics of Land Degradation in China in: *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*. Eds: Nkonya, E., Mirzabaev, A. and von Braun, J., Springer International Publishing, Cham, Switzerland. http://dx.doi.org/10.1007/978-3-319-19168-3

De Groot, R.S., Blignaut, J., Van Der Ploeg, S., Aronson, J., Elmqvist, T. and Farley, J., 2013. Benefits of Investing in Ecosystem Restoration. *Conservation Biology* 27:1286-1293.

De Groot, R., Brander, L., Van Der Ploeg, S., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L. and Hussain, S., 2012. Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem services*, 1(1), pp.50-61.

Devisscher, T., 2010. Ecosystem-based Adaptation in Tanzania. Ecosystems.

Dewulf, A., Meijerink, S. and Runhaar, H., 2015. Editorial: The governance of adaptation to climate change as a multi-level, multi-sector and multi-actor challenge: a European comparative perspective. *Journal of Water and Climate Change*, 6(1), pp.1-8.

Di Lorenzo, M., Claudet, J. and Guidetti, P., 2016. Spillover from marine protected areas to adjacent fisheries has an ecological and a fishery component. *Journal for Nature Conservation*, 32, pp.62-66.

Dixon, M.J.R., Loh, J., Davidson, N.C., Beltrame, C., Freeman, R. and Walpole, M., 2016. Tracking global change in ecosystem area: The Wetland Extent Trends index. *Biological Conservation* 193:27-35.

d'Odorico, P., Francesco Laio, Amilcare Porporato, Luca Ridolfi, A. Rinaldo, and I. Rodriguez-Iturbe. 2010. Ecohydrology of Terrestrial Ecosystems. *BioScience* 60:898-907.

Dominguez, G. 2015. How much is pollution costing China's economy? An interview with Qingfeng Zhang from ADB. Top stories: Asia.

Dorji, 2013.

Duan *et al.*, 2015.

Duarte, C.M., 1991. Seagrass depth limits. *Aquatic botany*, 40(4), pp.363-377.

Duarte, 2002.
Duarte, C.M., Dennison, W.C., Orth, R.J. and Carruthers, T.J., 2008. The charisma of coastal ecosystems: addressing the imbalance. *Estuaries and coasts*, 31(2), pp.233-238.
Dudley, N., Mansourian, S., Stolton, S. and Suksuwan, S. (2008), Safety net. Protected areas and poverty reduction, available at: www.iucn.org/content/safety-net-protected-areas-and-poverty-reduction (accessed 5 August 2016).
Duncan, J., Dash, J. and Tompkins, E.L., 2014. Mangrove forests enhance rice cropland resilience to tropical cyclones: evidence from the Bhitarkanika Conservation Area. In: Dudley, N., Buyck, C., Furuta, N., Pedrot, C., Renaud, F.G. and Sudmeier-Rieux, K., 2015. Protected areas as tool for disaster risk reduction. A handbook for practitioners. Ministry of Environment, Japan and International Union for Conservation of Nature and Natural Resources.
Duncker, P. S., Raulund-Rasmussen, K., Gundersen, P., Katzensteiner, K., De Jong, J., Ravn, H.P., Smith, M., Eckmüllner, O. and Spiecker, H., 2012. How Forest Management affects Ecosystem Services, including Timber Production and Economic Return: Synergies and Trade-Offs. *Ecology and Society* 17.
EIB. 2014. Natural Capital Financing Facility. European Investment Bank (EIB). Available at: http://ec.europa.eu/environment/life/funding/financial_instruments/documents/ncff_leaflet.pdf [accessed 6 September 2016].
Eib.org. (2016). *Natural Capital Financing Facility*. [online] Available at: www.eib.org/products/blending/ncff/index.htm [accessed 6 September 2016].
Ellis, J.B., 2012. Sustainable surface water management and green infrastructure in UK urban catchment planning. *Journal of Environmental Planning and Management*, 56(1), pp.24-41.
Ellison, D., Futter, M.N. and Bishop, K., 2012. On the forest cover–water yield debate: from demand-to supply-side thinking. *Global Change Biology*, 18(3), pp.806-820.
Emerton, L., Baig, S. and Saleem, M., 2009. Valuing Biodiversity. The economic case for biodiversity conservation in the Maldives. AEC Project Report, Ministry of Housing, Transport and Environment, Government of the Maldives and UNDP, Maldives. Available at: http://cmsdata. iucn. org/downloads/the_economic_case_for_biodiversity_in_the_maldives_1.pdf [accessed 10 January 2010].
Environmental Finance, 2016. *Sustainable forestry 2016: New Forests and Sampoerna Agro*. [online] Available at: hwww.environmental-finance.com/content/deals-of-the-year/sustainable-forestry-2016-new-forests-and-sampoerna-agro.html [accessed 31 August 2016].
FAO. 2007 STATUS AND TRENDS IN MANGROVE AREA EXTENT WORLDWIDE www.fao.org/docrep/007/j1533e/J1533E02.htm
FAO World Review of Fishing 2008 ftp://ftp.fao.org/docrep/fao/011/i0250e/i0250e.pdf
FAO, 2011.
FAO, 2012.
FAO, 2015a. Forests, trees and disasters. Unasylva: An international journal of forestry and forest industries 243/244.

FAO, 2015b. Global forest resources assessment 2015: desk reference. Food and Agriculture Organization of the United Nations, Rome.

FAO, 2015c. The State of World Fisheries and Aquaculture 2014 Opportunities and challenges A

FAO. Forest area (% of land area). *in* e. f. a. w. s. Food and Agriculture Organization, editor [accessed in June 2016].

FAO and RECOFTC, 2016. Forest landscape restoration for Asia-Pacific forests. Food and Agriculture Organisation of the United Nations (FAO); The Center for People and Forests (RECOFTC), Bangkok.

Farrugia, S., Hudson, M.D. and McCulloch, L., 2013. An evaluation of flood control and urban cooling ecosystem services delivered by urban green infrastructure. International Journal of Biodiversity Science, *Ecosystem Services & Management*, 9(2), pp.136-145.

Fay, M., Hallegatte, S., Bangalore, M., Kane, T., Rozenberg, J., Vogt-Schilb, A., Narloch, U., Bonzanigo, L. and Treguer, D., 2015. Shock Waves: Managing the impacts of climate change on Poverty. World Bank Publications.

Ferrario, F., Beck, M.W., Storlazzi, C.D., Micheli, F., Shepard, C.C. and Airoldi, L., 2014. The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. *Nature communications*, 5.

Ferraro, P.J., Hanauer, M.M. and Sims, K.R.E. (2011), Conditions associated with protected area success in conservation and poverty reduction*, Proceedings of the National Academy of Sciences of the United States of America*, Vol. 108 No. 34, pp. 13913–13918.

Forbes, K. and Broadhead, J., 2011. Forests and landslides: the role of trees and forests in the prevention of landslides and rehabilitation of landslide-affected areas in Asia. Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific, Bangkok.

Fourqurean, J.W., Duarte, C.M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M.A., Apostolaki, E.T., Kendrick, G.A., Krause-Jensen, D., McGlathery, K.J. and Serrano, O., 2012. Seagrass ecosystems as a globally significant carbon stock. *Nature Geoscience*, 5(7), pp.505-509.

Frumkin, H., 2003. Healthy places: exploring the evidence. *American journal of public health*, 93(9), pp.1451-1456.

Fui, Lim Hin; Luohui, Liang; Camacho, Leni D.; Combalicer, Edwin A.; Singh, Savinder Kaur Kapar, 2012. Southeast Asia. In John A. Parrotta, Ronald L. Trosper: Traditional Forest-Related Knowledge. Sustaining Communities, *Ecosystems and Biocultural Diversity*, vol. 12. Dordrecht: Springer Science+Business Media B.V (World Forests, 12), pp. 357–394, checked on 8/25/2016.

GEF, 2015. Impact Evaluation of Protected Areas.

Ghermandi, A., Bixio, D., Traverso, P., Cersosimo, I. and Thoeye, C., 2007. The removal of pathogens in surface-flow constructed wetlands and its implications for water reuse. *Water Science and Technology*, 56(3), pp.207-216.

Giesen, W., Wulffraat, S., Zieren, M. and Scholten, L., 2006. 'FAO and Wetlands International. Mangrove Guidebook for Southeast Asia. Dharmasarn Co., Ltd, pp.501-502.

Giri, C., Ochieng, E., Tieszen, L.L., Zhu, Z., Singh, A., Loveland, T., Masek, J. and Duke, N., 2011. Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography*, 20(1), pp.154-159.

Government of China, 2015. China's Policies and Actions on Climate Change (2015). The National Development and Reform Commission, Beijing.

