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ASSESSING COUNTRIES' FINANCIAL NEEDS TO MEET THE SDGS THROUGH NATURAL CAPITAL INVESTMENT

GGKP Expert Group on Natural Capital

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The Green Growth Knowledge Partnership (GGKP) is a global community of organizations and experts committed to collaboratively generating, managing and sharing green growth knowledge. Led by the Global Green Growth Institute (GGGI), Organisation for Economic Co-operation and Development (OECD), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO) and World Bank Group, the GGKP draws together over 70 partner organizations. For more information, visit www.greengrowthknowledge.org.

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CONTENTS

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The Green Growth Knowledge Partnership (GGKP) convenes inter-institutional expert groups to identify and address critical knowledge gaps in green growth theory and practice. The neutral, collaborative expert groups focus on knowledge generation, synthesis and on-the-ground application by partners and in-country stakeholders.

This report was prepared under the guidance of the GGKP Natural Capital Expert Group (hereinafter “Expert Group”). The Expert Group aims to push the knowledge frontier, mainstream natural capital in global green growth activities and support stronger implementation of natural capital commitments in national economic plans. In its deliberations, the group identified a key knowledge gap in the provision of natural capital data to inform national green growth plans.

To clarify this gap and identify pathways to address it, the Expert Group, with support from the GGKP Secretariat, commissioned the Basque Centre for Climate Change to prepare this report. This publication was produced by Anil Markandya (Basque Centre for Climate Change) and Suzette P. Galinato (Washington State University) with Expert Group guidance.

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EXECUTIVE SUMMARY

This report aims to provide national and global cost estimates of meeting those Sustainable Development Goals (SDGs) with targets that are linked to natural capital. Although there are some attempts to put a cost on achieving the SDGs, there is no exercise to date focusing on natural capital. The financial costs estimated here are also compared to the increase in natural capital the programmes generate, estimated in a previous study. This should be useful for countries to determine their priorities in financing the SDG programmes under limited resources.

The estimation is based on a combination of a bottom-up and a top-down approach. The bottom-up approach involves a review of the available literature that links target improvements to specific costs based on engineering and ecological data for each country. This approach has been used to estimate the costs of land remediation, materials efficiency, and conservation of terrestrial and marine ecosystems.

A top-down approach is taken for climate change, air quality and water and sanitation. This approach involves applying a macroeconomic model at a national, regional, or global level and then obtaining the estimated costs from it for specific countries. For climate change and air quality, an important academic study that modelled the costs of meeting targets has been used.

Ideally, all estimates would have been made using a bottom-up approach as it gives more details and more accurate numbers, but that was not possible for some of the SDGs. For water and sanitation, a World Bank study of the costs, disaggregated to a regional level, was used to derive costs per household, which were then applied for the selected countries. Details of the models are given in the relevant sections of the report.

The selected SDGs and natural capital changes covered in the report are the following:

- **SDG2:** Zero hunger — Restoration of degraded agricultural land
- **SDG3:** Good health and well-being, SDG6: Clean water and sanitation, and SDG11: Sustainable cities and communities — Reductions of pollutants in water and air
- **SDG9:** Industry, innovation and infrastructure, and SDG13: Climate action — Reductions in greenhouse gases (GHGs)
- **SDG12:** Responsible consumption and production — Reductions in the use of natural materials in production and consumption
- **SDG15:** Life on land — Increased flow of ecosystem services (ESS) from the terrestrial systems

In some cases, the SDG targets are given precise quantitative values by the United Nations. Where that is so, those figures have been used. In other cases, quantitative values have been derived from the SGD-associated literature.

The analysis is done in detail for 10 countries as well as at the global level: Australia, Brazil, China, India, Indonesia, Madagascar, Morocco, Senegal, Uganda and the United States. These countries were selected to cover low, middle and high-income levels and different geographical zones. They were drawn up following discussions between the Basque Centre for Climate Change (BC3) and Green Growth Knowledge Partnership (GGKP) to reflect a wide range of representative countries and due to data availability.