Government of India, 2014. Report to the people: Mahatma Gandhi National Rural Employment Guarantee Act, 2005. Ministry of Rural Development, Department of Rural Development, New Delhi.

Gray, K.A. and Finster, M.E., 2000. The urban heat island, photochemical smog, and Chicago: Local features of the problem and solution. Northwestern University, Department of Civil Engineering.

Greenwood, C., Scoville, O. and UNEP, 2012. Building a Green Economy in the Heart of Borneo: South-South Cooperation between Brunei Darussalam, Indonesia, and Malaysia. United Nations Environment Programme, Division of Regional Cooperation, UN Reform, South-South Cooperation, Nairobi, Kenya.

Grieg-Gran, M. and Bass, S., 2011. Forests: investing in natural capital.

Grim *et al*., 2008.

Grimes, 2008.

Gross National Happiness Commission, 2012. *Bhutan's Five Year Plan 2013-2018*. Gross National Happiness Commission, Royal Government of Bhutan.

Guarascio, F., Gunewardena, N., Holding-Anyonge, C., Kaaria, S., Stloukal, L., Sijapati Basnett, B. *et al.,* 2013. Forest, food security and gender: linkages, disparities and priorities for action. FAO. Rome.

Guha-Sapir, D., Guha-Sapir, R. and P. H. Below. EM-DAT: The CRED/OFDA International Disaster Database (www.emdat.be). *in* U. C. d. Louvain, editor. World Bank, Brussels, Belgium.

Mythili, G. and Goedecke, J., 2016. Economics of Land Degradation in India, in: *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*. Eds: Nkonya, E., Mirzabaev, A. and von Braun, J., Springer International Publishing, Cham, Switzerland. http://dx.doi.org/10.1007/978-3-319-19168-3

GWP, 2014. Integrated water resources management in Central Asia: The challenges of managing large transboundary rivers. Global Water Partnership.

GWP, 2015. Based on Siebert *et al*., 2010.

Hajat, S. and Kosatky, T., 2010. Heat-related mortality: a review and exploration of heterogeneity. *Journal of Epidemiology and Community Health*, 64(9), pp.753-760.

Halpern, B.S., Walbridge, S., Selkoe, K.A., Kappel, C.V., Micheli, F., D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E. and Fujita, R., 2008. A global map of human impact on marine ecosystems. *Science*, 319(5865), pp.948-952.

Hamilton, S.E. and Casey, D., 2016. Creation of a high spatio-temporal resolution global database of continuous mangrove forest cover for the 21st century (CGMFC-21). *Global Ecology and Biogeography*, 25(6), pp.729-738.

Hansen, J., Ruedy, R., Sato, M. and Lo, K., 2010. Global surface temperature change. *Reviews of Geophysics*, 48(4).

Hao *et al.,* 2013.

Harvey, L., Colina, L., Ravi, A. and Tarin, M., 2015. Natural capital risk exposure of the financial sector in India. Trucost, BMZ, GIZ.

He *et al.*, 2014.

He and Lang, 2015.

Heck Jr, K.L., Carruthers, T.J., Duarte, C.M., Hughes, A.R., Kendrick, G., Orth, R.J. and Williams, S.W., 2008. Trophic transfers from seagrass meadows subsidize diverse marine and terrestrial consumers. *Ecosystems*, 11(7), pp.1198-1210.

Hicapconference.com, 2016. *HICAP*. [online] Available at: http://hicapconference.com/hicap-home/ [accessed 2 September 2016].

Hoegh-Guldberg, O., Mumby, P.J., Hooten, A.J., Steneck, R.S., Greenfield, P., Gomez, E., Harvell, C.D., Sale, P.F., Edwards, A.J., Caldeira, K. and Knowlton, N., 2007. Coral reefs under rapid climate change and ocean acidification. *Science*, 318(5857), pp.1737-1742.

Hood, M.J., Clausen, J.C. and Warner, G.S., 2007. Comparison of stormwater lag times for low impact and traditional residential development. *Journal of the American Water Resources Association* Volume 43, Issue 4 pp 1036–1046.

(Hughes *et al.*, 2008.)

ICCTF, 2016.

IIED, 2003.

IFAD, 2008. Improving access to land and tenure security. IFAD, Rome. www.cpahq.org/cpahq/cpadocs/Land Access Rural Communities.pdf

Ilstedt, U., Tobella, A.B., Bazié, H.R., Bayala, J., Verbeeten, E., Nyberg, G., Sanou, J., Benegas, L., Murdiyarso, D., Laudon, H. and Sheil, D., 2016. Intermediate tree cover can maximize groundwater recharge in the seasonally dry tropics. Scientific reports, 6.

IMF, 2014. Asia and Pacific Small States Monitor, Quarterly Bulletin, *Special Topic* — Leveraging Marine Fishery Resources: Implications for Fiscal Policy, www.imf.org/external/np/apd/ssm/2014/0414.pdf

IMF, 2015. World economic outlook database, October 2015. See: www.imf.org/external/pubs/ft/weo/2015/02/weodata/index.aspx

Inniss, L., Simcock, A., Ajawin, A.Y., Alcala, A.C., Bernal, P., Calumpong, H.P., Araghi, P.E., Green, S.O., Harris, P., Kamara, O.K. and Kohata, K., 2016. The First Global Integrated Marine Assessment.

ITS, 2011. The Economic Contribution of Indonesia's Forest-Based Industries. ITS Global.

Jackson, L.E., Pascual, U. and Hodgkin, T., 2007. Utilizing and conserving agrobiodiversity in agricultural landscapes. *Agriculture, Ecosystems & Environment*, 121(3), pp.196-210.

Jacobson, C.R., 2011. Identification and quantification of the hydrological impacts of imperviousness in urban catchments: A review. *Journal of environmental management*, 92(6), pp.1438-1448.

Jaramillo, J., Setamou, M., Muchugu, E., Chabi-Olaye, A., Jaramillo, A., Mukabana, J., Maina, J., Gathara, S. and Borgemeister, C., 2013. Climate change or urbanization? Impacts on a traditional coffee production system in East Africa over the last 80 years. *PloS one*, 8(1), p.e51815.

Jiahua, Pan; Haibing, Ma; Ying, Zhang, 2011. Green Economy and Green Jobs in China. Current Status and Potentials for 2020. Worldwatch Institute. Washington, D.C. (Worldwatch Report 185).

Jin and Wenjuan, 2010.
Jodha, N.S., 1986. Common property resources and rural poor in dry regions of India. *Economic and Political Weekly,* 21, 1169–1181.
Jones, H.P., Hole, D.G. and Zavaleta, E.S., 2012. Harnessing nature to help people adapt to climate change. *Nature Climate Change*, 2(7), pp.504-509.
Jong, H, 2016. Govt to reform forestry revenue system to foil rampant graft. *The Jakarta Post*. [online] Available at: www.thejakartapost.com/news/2016/02/23/govt-reform-forestry-revenue-system-foil-rampant-graft.html [accessed 4 September 2016].
Juffe-Bignoli, D., Bhatt, S., Park, S., Eassom, A., Belle, E.M.S., Murti, R., Buyck, C., Raza Rizvi, A., Rao, M., Lewis, E., MacSharry, B. and Kingston, N., 2014. Asia Protected Planet Report 2014: Tracking progress towards targes for protected areas in Asia. World Conservation Monitoring Centre of the United Nations Environment Programme.
Kareiva, P., Chang, A. and Marvier, M., 2008. Development and Conservation Goals in World Bank Projects. *Science*, Vol. 321, pp. 1638–1639.
Kaźmierczak, A., 2013. The contribution of local parks to neighbourhood social ties. *Landscape and Urban Planning*, 109(1), pp.31-44.
Kerwath, S.E., Winker, H., Götz, A. and Attwood, C.G., 2013. Marine protected area improves yield without disadvantaging fishers. *Nature Communications*, 4.
Kirwan, M.L. and Megonigal, J.P., 2013. Tidal wetland stability in the face of human impacts and sea-level rise. *Nature* 504, 53–60.
Kirwan, M.L., Temmerman, S., Skeehan, E.E., Guntenspergen, G.R. and Fagherazzi, S., 2016. Overestimation of marsh vulnerability to sea level rise. *Nature Climate Change*, 6(3), pp.253-260.
Kjellstrom, T., Holmer, I. and Lemke, B., 2009. Workplace heat stress, health and productivity – an increasing challenge for low and middle-income countries during climate change. *Global Health Action*, 2, 10.3402/gha.v2i0.2047. http://doi.org/10.3402/gha.v2i0.2047
Koch, E.W., Sanford, L.P., Chen, S.N., Shafer, D.J. and Smith, J.M., 2006.Waves in seagrass systems: review and technical recommendations (No. ERDC-TR-06-15). MARYLAND UNIV CAMBRIDGE CENTER FOR ENVIRONMENTAL SCIENCE.
Köhler, M., Schmidt, M., Wilhelm Grimme, F., Laar, M., Lúcia de Assunção Paiva, V. and Tavares, S., 2002. Green roofs in temperate climates and in the hot-humid tropics-far beyond the aesthetics. *Environmental management and health*, 13(4), pp.382-391.
Kossoy, A., Oppermann, K., Platanova-Oquab, A. and Suphachalasai, S., 2014. State and trends of carbon pricing. World Bank Group, Climate Change, Washington DC.
Kouskya, C., 2010. Using natural capital to reduce disaster risk. *Journal of Natural Resources Policy Research* 2:343-356.
KPK, 2015. Preventing State Losses in Indonesia's Forestry Sector: An Analysis of Non-tax Forest Revenue Collection and Timber Production Administration. 1st ed. [ebook] Komisi Pemberantasan Korupsi (KPK). Available at: http://acch.kpk.go.id/documents/10180/445776/Preventing+State+Losses+in+Indonesia's+Forestry+Sector+-+KPK+Research+Report.pdf/4d7695a4-de4e-4bcb-8f4b-c645238c000e [accessed 4 September 2016].

Krasny, M.E. and Tidball, K.G., 2009. Applying a resilience systems framework to urban environmental education. *Environmental Education Research*, 15(4), pp.465-482.

Krishnaswamy, J., Bonell, M., Venkatesh, B., Purandara, B. K., Rakesh, K. N., Lele, S. and Badiger, S., 2013. The groundwater recharge response and hydrologic services of tropical humid forest ecosystems to use and reforestation: Support for the "infiltration-evapotranspiration trade-off hypothesis". *Journal of Hydrology*, 498, 191-209.

Lavorel, S., Colloff, M.J., Mcintyre, S., Doherty, M.D., Murphy, H.T., Metcalfe, D.J., Dunlop, M., Williams, R.J., Wise, R.M. and Williams, K.J., 2015. Ecological mechanisms underpinning climate adaptation services. *Global change biology*, 21(1), pp.12-31.

Lawrence, D. and Vandecar, K., 2015. Effects of tropical deforestation on climate and agriculture. *Nature climate change*, 5(1), pp.27-36.

Layton, K. and Ellison, D., 2016. Induced precipitation recycling (IPR): A proposed concept for increasing precipitation through natural vegetation feedback mechanisms. *Ecological Engineering*, 91, pp.553-565.

Leadley *et al.*, 2010.

Lebedys, A. and Li, Y., 2007. Contribution of the forestry sector to national economies, 1990-2011. Food and Agriculture Organization of the United Nations, Rome.

Lee, G. and Kim, M., 2016. Shallow Landslide Assessment Considering the Influence of Vegetation Cover. *Journal of the Korean Geoenvironmental Society*, 17(4), pp.17-31.

Leisher, C., van Beukering, P. and M. Scherl, L., 2007. Nature's Investment Bank. How Marine Protected Areas Contribute to Poverty Reduction, available at: www.scribd.com/doc/55899585/Nature-s-Investment-Bank-How-marine-protected-areas-contribute-to-poverty-reduction (accessed 5 August 2016).

Lewis, R.R., Phillips, M.J., Clough, B. and Macintosh, D.J., 2002. Thematic review on coastal wetland habitats and shrimp aquaculture. Report prepared under the World Bank, NACA, WWF and FAO Consortium Program on Shrimp Farming and the Environment, 81. http://library.enaca.org/Shrimp/Case/Thematic/FinalMangrove.pdf

Li *et al.*, 2015.

Liu, W., Chen, W. and Peng, C., 2014. Assessing the effectiveness of green infrastructures on urban flooding reduction: A community scale study. *Ecological Modelling*, 291, pp.6-14.

(Liu and Lan, 2015.)

Lloyd, D., 1996. Seagrass: A lawn too important to mow. Great Barrier Reef Marine Park Authority: Townsville, Qld.

Lotze, H.K., Lenihan, H.S., Bourque, B.J., Bradbury, R.H., Cooke, R.G., Kay, M.C., Kidwell, S.M., Kirby, M.X., Peterson, C.H. and Jackson, J.B., 2006. Depletion, degradation, and recovery potential of estuaries and coastal seas. *Science*, 312(5781), pp.1806-1809.

Maas, J., Verheij, R.A., de Vries, S., Spreeuwenberg, P., Schellevis, F.G. and Groenewegen, P.P., 2009. Morbidity is related to a green living environment. *Journal of Epidemiology and Community Health*, 63(12), pp.967-973.

Macusi, E.D., Katikiro, R.E., Deepananda, K.A., Jimenez, L.A., Conte, A.R. and Fadli, N., 2011. Human induced degradation of coastal resources in Asia Pacific and implications on management and food security. *Journal of Nature Studies*, 9, pp.13-28.

Maldives Inland Revenue Authority, 2015. *Annual Report 2014*. Maldives Inland Revenue Authority.

Mandle, L., Wolny, S, Hamel, P., Helsingen, H., Bhagabati, N. and Dixon, A., 2016. Natural connections: How natural capital supports Myanmar's people and economy. WWF-Myanmar.

Mantyka-Pringle *et al*., 2011.

Mass *et al*., 2009, demonstrated that the annual prevalence rate of 15 of the 24 disease clusters was lower in living environments with more green space within a 1 km radius.

Matta, 2015.

Granahan, G., Balk, D. and Anderson, B., 2007. The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and Urbanization*, 19(1), pp.17-37.

McIvor, A.L., Möller, I., Spencer, T. and Spalding, M., 2012. Reduction of wind and swell waves by mangroves. The Nature Conservancy and Wetlands International.

Mckinney, 2006.

MA, 2005.

MEA, 2005. Ecosystems and human well-being: biodiversity synthesis, Washington D.C.

Methods for mangrove ecosystem services. *Ecol. Indicat*., 230: 431-446.

Meehl, G.A., Stocker, T.F., Collins, W.D., Friedlingstein, P., Gaye, A.T., Gregory, J.M., Kitoh, A., Knutti, R., Murphy, J.M., Noda, A. and Raper, S.C., 2007. Global climate projections. *Climate Change*, 3495, pp.747-845.

Mentens, J., Raes, D. and Hermy, M., 2006. Green roofs as a tool for solving the rainwater runoff problem in the urbanized 21st century? *Landscape and Urban Planning*, 77(3), pp.217-226.

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-being: Synthesis. Island Press, Washington, DC.

Miller, M. A. and T. Bunnell, editors, 2016. *Asian Cities in an Era of Decentralisation*. Routledge Taylor & Francis Group, London and New York.

Mirzabaev, A., Goedecke,J., Dubovyk, O., Djanibekov, U., Le, Q.B. and Aw-Hassan, A., 2016. Econokics of Land Degradation in Central Asia in: *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*. Eds: Nkonya, E., Mirzabaev, A. and von Braun, J., Springer International Publishing, Cham, Switzerland. http://dx.doi.org/10.1007/978-3-319-19168-3

Mitsch, W.J., Zhang, L., Stefanik, K.C., Nahlik, A.M., Anderson, C.J., Bernal, B., Hernandez, M. and Song, K., 2012. Creating wetlands: primary succession, water quality changes, and self-design over 15 years. *Bioscience*, 62(3), pp.237-250.

Moberg and Persson, 2011.

Moberg and Ronnback, 2003 (from Jones).

Moss, R.H., Meehl, G.A., Lemos, M.C., Smith, J.B., Arnold, J.R., Arnott, J.C., Behar, D., Brasseur, G.P., Broomell, S.B., Busalacchi, A.J. and Dessai, S., 2013. Hell and high water: practice-relevant adaptation science. *Science*, 342(6159), pp.696-698.

Mullan and Kontoleon, 2008.

Munang, R., Thiaw, I., Alverson, K., Mumba, M., Liu, J. and Rivington, M., 2013. Climate change and Ecosystem-based Adaptation: a new pragmatic approach to buffering

climate change impacts. *Current Opinion in Environmental Sustainability*, 5(1), 67-71. Pacific Climate.

Naish, A., 2016a. Government revenue increases in first half of 2016. *Maldives Independent*. [online] Available at: http://maldivesindependent.com/business/government-revenue-increases-13-in-2016-124811 [accessed 6 September 2016].

Naish, A., 2016b. Tourist arrivals reach 1.2m in 2015. *Maldives Independent*. [online] Available at: http://maldivesindependent.com/business/tourist-arrivals-reach-1-2m-in-2015-121424 [accessed 6 September 2016].