The average annual costs of meeting the said SDG targets, which are directly linked to enhancing natural capital, are estimated in the selected countries for the next 10 years. Globally, it is estimated that about $774 billion per year is required to meet the selected SDG targets by 2030. This compares to an estimate of $2.5 trillion to $3 trillion per year for all 17 SDGs across all developing countries in two UN reports published within the last two years. Globally, the share of costs is highest for investments in GHG emissions reduction and cleaner air (47%), followed by reduction in losses of terrestrial ecosystems (35%), efficiency in material use (9%), safer water and sanitation (8%) and land remediation (1%).

Results show that China requires the largest total investment cost at about $163 billion per year, followed by India ($91 billion/year) and the US ($80 billion/year). The bulk of the investments in the three countries are for measures that will reduce greenhouse gas emissions. Reduction of GHG emissions and improvement of air quality comprise more than one-third of investment costs in six countries – Senegal (39%), India (50%), Indonesia (37%), China (77%), Australia (57%) and the United States (48%). In low-income countries, investments in safer water and sanitation are in the top two relative to other SDG targets – Senegal (26%), Uganda (36%) and Madagascar (8%).

There are SDGs for which some countries do not need to invest, mainly because the targets have already been met. For instance, water and sanitation targets are already met in the industrialized countries (Australia and the US). In terms of deforestation, four countries (India, Morocco, China and the US) do not have investment costs to address the SDG target because they have positive annual rates of change in their forest areas.

The results reported above are the best that could be estimated given the data available. There are some forms of natural capital not covered for this reason. The most important are marine ecosystems. In addition, the assessment of SDG15 mainly covers forests, wetlands and protected areas, although the targets under SDG15 are much broader. Therefore, the findings presented are likely to be an underestimate of the total financing needed to achieve all targets under SDG15.

The costs of attaining the SDG targets at the global level can be compared to the increase in natural capital generated by their implementation. These benefits were estimated in Markandya (2020), based on an estimation of the present value of the additional flow of ecosystem services that meeting the SDGs would provide. The present value of the global costs is estimated similarly over the period 2021-2030. Globally, the greatest gains, on average, come from investments in land remediation, followed by avoided deforestation, wetlands, materials efficiency and air pollution reduction. In all cases, the increases in natural capital exceed the costs of the programmes, with the exception of protected areas where the increase in natural capital is less than the cost. Knowledge of these gains in natural capital can also be important in securing financing for the associated projects in the first place.

Focusing on the selected SDG targets related to natural capital, this paper estimated the cost of meeting these targets globally and in 10 selected countries. Like the findings of recent UN studies, the financing needed to meet the SDG targets are undoubtedly immense. Limited data, however, introduce uncertainties in the cost ranges estimated in this paper.

The next steps of the study are to: apply the methodology to 10 additional countries, aiming that altogether the 20 countries would represent about two-thirds of the world economy as well as significant biodiversity; compare the country level costs with the benefits in terms of natural capital at the country level; compare the estimates of required finance against the rate of actual investment to see where there is a gap and how big it is; and identify actions that can accelerate the mobilization of finance where the gap is greatest and where the need in terms of meeting the SDGs has highest priority.

1. INTRODUCTION

The Sustainable Development Goals and costs of achieving them

The UN Sustainable Development Goals (SDGs) form the central objectives for sustainable development globally and nationally, and even at the local level, until 2030. In total, there are 17 SDGs, 169 targets and 230 associated indicators (UN, 2016).

There are several reports that provide an estimate of the costs of meeting these targets. Much of the focus has been on developing countries, with two major reports covering this group published by the United Nations Conference on Trade and Development (UNCTAD) and the United Nations.

UNCTAD (2020, Chapter 5) used their *World Investment Report 2014* as a basis for assessing the investment needs and associated financing gaps of developing countries for 10 industry sectors that are linked to the 17 SDGs.[1] It found some increased investments had been made between 2014 and 2019 in six sectors, but concluded that the targets were still quite far from being achieved. The annual investment gap needing to be financed to meet the SDGs across the 10 sectors was estimated at $2.5 trillion per year, on average, between 2015 and 2030. This figure is within the range of the financing gap estimated by another UN report for developing countries, which gave a range of $2.5 trillion to $3 trillion a year (UN, 2019). A breakdown of annual investment gaps in the 10 sectors is given in Table 1.