Narain, Urvashi, Shreekant Gupta, Klaas van 't Veld, 2005. Poverty and the Environment: Exploring the Relationship between Household Incomes, Private Assets, and Natural Assets, Resources.

Narayan, S., Beck, M.W., Reguero, B.G., Losada, I.J., van Wesenbeeck, B., Pontee, N., Sanchirico, J.N., Ingram, J.C., Lange, G.M. and Burks-Copes, K.A., 2016. The Effectiveness, Costs and Coastal Protection Benefits of Natural and Nature-Based Defences. *PloS one*, 11(5), p.e0154735.

Natural Capital Coalition, 2016. Natural Capital Protocol.

NatureVest and EKO, 2014. Investing in conservation: a landscape assessment of an emerging market., The Nature Conservancy, Arlington, VA.

Naumann, S., Anzaldua, G., Berry, P., Burch, S., Davis, M., Frelih-Larsen, A., Gerdes, H. and Sanders, M., 2011. Assessment of the potential of ecosystem-based approaches to climate change adaptation and mitigation in Europe. Final report to the European Commission, DG Environment.

Neumann, B., Vafeidis, A.T., Zimmermann, J. and Nicholls, R.J., 2015. Future coastal population growth and exposure to sea-level rise and coastal flooding-a global assessment. *PloS one*, 10(3), p.e0118571.

New Forests, 2015. Sustainability Report. Available at: www.newforests.com.au/new-forests-releases-2015-sustainability-report/ [accessed 31 August 2016].

Nicholls *et al.,* 2008.

Nowell, K. and Pervushina, N., 2015. *REVIEW OF IMPLEMENTATION OF RESOLUTION CONF. 12.5 (REV. COP16) ON CONSERVATION OF AND TRADE IN TIGERS AND OTHER APPENDIX-I ASIAN BIG CAT SPECIES*. [online] Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Available at: https://cites.org/sites/default/files/eng/com/sc/65/E-SC65-38-A01_0.pdf [accessed 5 September 2016].

OECD, 2012.

OECD and IEA, 2013. Southeast Asia Energy Outlook. International Energy Agency and ERIA, Paris, France.

OECD and IEA, 2015. World Energy Outlook.

Onishi *et al.,* 2010.

Parmesan, 2006.

Parrotta, JA., Trosper, RL., 2012. Traditional forest-related knowledge. Sustaining communities, ecosystems and biocultural diversity. Dordrecht: Springer (World Forests, 12), checked on 8/25/2016.

Pauleit, S., Liu, L., Ahern, J. and Kaźmierczak, A., 2011. Multifunctional green infrastructure planning to promote ecological services in the city. *Urban ecology*. Oxford University Press, Oxford, pp.272-286.

Peña, H., 2011. Social equity and Integrated Water Resources Management. Global Water Partnership.

Perret, S. R., Babel, M.S., Rahatwal, S.D. and Yamsiri, R., 2010. Resource efficiency and ecosystem services in rice production in Thailand's central plain: baseline research. Asian Institute of Technology (AIT) and CIRAD (UMR G-Eau).

Perry, C. T., Kench, P.S., O'Leary, M.J., Morgan, K.M. and Januchowski-Hartley, F., 2015. Linking reef ecology to island building: Parrotfish identified as major producers of island-building sediment in the Maldives. *Geology*, DOI: 10.1130/G36623.1

Pigou, A.C., 1920. The Economics of Welfare. Macmillan and Co., London.

Piper A and Smith P.L. 2015 SPREP-USAID Choiseul Ecosystem based Adaptation PLAN FOR Choiseul Bay.

Porras, I., Steele, P and Mohammed, E.Y., 2016. Upscaling solutions: The role of conditional transfers for poverty reduction and ecosystem management. International Institute for Environment and Development, London, UK.

Porras, I., Vorley, B., Amrein, A., Douma, W. and Clemens, H., 2015. Payments for ecosystem services in smallholder agriculture: lessons from the Hivos-IIED learning trajectory. IIED, Hivos, London.

Prabhu, N. May 7, 2016. Poor execution of watershed projects caused water crisis. The Hindu, Bengaluru.

Pramova, E., Locatelli, B., Djoudi, H. and Somorin, O.A., 2012. Forests and trees for social adaptation to climate variability and change. *Wiley Interdisciplinary Reviews: Climate Change*, 3(6), pp.581-596.

Pravongviengkham, P., Khamhung, A., Sysanhouth, K. and Qwist-Hoffmann, P., 2003. Integrated watershed management for sustainable upland development and poverty alleviation in Lao People's Democratic Republic *in* Proceedings of the Asian Regional Workshop on Watershed Management.

PwC, 2016. *China takes a closer step towards the completion of the Resource Tax Reform*. [online] Available at: www.pwccn.com/home/eng/chinatax_news_may2016_17.html [accessed 4 September 2016].

Rai, N., Kaur, N., Greene, S., Wang, B. and Steele, P., 2015. Topic guide: A guide to national governance of climate finance. International Institute for Environment and Development, London, UK.

Ramakrishnan, P.S., Rao, K.S., Chandrashekara, U.M., Chhetri, N., Gupta, H.K., Patnaik, S., *et al.,* 2012. South Asia. In: John A. Parrotta, Ronald L. Trosper: Traditional Forest-Related Knowledge. Sustaining Communities, *Ecosystems and Biocultural Diversity*, vol. 12. Dordrecht: Springer Science+Business Media B.V (World Forests, 12), pp. 315–356, checked on 8/25/2016.

Ramsar, no date. Wetland ecosystem services factsheets. In: Secretariat, R.C. (Ed.).

Ramsar Secretariat, R. S. T. R. P. a. B. C. S. 2007. Water, wetlands, biodiversity and climate change. Report on outcomes of an expert meeting. Gland, Switzerland.

Rao N.S., Carruthers T.J.B., Anderson P., Sivo L., Saxby T., Durbin, T., Jungblut V., Hills T. and Chape S., 2012. An economic analysis of ecosystem-based adaptation and engineering

options for climate change adaptation in Lami Town, Republic of the Fiji Islands. A technical report by the Secretariat of the Pacific Regional Environment Programme.
Ratnadass, A., Fernandes, P., Avelino, J. and Habib, R., 2012. Plant species diversity for sustainable management of crop pests and diseases in agroecosystems: a review. *Agronomy for sustainable development*, 32(1), pp.273-303.
Rausser and Small, 2000.
The REDD Desk, 2016.
Reddy, S.R.C., Chakravarty, S.P., 1999. 'Forest dependence and income distribution in a subsistence economy: evidence from India', *World Development* 27, 1141–1149.
Rogelj, J., den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., Schaeffer, R., Sha, F., Riahi, K. and Meinshausen, M., 2016. Paris Agreement climate proposals need a boost to keep warming well below 2 C. *Nature*, 534(7609), pp.631-639.
Rogner, H.-H., Zhou, D., Bradley, R., Crabbé, P., Edenhofer, O., Hare, B., Kuijpers, L.Y., M., 2007. Introduction. In: Metz, B., Davidson, O., Bosch, P., Dave, R., Meyer, L.A. (Eds.), Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA.
Rose, S., Peters, N.E., 2001. Effects of urbanization on streamflow in the Atlanta area (Georgia, USA): a comparative hydrological approach. *Hydrological Processes,* 15, 1441e1457.
Ross, L., Arrow, K., Cialdini, R., Diamond-Smith, N., Diamond, J., Dunne, J., Feldman, M., Horn, R., Kennedy, D., Murphy, C. and Pirages, D., 2016. The Climate Change Challenge and Barriers to the Exercise of Foresight Intelligence. *BioScience*, 66(5), pp.363-370.
Ruckelshaus, M., Doney, S.C., Galindo, H.M., Barry, J.P., Chan, F., Duffy, J.E., English, C.A., Gaines, S.D., Grebmeier, J.M., Hollowed, A.B. and Knowlton, N., 2013. Securing ocean benefits for society in the face of climate change. *Marine Policy*, 40, pp.154-159.
Satterwaithe, 2007.
Schuyt, K., 2005. Freshwater and Poverty Reduction: Saving People, Saving Nature (Worldwide Fund for Nature, 2005).
Schwendenmann, l., Veldkamp, E., Moser, G,H., Olscher, D., Kohler, M., Clough, Y., Anas, I., Djajakirana, G., Erasmi, S. and Hertel, D., 2010. Effects of an experimental drought on the functioning of a cacao agroforestry system, Sulawesi, Indonesia. *Glob Change Biol* 2010, 16:1515–1530.
Shackleton, C.M. and Blair, A., 2013. Perceptions and use of public green space is influenced by its relative abundance in two small towns in South Africa. *Landscape and Urban Planning*, 113, pp.104-112.
Shanahan, D.F., Lin, B.B., Bush, R., Gaston, K.J., Dean, J.H., Barber, E. and Fuller, R.A., 2015. Toward Improved Public Health Outcomes From Urban Nature. *American Journal of Public Health* 105:470-477.
Shepard *et al*., 2011.
Shine and Campillo, 2016.
Simpson *et al.,* 1996.