1 The financing needs of meeting the SDGs cover required investments, but are not limited to those. They also cover recurrent costs and costs associated with policy changes.

Table 1: Projected annual investment gaps in industry sectors linked to the 17 SDGs (average from 2015 to 2030) in developing countries

Industry	Projected investment gap ($ billion/year)	As percentage of total
Climate change adaptation	60-100	3%
Climate change mitigation*	380-680	21-22%
Ecosystems and biodiversity*	ND	ND
Education**	250	8-14%
Food and agriculture*	260	8-14%
Health*	140	5-8%
Power	370-690	20-22%
Telecommunications Infrastructure*	70-240	4-8%
Transport infrastructure*	50-470	3-15%
Water, sanitation and hygiene**	260	8-14%
Total	**1,840–3,090**	**100%**

Source: UNCTAD (2020)

* Six sectors where there have been signs of increased investments between 2014 and 2019
** Two sectors where investment levels have been declining in 2014-2019
ND – Not determined

The UNCTAD report also noted that investments in the SDGs are financed by a combination of domestic, international, public and private sources, with private investments (domestic and foreign) playing an important role in bridging the financing gap.

Some costs for meeting the goals have been estimated globally, as well as for developing countries and for specific SDGs. For instance, ending hunger (SDG2) is attained in a country when the number of hungry people is less than 5 per cent of the country's population. Laborde et al. (2016) estimated that, on top of the $8.6 billion given by donors annually for food security and nutrition, an additional $11 billion per year, on average, is needed to meet SDG2 globally between 2015 and 2030.

While the above reports look at all 17 SDGs or various subsets of them, this paper aims to provide national and global cost estimates of meeting the SDGs where the targets are linked to natural capital, and where the targets can be quantified and financial costs estimated in a credible fashion. To date, such an exercise has not yet been done and our paper's contribution will fill this knowledge gap. These financial costs can be compared to the increase in natural capital the programmes generate, allowing for countries to determine their priorities in financing the SDG programmes under limited resources.

Aims and objectives

The aim of this paper is to estimate the financing needs of meeting selected SDGs in a focused and targeted way by answering the following question: What additional resources are needed to bring about the increase in natural capital associated with selected SDGs where natural capital has a major role?

Markandya (2020) estimated the gains in natural capital that would be generated if a selected set of SDG targets were met by 2030. These gains are estimated as the present value of the increase in services provided by a given type of natural capital associated with the SDGs. The ones looked at were those where the SDG target was closely related to creating or protecting natural capital, such as land remediation, improvements in air and water, reductions in greenhouse gas (GHG) emissions and conserving, or strengthening natural ecosystems. Thus, not all SDGs were covered.

The value of the gains of natural capital from meeting the targets was found to be considerable: the global estimate ranged from $40 to $95 trillion, equal to between 30 and 80 per cent of the value of existing natural capital as estimated by the World Bank (Lange et al., 2018), or between 4 and 8 per cent of the value of all capital.[2]

This paper is intended to provide guidance to countries of the likely costs of meeting their respective SDG targets and to indicate how much natural capital increase can be expected from each dollar spent on each of the SDGs. This information will help them determine priorities where funds are scarce. Finally, once an estimate can be made of the current rates of financial flows to these SDGs, an indication of the financial gap can be made.

Methodology

This paper builds on the natural capital approach (NCA) in Markandya (2020) for estimating the natural capital gaps that need to be filled to achieve related SDGs and for assessing the financial needs to bridge these gaps. In this paper, NCA is applied for selected SDG targets related to natural capital at the country level. Estimates are also made of the financial costs of programmes linked to the relevant SDG targets through a bottom-up or top-down approach.

2 The estimate of existing natural capital in the World Bank study covers energy (oil, natural gas and coal), minerals, agricultural land (cropland and pastureland), protected areas and forests (timber and some non-timber forest products). Thus, it is narrower than our definition, which includes carbon sequestration, clean air and clean water, and so the two are not quite comparable. On the narrower basis of only valuing the increase in natural capital for the categories in the World Bank study, the estimate in Markandya would represent an increase of between 20 per cent and 58 per cent.

Ten countries were selected for the study, representing low, middle and high-income levels and covering different geographical zones, as shown in Table 2. They were selected following discussions between the Basque Centre for Climate Change (BC3) and Green Growth Knowledge Partnership (GGKP) to reflect a wide range of representative countries and due to data availability.

Table 2: Countries selected for in-depth analysis of financial needs

Country	Level of Income	Region
Senegal	Low	Sub-Saharan Africa
Uganda	Low	Sub-Saharan Africa
Madagascar	Low	Sub-Saharan Africa
India	Lower-middle	South Asia
Indonesia	Lower-middle	East Asia and the Pacific
Morocco	Lower-middle	Middle East and North Africa
China	Upper-middle	East Asia and the Pacific
Brazil	Upper-middle	Latin America and the Caribbean
Australia	High	East Asia and the Pacific
USA	High	North America

Source: World Bank (2020)

The bottom-up approach involves a review of the available literature that links target improvements to specific costs based on engineering and ecological data. This has been used to estimate the costs of land remediation, materials efficiency, and conservation of terrestrial and marine ecosystems. A top-down approach is taken for climate change, air quality and water and sanitation. This approach involves applying a macroeconomic model at a national, regional, or global level and then obtaining the estimated costs from it for specific countries.

For climate change and air quality, an important academic study that modelled the costs of meeting targets has been used. Ideally, all estimates would have been made using a bottom-up approach as it gives more details and more accurate numbers, but that was not possible for some of the SDGs. Details of the models are given in the relevant sections. For water and sanitation, a World Bank study of the costs disaggregated to a regional level was used to derive costs per household, which were then applied for the selected countries. In summary, the methodology is an eclectic one, combining the best available sources to derive estimates of the costs of achieving diverse SDGs.

The financial needs are estimated for natural capital-related SDG targets that are given in Table 3. The list of targets covered is extensive, but it is not comprehensive. Some SDGs related to natural capital could not be covered because of a lack of data. These include SDG targets related to marine ecosystems and some related to terrestrial ecosystems. The coverage of air quality does not include targets of indoor air fully (although the measures considered with respect to climate change will have a positive impact on indoor air quality). Notwithstanding these limitations, the authors consider that most of the SDGs related to natural capital have been assessed. The expenditures are those required to meet the SDGs. A number of points should be noted about the costs covered by the categories in the list:

- Financial costs cover the capital investments required, as well as additional variable costs and costs of ensuring the continued effectiveness of the initial investments.
- In some cases, the measures required to enhance or protect the natural capital do not involve physical investments. They may require a change of policy (such as increased taxes on fossil fuels), or actions that change behaviour (e.g. a change in diet). Financial costs can arise from such measures, but they are indirect and must be included in the estimates.
- The financial burden of the measures falls on the public and private sectors and in some cases the party that bears the burden is itself a matter of policy. That is something to bear in mind given difference in the capacity of different agencies in society to raise the financial resources.
- There are cross-sectoral effects in the financing of the SDGs. For example, measures to reduce GHGs (SDGs 9 and 13) will typically result in lower local pollutants and cleaner air. Measures to improve diets that support healthy lives can also imply a reduction of GHGs. These cross effects should be taken into account when appraising the effectiveness of different measures in terms of the cost relative to the improvement in the SDGs.

Sections 2 to 6 describe the types of investments needed to meet the SDG targets related to restoration of degraded land, safe water and sanitation, reduction of GHGs and improvement of air quality, increased efficiency of using natural materials in production and consumption, and reduction of losses in terrestrial ecosystems, respectively. Section 7 provides a summary of the estimated costs across the selected SDG targets, and comparison of benefits and costs. Section 8, concludes and lays out the next steps.