Singha, K., 2012. Nexus Between Tourism and Environment in Bhutan. *American Journal of Tourism Management*, [online] 1, pp.1-9. Available at: http://article.sapub.org/10.5923.j.tourism.20120101.01.html

Sloan, S. and Sayer, J., 2015. Forest Resources Assessment of 2015 shows positive global trends but forest loss and degradation persist in poor tropical countries. *Forest Ecology and Management*, 352.

Small, C. and Nicholls, R.J., 2003. A global analysis of human settlement in coastal zones. *Journal of Coastal Research*, pp.584-599.

Socialist Republic of Vietnam, 2007. Viet Nam Forestry Development Strategy 2006-2020. Viet Nam.

Solecki *et al.,* 2013.

Solomons Government National Census, 2009 Volume 1.

Song *et al.*, 2014.

Spracklen, D.V., Arnold, S.R., Taylor, C.M., 2012. Observations of increased tropical rainfall preceded by air passage over forests. *Nature* 489, 282–285.

Stanton, T., Echavarria, M., Hamilton, K., Ott, C., 2010. State of watershed payments: an emerging marketplace. Ecosystem Marketplace, Washington, DC.

Steele, 2015.

Suich, H., 2012. Conceptual framework: Poverty. ESPA, DFID, ESRC, NERC, London.

Sunderland, T., Achdiawan, R., Angelsen, A., Babigumira, R., Ickowitz, A., Paumgarten, F., *et al.*, 2014. Challenging Perceptions about Men, Women, and Forest Product Use. A Global Comparative Study. In: *World Development* 64, pp. S56-S66. DOI: 10.1016/j.worlddev.2014.03.003.

Svirejeva- Hopkins *et al.,* 2004.

Syahrani, 2013.

TEEB, 2009. Chapter 5 'Rewarding benefits through payments and markets'. The Economic of Ecosystems and Biodiversity: TEEP for national and international policy makers.

Thorsson, S., Honjo, T., Lindberg, F., Eliasson, I. and Lim, E.M., 2007. Thermal comfort and outdoor activity in Japanese urban public places. *Environment and Behavior*.

Tilley, D.R. and Brown, M.T., 1998. Wetland networks for stormwater management in subtropical urban watersheds. *Ecological Engineering*, 10(2), pp.131-158.

Tiwari, K. R., Bajracharya, R.M. and Sitaula, B.K., 2008. Natural resource and watershed management in South Asia: a comparative evaluation with special reference to Nepal. *The Journal of Agriculture and Environment* 9.

Tiwari, R., Somashekhar, H.I., Parama, V.R.R., Murthy, I.K., Mohan Kumar, M.S., Mohan Kumar, B.K., Parate, H., Varma, M., Malaviya, S., Rao, A.S., Sengupta, A., Kattumuri, R. and Ravindranath, N.H., 2011. MGNREGA for environmental service enhancement and vulnerability reduction: rapid appraisal in Chitradurga district, Karnataka. *Economic and Political Weekly* 46:39-47.

Trade Arabia, 2016). Maldives invests in the future of tourism. [online] Available at: www.tradearabia.com/news/TTN_302623.html [accessed 2 September 2016].

Tri, N. H., Adger, W. N. and Kelly, P.M., 1998. Natural resource management in mitigating climate impacts: The example of mangrove restoration in Vietnam. *Glob. Environ. Change,* 8, 49–61 (1998).

Trung, 2015.

Trucost PLC, 2013. Natural Capital at Risk: The Top 100 Externalities of Business. London, UK.

UNDESA, 2014.

UNDP, 2012. The Future We Want: Biodiversity and Ecosystems— Driving Sustainable Development. United Nations Development Programme Biodiversity and Ecosystems Global Framework 2012-2020. New York: United Nations Development Programme (UNDP). Available at: www.undp.org/content/undp/en/home/librarypage/environment-energy/ecosystems_and_biodiversity/biodiversity-and-ecosystems-global-framework-2012-to-2020.html [accessed 6 September 2016].

(UN, 2015b.)

UNEP, 2010. From concept to practice: Key features, lessons learned and recommendations from implementation of the IWRM 2005 Target. UNEP.

UNEP, 2011.

UNEP, 2014.

UNEP, 2015. World Oceans Report.

UNESCAP, 2000.

UNESCAP, 2014. Statistical Yearbook for Asia and the Pacific 2014. Available at: www.unescap.org/sites/default/files/ESCAP-SYB2014.pdf [accessed 6 September 2016].

UNESCO-WWAP, 2006. Water: a shared responsability: The United Nations World Water Development Report 2. United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris.

(UN Habitat, 2013.)

United Nations, 2012. Low Carbon Green Growth Roadmap for Asia and the Pacific: turning resource constraints and the climate crisis into economic growth opportunities. United Nations ESCAP; Korea International Cooperation Agency, Bangkok.

UNORCID, 2015.

UN Secretariat, 2014.

Uriarte, M., Yackulic, C.B., Lim, Y. and Arce-Nazario, J.A., 2011. Influence of land use on water quality in a tropical landscape: a multi-scale analysis. *Landscape Ecology*, 26(8), pp.1151-1164.

Valiela, I., 2006. Global Coastal Change. Blackwell, Oxford, 368 pp.

van Eijk, P., Kumar, R., 2009. Bio-rights in theory and practice: a financing mechanism for linking poverty alleviation and environmental conservation. Wetlands International, Wageningen, The Netherlands, p. 134.

Vignola, R., Harvey, C.A., Bautista-Solis, P., Avelino, J., Rapidel, B., Donatti, C. and Martinez, R., 2015. Ecosystem-based adaptation for smallholder farmers: Definitions, opportunities and constraints. *Agriculture, Ecosystems & Environment*, 211, pp.126-132.

VNFF, 2014.

Vo, Q.T., Kuenzer, C., Vo, Q.M., Moder, F. and Oppelt, N., 2012. Review of valuation.

Vos, P.E., Maiheu, B., Vankerkom, J. and Janssen, S., 2013. Improving local air quality in cities: to tree or not to tree? *Environmental pollution*, 183, pp.113-122.

Walther, 2010.

Wang, J., 2016. Green Taxation Stepped up. *Beijing Review*. [online] Available at: www.bjreview.com/Business/201608/t20160801_800063634.html [accessed 4 September 2016].

Wang and Maclaren, 2012.

Waycott, M., Duarte, C.M., Carruthers, T.J., Orth, R.J., Dennison, W.C., Olyarnik, S., Calladine, A., Fourqurean, J.W., Heck, K.L., Hughes, A.R. and Kendrick, G.A., 2009. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences*, 106(30), pp.12377-12381.

West *et al*., 2012.

Whitten, S., Shelton, D., 2005. Markets for ecosystem services in Australia: practical design and case studies.

WOA, 2015.

WHO, 2002. The world health report 2002: reducing risks, promoting healthy life. World Health Organization.

WHO, 2009. Global health risks: mortality and burden of disease attributable to selected major risks. World Health Organization.

WHO, 2014. Burden of disease from air pollution for 2012. World Health Organisation, Geneva, Switzerland.

World Bank megacities report.

World Bank, 2010. The changing wealth of nations: measuring sustainable development in the new millennium. The World Bank, Environment and Development, Washington D.C.

World Bank, 2010. Climate Risks and Adaptation in Asian Coastal Megacities: A Synthesis Report.

World Bank, 2011. The changing wealth of nations: Measuring Sustainable Development in the New Millennium. Washington D.C.

World Bank Group, 2014. Turn Down the Heat: Confronting the New Climate Normal. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/20595 License: CC BY-NC-ND 3.0 IGO.

World Bank Group, 2014. *Investing in Natural Capital for Eradicating Extreme Poverty and Boosting Shared Prosperity: A Biodiversity Roadmap for the WBG*. Agriculture and Environmental Services Discussion Paper 11. [online] World Bank. Available at: http://documents.worldbank.org/curated/en/798341468331028202/pdf/887530REVISED000NC0385272B00PUBLIC0.pdf [accessed 5 September 2016].

World Bank, 2016. Data.worldbank.org. Available at: http://data.worldbank.org/ [accessed 6 September 2016].

WRI, 2013-3, based on IFDC.org

WWF, 2012. Forests and Wood Products. WWF Living Forests Report: Chapter 4.

WWF, Horwath HTL and HICAP, 2010. Towards the Business Case for Sustainable Hotels in Asia: Motivations and Impacts of Sustainable Hotel Development in Asia. Available at: http://sustain.pata.org/towards-the-business-case-for-sustainable-hotels-in-asia-motivations-and-impacts-of-sustainable-hotel-development-in-asia/ [accessed 2 September 2016].

Xiao, Q. and McPherson, E.G., 2011. Performance of engineered soil and trees in a parking lot bioswale. *Urban Water Journal*, 8(4), pp.241-253.

Xinhua News Agency, 2016. *Resource Tax is Coming, with Four Signs Showing How Tax Drives Green Economic Growth*. [online] Available at: www.chinatax.gov.cn/2013/n2925/n2953/c2256050/content.html [accessed 4 September 2016].

Yeo-Chang, Youn, Jinlong, Liu, Daisuke, Sakuma, Kiweon, Kim, Ichikawa, Masahiro, Joon-Hwan, Shin, Juanwen, Yuan, 2012. Northeast Asia. In: John A. Parrotta, Ronald L. Trosper: Traditional Forest-Related Knowledge. Sustaining Communities, Ecosystems and Biocultural Diversity, vol. 12. Dordrecht: Springer Science+Business Media B.V (World Forests, 12), pp. 281–313, checked on 8/25/2016.

(Yin *et al.*, 2014a.)

Yin and Zhao, 2012.

Zhai *et al.*, 2014.

Zhang, D.Q., Jinadasa, K.B.S.N., Gersberg, R.M., Liu, Y., Tan, S.K. and Ng, W.J., 2015. Application of constructed wetlands for wastewater treatment in tropical and subtropical regions (2000–2013). *Journal of Environmental Sciences*, 30, pp.30-46.

Zhang, Q., Crooks, R. and Jiang, Y., 2011. Environmentally sustainable development in the People's Republic of China: visions for the future and the role of the Asian Development Bank. Asian Development Bank, Manila, the Philippines.

(Zhou *et al.*, 2009.)

Annex 1: Biophysical relations

This section presents a summary of the scientific evidence of the impacts of ecosystem management on the provision of natural capital and associated ecosystem services.

Forests and freshwater ecosystems

Water controls the dynamic of terrestrial ecosystems – as a driver for the biota and the abiotic processes on the Earth surface. At the same time, the management of these ecosystems plays a key role modulating several hydrological processes for example soil moisture dynamics and river flow. By affecting evapotranspiration and controlling surface runoff terrestrial ecosystems (like protected areas and agricultural and forests areas) play a crucial role in the water cycle (Calder 2005, Paolo D'Odorico et al. 2010).

Investments in natural capital that promote sustainable management of ecosystems can have important benefits to people, by impacting different ecosystem services. These impacts can be assessed through the individual consumption or production functions, or at macroeconomic levels by aggregating societal benefits (MEA 2005, De Groot *et al,* 2013, Perret *et al* 2010). The nature of the ecosystem service is highly associated with the particular ecosystem, in this case wetlands:

- Provisioning services, including vital staples, such as rice and fish. Harvesting and commercialization of wetland products range takes place at all levels and intensities, from subsistence to intensive exploitation from multinational corporations. The economic values associated are strongly linked to the particular ecosystem and their geography. Fisheries in the Lower Mekong basin (shared by Cambodia, Laos and Viet Nam) for example contribute to the livelihoods of the basin's 55 million people many of whom depend on fishing.
- Water quantity and regulation: open-air wetlands (including lakes, rivers, and swamps) and groundwater reserves are one of the main sources of freshwater. The impacts on river flow and hydrological regimes vary depending on the type of wetland, as well as actual precipitation. Generally, inland wetlands can store water during wet periods, which can be used as a reserve during dry periods. The upper parts of river wetlands (peat land or marshland) can slow down rainwater runoff and spring snowmelt.
- Microclimate: The extra evaporation from wetlands and forests can bring a local microclimate cooling benefit (Perret et al. 2010).
- Flood control: Wetlands enable excess water to spread out over a wide area. Floodplain wetlands reduce floods and their peaks, or delay them, and many wetlands in the headquarters of river systems do the same -unless saturation levels are reached or compromised by land conversion
- Groundwater recharge: Evidence on the impact on groundwater recharge is uncertain, and highly dependent on season, hydrological conditions, and type of soil (permeable, impermeable rock). Some wetlands may have no contact at all with

groundwater – for example a lake that has formed over a thick, impermeable layer of clay – while others owe their very existence to groundwater that has returned to the surface either as springs, or areas of more general seepage. If wetlands occur over permeable sediments overlying aquifers, water is able to percolate through the soil into the aquifer below and recharge groundwater. The magnitude of the impact also depends on whether the water table is high or low.

- Water quality: Production of nutrients in wetlands depends on type, climate, and how much is left in the system when plants die or are harvested. Wetlands act as 'sediment traps', floodplains have been traditionally used by agriculture.
- Pollution control: There is well established evidence that wetlands contribute to pollution control and detoxification of agricultural runoff and sewage effluent (principally phosphorous and nitrogen). Wetlands 'lock-up' pollutants in their sediments, soils and vegetation. By preventing flow of these nutrients downstream, wetlands help reduce the risk of eutrophication. For example the 8,000 hectare East Kolkata Wetland Ramsar Site (tree-fringe canals, vegetable plots, rice paddies, fish ponds) help to transform refuse and sewage disposal generating additional local benefits. For example, the Mudialy Fishermen's Cooperative Society uses several natural treatment processes manage a fish farm and nature park, with an annual turn-over of over US$135,000 in 2005/06 (Ramsar Convention Secretariat, 2011)
- Shoreline stabilization and storm protection (UNISDR/UNDP 2012): The roots of wetland plants in coastal areas (coral reefs, mangroves, salt marshes and tidal flats) bind the shoreline together and act as a physical barrier slows down the impact of natural destructive phenomena like storm surges and tidal waves. For example shore protection of the Rekawa mangrove/lagoon system in Sri-Lanka has been estimated at about US$60,000/year, which represents approximately 30% of its total economic value. In the Caribbean this value is estimated between US$700 thousand to US$2 million per year.
- Protection of biodiversity: Many coastal ecosystems such as mangroves, estuaries, and seagrass beds are extremely rich in biodiversity, and many species of plants and animals they support are highly dependent or endemic, and provide important services supporting fisheries food chains (UNISDR/UNDP 2012).
- Carbon and GHG reductions: Wetlands (especially peatland, mangroves, and saltmarshes) are sources for methane and sulphur compounds, and provide opportunities for reducing or fixing carbon and nitrogen by avoiding conversion to other land uses or reducing the intensity of present use (http://wetcarbon.com). Conversion of peatlands, for example, generate high amount of carbon emissions. Paddy rice –a cultivated form of wetland - is a major source of GHG emissions and high contributor to climate change. Flooded rice grows under anaerobic conditions, which favour methane formation and release. This potentially provides opportunities for reduction of GHG through cropland management and improved water and rice cropping patterns (Perret et al. 2010). Overall results indicate that the long-term negative effect of methane emissions is lower than the positive effect of CO2 sequestration. Wetlands account for about one-third of terrestrial carbon stores, and

a claimed return on wetlands on investment of 100 times that of alternative carbon mitigation investments (Ramsar Secretariat 2007)

- Recreational/ educational / cultural: Some ecosystems like wetlands are rich and diverse and in many cases strongly entwined with local cultures and history, and provide many important social values (therapeutic value, amenity value, heritage value, spiritual value, and existence value). Important cultural benefits range from historical, such as preservation of archaeological sites in peatlands, to recreational such as diving in coral reefs. Some of the recreational values are the easiest to estimate. For example, within Bonaire National Marine Park in the Netherlands Antilles, scuba-divers pay a US$25 fee each year, which covers the operational costs of the park and are estimated to contribute over US$30 million per year to the island's wider economy.

Marine ecosystems

Marine ecosystems provide multiple benefits, from food to climate control. Coastal ecosystems, like deltas, barrier islands and estuaries provide habitats for fish nurseries and offer protection against storm surges. This section presents a summary of the roles of mangroves, seagrass meadoes and coral reefs as providers of ecosystem services.