Table 3: Relevant SDG targets and natural capital covered in the analysis

SDG*	SDG target/s*	Relevant natural capital**	Natural capital change	Estimation of financial costs	Data sources
SDG2: Zero Hunger	2.4 – Productive and sustainable agriculture	Agricultural land	Restoration of degraded agricultural land	Costs of remediation	Various WRI World Bank GEF National
SDG3: Good Health and Well-being SDG6: Clean Water and Sanitation SDG11: Sustainable Cities and Communities	3.9 – Reduction of mortality rate due to hazardous chemicals, air, water and soil pollution and contamination 6.1 & 6.2 – Adequate and equitable access to safe water and sanitation services 11.6 – Reduction of environmental impacts, including air quality and waste management	Air quality Water quality	Reduction of pollutants in air and water	Costs of safe water provision Costs of air pollutant reductions	Various WHO World Bank National
SDG9: Industry, Innovation and Infrastructure SDG13: Climate Action	9.4 - More environmentally sustainable infrastructure and industries 13.2 – Integration of climate change measures into national policies, strategies and planning	Atmosphere to sustain a stable climate	Reductions in emissions of GHGs	Costs of programmes to reduce GHGs	Various National
SDG12: Responsible Consumption and Production	12.2 - Sustainable management and efficient use of natural resources	Terrestrial biomes that deliver materials	Less use of natural materials in consumption and production	Costs of introducing efficiency measures to save materials	OECD UNEP National
SDG15: Life on Land	15.1 Conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services	Terrestrial biomes that deliver ecosystem services	Increased flow of ecosystem services (ESS) from the terrestrial systems	Estimates of costs of reforestation, protection of conservation areas	Various UN studies

* Details obtained from UN (2015)
** Natural capital as addressed in this report

2. RESTORATION OF DEGRADED AGRICULTURAL LAND

This section applies to SDG2 – end hunger, achieve food security and improved nutrition, and promote sustainable agriculture – and target 2.4, which uses the “proportion of agricultural area under productive and sustainable agriculture” indicator. The indicator is interpreted further as remediating given areas of degraded land, details of which are given below. The section then calculates the costs associated with the remediation of those areas of degraded agricultural land.

SDG2’s target 2.4 does not give a figure for what proportion of agricultural land should be productive and sustainable by 2030. This figure is estimated by using available data on degraded land, land restoration commitments, and share of agricultural land in total agricultural and forest areas in the selected countries, as described below.

Total degraded land and land restoration commitments

One target that is linked to SDG2 is the Bonn Challenge, which demands restoring 350 million hectares of degraded and deforested landscapes by 2030. As of 2019, 74 participants from 64 countries had made commitments to making a contribution to this restoration. If this were to be met, it would amount to remediating about 64 per cent of all degraded land by 2030 (IUCN, 2020a). One potential way to allocate the 350 million hectares across countries would be proportional to national shares in total degraded land. Another would be to base it on national commitments to the Bonn Challenge.[3] The areas that would need to be remediated under the two criteria for the selected countries are given in Table 4.

Not all countries have a commitment under the Bonn Challenge: Indonesia, Morocco, China and Australia in the selected groups for this study fall into this category. Of those that do, some commit to more than would be considered equitable on a proportional basis (e.g. India, Madagascar) and some commit to less (e.g. Brazil, USA). Table 4 shows the remaining area to be remediated by 2030 given the two criteria. Under the proportional rule, India appears to already meet their target of restoration.

In 2016, IUCN developed the Restoration Barometer and its reporting protocol to help the pledgers assess and monitor their progress, identify obstacles and report on restoration commitments they have met under the Bonn Challenge (IUCN, 2020a). The protocol was applied in depth to six countries in 2018 — Brazil, El Salvador, Mexico, Rwanda, Sri Lanka and the United States; while rapid assessments were conducted in additional 13 countries to obtain a snapshot of their progress during the same period (Dave et al., 2018). The total area pledged under the Bonn Challenge is about 208 million hectares. Altogether, the 19 countries that underwent the Barometer assessments pledged about 97.8 million hectares (i.e. representing nearly half of current total commitments), and 44 per cent of their pledge is under restoration. Of the selected countries in Table 4, two

3 Note that the two criteria represent scenarios. Because only six of the 10 selected countries committed to the Bonn Challenge, the proportional shares are useful in deriving estimates of degraded land areas that need to be restored in the other four countries, as well as in providing a range of values for the six countries with Bonn Challenge commitments.

are notable — the US has surpassed their restoration commitment to the Bonn Challenge by 13 per cent, while Brazil has already met about 79 per cent of its pledge. It is expected that the Barometer will be applied to more than 20 countries in 2020 (IUCN, 2020a, 2020b).