Mangroves

Mangroves are trees, shrubs or palms that exceed half a metre in height that grow in the intertidal zone of coastal environments, predominantly within the tropical and subtropical regions of the globe generally between 30^0 North and 30^0 South (Giri *et al.,* 2011). Typically, mangrove can also be used to describe the habitat of the intertidal zone dominated by trees and shrubs. Mangroves typically grow in low wave energy environments on muddy or sandy substrates in the area between mean sea level and the highest spring tides (Alongi 2009). Mangrove species are therefore adapted to unusually harsh environmental settings such as frequent or diurnal flooding, high salinity, periodic anaerobic conditions and high soil temperatures. The largest areas of mangroves are usually found on fine organic rich sediments such as the deltas and estuaries of large rivers, The largest single area of mangroves are the Sundarban forest of Southern Bangladesh and West Bengal, India but they can also occur in coastal lagoons, embayments, tidal riparian zones and reef flats protected by coral reefs or fringing coastal zones on fine sediments and low wave energy.

Globally coastal wetlands that include mangroves and saltmarsh provide ecosystem goods and services which makes them the second most valuable biome type after coral reefs (De Groot 2012). Mangroves are important coastal ecosystems that have a major role in providing nursery for fish and other marine life. They play an important role in the reduction of coastal erosion, filtration of pollutants from a land-based origin, trap sediments from run-off as well as providing a wide range of other economic activities as timber and firewood harvesting, traditional medicine and many customary practices. Finally, mangrove forests are critical for food security and livelihoods of many coastal communities (Albert, 2013).

Seagrass meadows

Seagrasses are submerged aquatic flowering plants that colonise shallow near shore marine and estuarine habitats. Sea grasses tend to colonise soft substrates such as sand or mud that are protected from significant wave action or currents (Koch *et al.,* 2006). Sea grasses can grow to significant depths of water but are limited to areas where more than 11% of the surface light reaches the bottom (Duarte 1991) and develop highly productive ecosystems which play a key role in many marine ecosystem processes. Seagrasses have a global distribution but are almost entirely restricted to the tropical and temperate regions making the Asia Pacific region a hotspot.

Seagrasses are particularly valuable component of natural capital as they grow quickly and produce a large amount of organic material. One study in Australia has estimated that each hectare of seagrass bed can generate up to 20 tonnes of organic leaf material each year (Lloyd 1996). This high productivity and the ability for seagrass to trap organic rich sediments mean that seagrass meadows are one of the most important natural sites for carbon sequestration. A recent study estimated that seagrass meadows capture 27.4 million tonnes of carbon each year which is approximately 10% of the estimated global sequestration of the oceans (Fourqurean *et al.,* 2012). The total carbon pool within seagrass meadows and the top 1 metre of soil is estimated to be 4.2 and 8.4 billion tonnes of carbon.

Coral reefs

Coral reefs are diverse and structurally complex biological communities that form in shallow coastal waters of the tropics and sub tropics between 30 degress north and south of the equator. Coral reefs are created by millions of tiny sedentary animals called cnidarians that build external skeletons of calcium carbonate (limestone) that can form very diverse and complex structures. The majority of the coral reef is made up of the dead coral skeletons that have been laid down over very long periods of time. They feed on both microscopic zooplankton in the water but get most of their energy via the photosynthesis as well as their colour from micro algae (zooxanthellae) that live within the coral structures in a mutually beneficial relationship.

Coral reefs occupy less than 0.2% of the Global surface of the Ocean, equivalent to an area of between 260 000 to 600 000 km^2. Warm-water coral reef species diversity decreases with distance from the equator and is concentrated in the central Indo-Pacific (the “Coral Triangle”: see Box 5). Diversity also decreases the further away from the Indo- Australasian archipelago. This region is approximately 10 times more diverse than the other large area of corals in the western Atlantic with an estimated 500 – 600 species in the Indo Pacific and only 60 in the western Atlantic. The Coral Triangle region in the centre of this region which includes Indonesia, the Philippines, New Guinea and The Solomon Islands, is home to almost 75% of all known coral species and 40% of reef fish species.

Coral reefs provide a number of ecosystem services including raw materials (for lime), coastal protection via the reduction of wave energy and providing habitat for a large range of important fisheries where a quarter of the known fish species are found in coral reefs. In a global study of the importance of the ecosystem services provided by major biomes, the ecosystems services provided by coral reefs and reef flats were estimated to be worth

$352,249 per hectare per year, which makes them the most valuable major biome on the planet (De Groot *et al.,* 2012).

Urban ecosystems

This section discusses the impacts of cities on natural cycles, and the benefits of introducing natural ecosystems in cities.

Cities and biogeochemical cycles

Urbanisation can alter the flow and stock of chemical elements between living organisms and the physical environment. These cycles are one of the most important environmental services provided by biodiversity and these cycles are vital in maintaining water and air quality, soil health and climate regulation (Grimes 2008). Cities can have major implications on these cycles in three major ways. Firstly, by increasing the concentration of certain elements to levels that exceed the capacity of natural systems to deal with them. Examples include phosphorous and nitrogen in soils or water bodies particularly from poorly functioning sewage systems and urban runoff and the emissions of CO2 and other greenhouse gases. Secondly, the industrial processes in cities can lead to the release of chemicals that are toxic to organisms thus disrupting the cycling of other elements for example, the release of trace gases and organic acids influence nutrient cycling and primary production in adjacent exposed natural or agricultural ecosystems (Grimes 2008). Finally, the removal of natural or agricultural habitats and the replacement of vegetative surfaces with artificial surfaces reduces the stock of biodiversity or natural capital that drives the process.

Cities and hydrological systems

Among the most important modifications that affect streams of hydrological flow in urban areas is increased impervious cover (Grimes 2008). Because of the preponderance of impervious surfaces most rainfall in urban areas is quickly converted to surface run off. As such urban areas always present some risk of flooding when rainfall occurs. Buildings, roads, infrastructure and other paved areas prevent rainfall from infiltrating into the soil – and thus produce more runoff (Satterwaithe 2007). Heavy and/or prolonged rainfall produces very large volumes of surface water in any city, which can easily overwhelm drainage systems. Any stream or river in urban landscapes therefore tends to have greater fluctuations in the hydrograph with higher peak flows and longer low flow or even dry periods between rain events.

There is considerable scope for the use of natural capital such as the use of parks and greenspace to increase urban infiltration and urban wetlands and other areas of open space to both accommodate floodwaters safely from unusually serious storms and improve water quality and amenity (Satterthwaite 2007). Urban wetlands provide a range of services including increased infiltration, groundwater recharge and flood retention and their restoration and rehabilitation is critical. In particular the “sponge city” concept being adopted within PRC is showing the benefits of using natural capital to improve urban hydrology management (see Box 4.10).

Cities and climate

The extent and rate of growth of urbanisation has global implications for climate. Because of their intensification of human activities, cities account for 70% (Solecki *et al.,* 2013) and up to 90% (Svirejeva- Hopkins *et al.,* 2004) of the global emissions of anthropogenic greenhouse gases. In addition, the removal of vegetation for the construction of roads and other urban infrastructure and the increasing demand for services provided by natural capital are some of the major drivers of regional land use change, such as deforestation which has reduced the magnitude of global carbon sinks. Angel *et al.,* 2011 estimate that 10% increase in urban landcover will increase the national CO_2 equivalents by more than 11%.

Cities however do not just affect global climate but can have a profound influence on local climate conditions as well. The phenomenon known as Urban Heat Island (UHI) effect means that air temperatures in urban areas are on average 2–5 ◦C higher, and in some cases more than 10 degrees higher, than those in surrounding non-urban areas (Onishi *et al.,* 2010; Collier 2006, Adams and Smith 2014). The UHI effect can be ameliorated somewhat by the inclusion of vegetated surfaces (natural capital) into the urban fabric. Adams & Smith 2014 in a study in Sydney, Australia on the local climate effects of urban vegetation found that increasing tree cover reduces surface temperatures of a local area more than grasslands or mixed vegetation cover. They found that increasing the tree cover by 30% resulted in a reduction of local surface temperatures of 3.48 C^0 as opposed to only 0.6 C^0 for herbaceous cover.

Cities and biodiversity

The replacement of natural and to a lesser extent agricultural landscapes with urban landform both reduces the diversity of habitats and simplifies habitat structure of the habitats that remain. Complex forests become at best manicured parks or concrete surfaces and streams, wetlands and ponds are converted to concrete channels. This reduction in habitat complexity reduces the richness and diversity of indigenous biodiversity and leads to a homogenisation of global biodiversity where the species assemblages tend to be more similar to other cities than they are to the surrounding landscapes and are often dominated by species not indigenous to that region (Mckinney 2006). Bird communities often become dominated by graminvores as opposed to insectivores and large grazing mammals and predators are replaced with omnivores such as rodents. Many species build populations that become pests as they are released from predatory pressure. Because the ecological footprint (discussed in the next section) extends far beyond municipal boundaries, urbanization may also reduce native species diversity at regional and global scales (Mckinney 2006).

Climate change and impacts on natural capital

Climate is the key driver of global distribution of ecosystem types and species distribution and has a significant influence on ecological functions. Ecosystems and the species that they are comprised of are complex entities and projecting or modelling the impact of future climate change is inherently difficult. Nevertheless, climate change is already having widespread impacts across multiple scales of biodiversity including genes, species,

communities, and ecosystems (Parmesan, 2006; Walther, 2010; Bellard *et al.,* 2012). As a global driver of biodiversity loss, climate change currently ranks second only to habitat destruction, and is predicted to be the most influential driver by end of the 21st century (Leadley et al., 2010).

Climate change is expected to act synergistically with existing threats and stressors exacerbating the impact on biodiversity (Brook et al., 2008; West et al., 2012, Mantyka-Pringle et al., 2011). Climate change will have multiple impacts on ecological processes, function and structure and will influence biodiversity via a multitude of mechanistic pathways. The IPCC (2014) report looks for the first time at the impact of climate change on the poor and general livelihoods, and concludes that climate change will slow down the pace of poverty reduction, jeopardize sustainable development, and undermine food security. For example:

- Inland freshwater wetlands will be affected mainly through changes to precipitation and more frequent or intense droughts, storms and floods. This can increase fatalities or reducing vigour or reproduction through thermal or water stress. Drying conditions may reduce the capacity of agricultural lands and more land may be required to maintain food production.
- Changes in the timing and amount of rainfall entering river systems will alter the water supply to coastal wetlands such as deltas and estuaries, affecting salinity and supply of sediment and nutrients. Mountain snowfields and glaciers that feed many of the world's major river and wetland systems will shrink due to melting.
- Changing the extent and distribution of suitable habitats for individual species (including inundation of coastal habitats by rising sea levels). This in turn affect species behaviour further altering ecosystem structure and functioning.
- Altering large scale oceanic processes. For example, sea surface temperature changes may affect ocean currents which alter nutrient availability and juvenile dispersal and connectivity for a range of marine species.
- Higher water temperatures, floods and droughts, will reduce water quality and worsen many forms of pollution. Many semi-arid areas are particularly exposed to the impacts of climate change and are expected to suffer serious pressure on water resources and wetlands.
- Changes in precipitation regimes and extreme events can overwhelm the ability of natural systems to mitigate harm to people from these events.

Annex 2: Glossary of terms

Additionality	In the context of carbon offsets, a project activity is 'additional' if anthropogenic GHG emissions are lower than those that would have occurred in the absence of the project activity. In the context of other ecosystem services, additionality refers to incremental services being delivered by the project (Porras et al. 2015) Additionality of climate finance – climate finance that is not included in and is therefore over and above existing Official Development Assistance (ODA) contributions (Rai et al. 2015)
Carbon dioxide equivalent (CO2e)	The universal unit of measurement used to indicate the global warming potential of each of the six GHGs regulated under the Kyoto Protocol. Carbon dioxide – a naturally occurring gas that is a by-product of burning fossil fuels and biomass, landuse changes, and other industrial processes – is the reference gas against which the other GHGs are measured, using their global-warming potential (Kossoy et al. 2014)
Climate Change Adaptation and Mitigation	CCAM
Concessional loans	Loans issued with minimal or non-existent interest rates, or with extended repayment deadlines
Greenhouse gas (GHG)	Both natural and anthropogenic, GHGs trap heat in the Earth's atmosphere, causing the greenhouse effect. Water vapour (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4), and ozone (O3) are the primary GHGs. The emission of GHGs through human activities (such as fossil fuel combustion or deforestation) and their accumulation in the atmosphere contributes to climate change (Kossoy et al., 2014)
Loan	An agreement under which an owner of assets (the lender) allows another entity (the borrower) to use the assets for a specified time period. In return, the borrower agrees to pay the lender a payment (interest) and return the assets (cash) at the end of the agreed upon time period (ADB 2005).
Mitigation	The process of reducing the future threat of climate change by reducing the amount of carbon emitted into the atmosphere (Rai et al. 2015)
Multilateral development bank (MDB)	A bank supported by contributions, both technical and financial, from several countries. MDBs might also have their own private finance arms. They usually have large amounts of capital and high fiduciary standards (Rai et al. 2015).
Natural capital and ecosystem services	Natural capital refers to the source or supply of resources (or assets) and services that are derived from ecosystems within a geographic or economic unit –like a country or a firm. It includes provisioning services (also known as environmental assets) like timber, mineral deposits, fisheries, water and soil. NC also refers to regulating ecosystem services (e.g. air and water purification, and flood control), cultural and recreational services, and other supporting ecosystem services necessary to regulate natural processes, like nutrient and waste recycling, and soil formation. (MEA 2005)
Non-revenue-earning Project	For ADB, this is a project for which cost recovery is not generally sought, or is partial or indirect. Nonrevenue-earning projects are usually implemented and operated by public entities that are largely dependent on government budget allocations (ADB 2005)
Opportunity cost	The benefit foregone from not using a good or resource in its best alternative use.
Payments for Ecosystem Services	An economic instrument that addresses an environmental externality through variable conditional payments made in cash or kind, with a land user, provider or seller of environmental services who voluntarily responds to an offer of compensation by a private company, NGO or local or central government agency. PES is anchored in the use of payments to correct an economic externality (Pigou 1920, Coase 1960). Coase argues that socially sub-optimal situations, in this case poor provision of ecological services, can be corrected through voluntary market-like transactions provided transaction costs are low and property rights are clearly defined and enforced (Porras et al. 2015).
Poverty	While there can be many definitions of poverty, we understand it as the lack of, or inability to achieve, a socially acceptable standard of living, or the possession of insufficient resources to meet basic needs. Multidimensions of poverty imply going beyond the economic components to wider contributory elements of well-being. Poverty dynamics are the factors that affect whether people move out of poverty, stay poor, or become poor (Suich 2012, Porras et al. 2015).

Rate of return on investment	The rate of return on investment (ROI) is the gain or loss from an investment over a period of time. It also refers to the net amount of discounted flows to an investment. ADB uses different indicators to assess projects depending on whether they are revenue earning or non-revenue earning, private or public sector: (ADB 2005) *Economic internal rate of return (EIRR*): The rate of return that would be achieved on all project resource costs, where all benefits and costs are measured in economic prices. The EIRR is calculated as the rate of discount for which the present value of the net benefit stream becomes zero, or at which the present value of the benefit stream is equal to the present value of the cost stream. For a project to be acceptable the EIRR should be greater than the economic opportunity cost of capital. *Financial Internal Rate of Return (FIRR)*: The rate of return that would be achieved on all project costs, where all costs are measured in financial prices and when benefits represent the financial revenues that would accrue to the main project participant. The FIRR is the rate of discount for which the present value of the net revenue stream becomes zero, or at which the present value of the revenue stream is equal to the present value of the cost stream. It should be compared with the opportunity cost of capital, or the weighted average cost of capital, to assess the financial sustainability of a project. *Net present value (NPV):* A method used in evaluating investments, whereby the net present value of all cash outflows (such as the cost of the investment) and cash inflows (returns) is calculated using a given discount rate, usually required rate of return. An investment is acceptable if the NPV is positive. In capital budgeting, the discount rate used is called the hurdle rate and is usually equal to the incremental cost of capital.
REDD+	A UNFCCC framework where developing countries are rewarded financially for activities that reduce emissions from deforestation and forest degradation and contribute to conservation, sustainable management of forests, and enhancement of forest carbon stocks (Porras et al. 2015).
Resilience	(to CC)
Revenue-earning project	These are projects usually executed, in whole or significant part, by a financially autonomous or semiautonomous entity (such as a corporate business or a public authority) that supplies products or services to customers in return for payment of a price or charge (ADB 2005).
Risk	We use the term “risk” in different ways throughout the document. *Financial*: The measurable possibility of losing or not gaining value. Risk is different from uncertainty. Uncertainty is not measurable (ADB 2005). A risk analysis looks at the project risks associated with the value of key project variables, and therefore the risk associated with the overall project result. To climate change:
Risk sharing	Refers to measures taken by national financial institutions (or governments) to incentivise motivate private sector engagement in fledgling sectors. Sharing the risk reduces potential losses to investors, making innovation and investment more palatable (Rai et al. 2015).
Wealth and types of capital	Total wealth is an index prepared for national accounts using existing national indicators. It is built on the principle that current wealth must constrain future consumption. It includes indicators for *produced capital* (e.g. machinery, structures, and equipment), natural capital (agricultural land, protected areas, forests, minerals, and energy) and intangible capital (e.g. human, social, and institutional capital). (The World Bank 2011)