Table 4: Land areas to be remediated in selected countries by 2030 (thousand hectares)

Country	Under proportional rule	Committed under Bonn Challenge	Area under restoration as of 2018*	Remaining area to be remediated by 2030**	
				Under proportional rule	Under Bonn Challenge
Senegal	443	2,000	0	451	2,000
Uganda	530	2,500	52	487	2,448
Madagascar	2,093	4,000	0	2,130	4,000
India	7,568	21,000	9,811	-2,108	11,189
Indonesia	13,143	-	-	13,376	-
Morocco	861	-	-	876	-
China	28,022	-	-	28,518	-
Brazil	24,036	12,000	9,425	15,037	2,575
Australia	25,474	-	-	25,925	-
USA	25,342	15,000	16,959	8,832	-1,959
World	**350,000**	**208,376**	**42,843**	**307,157**	**165,533**

Sources: IUCN (2020a) and Markandya (2020)

* Area restored by pledgers under the Bonn Challenge

** Calculated as the difference between the target area to be remediated under the proportional rule or Bonn Challenge pledge, and the area under restoration as of 2018

Degraded agricultural land

As mentioned at the beginning of this section, the focus is on estimating the costs of remediation for degraded agricultural land (i.e. cropland, rangeland) in the selected countries. Degraded forest land will be addressed in the section dealing with terrestrial ecosystems (Section 6). Because the Bonn Challenge does not separate targets between degraded agricultural land and forest land, the former is estimated by taking the per cent of agricultural land area with respect to the total agricultural and forest areas of each country. This percentage is then applied to the remaining area that must be remediated to meet the target in 2030 given the two criteria (see Appendix 1).

Estimates of remediation costs for the selected countries have been collected from the following sources: agricultural land remediation projects funded by multilateral organizations (GEF, 2008, 2011a, 2011b, 2013a, 2013b, 2016; IEG, 2017; Roby and Mbengue, 2013; World Bank, 2019); government and NGO-supported grants and programmes for

IUCN, 2016; USDA FSA, 2019, 2020; USDA NRCS, 2020); and related project reports and journal articles (Dave et al., 2018; Development Alternatives, 2020; Santos and Grzebieluckas, 2014; Haufler et al., 2013; Gama, 2003; Schell, 2010; Vinholis et al., 2010).

Projects or programmes considered are those that implement strategies to remediate degraded agricultural land (i.e. not field experiments, on-farm demonstrations, development or testing of tools, or workshops/trainings only). These include rehabilitation of rangelands, soil erosion control, treatment or reclamation of sodic or saline fields, integration of fertility management, soil and water conservation, agroforestry, silvopasture and associated technical assistance (e.g. trainings or workshops, agricultural services, improvement of institutional capacity, project management).

The above sources also provided the targeted area of land, so the per hectare cost of a project or programme in each country was derived. Since the sources have different publication dates, the costs were adjusted using the GDP deflator with 2019 as the base year to make the estimates comparable. Country-specific data are unbalanced in that some countries have fewer or more programmes/projects than others. For this reason, the data are grouped by income level. The minimum, average and maximum per hectare costs for a certain group of countries represented the low to high bound ranges for that group, as presented in Table 5.[4]

Cost estimates include both investment and technical assistance components. The global estimate is a weighted average of the remediation costs in the selected countries. The differences in the costs come from the diverse methods implemented in projects. The lower end of the range will include operating costs and materials (e.g. seedlings, training materials). The costs become higher when there is equipment used or the methods are more complex, for instance when treating or reclaiming saline/sodic soils, improving drainage networks in agricultural fields and establishing perennial crops for agroforestry.

Table 5: Estimated remediation cost ranges by level of income (US$/hectare)

Level of income/ world	Low	Average	High
High	$85.27	$1,381.29	$6,511.89
Upper-middle	$155.71	$2,426.36	$9,120.00
Lower-middle	$100.00	$550.18	$1,994.67
Low	$340.75	$365.14	$389.53
World (mixed income)	**$127.51**	**$1,706.66**	**$6,922.13**

Note: Number of projects for each income group, from which the costs have been estimated: low - 2; lower-middle - 5; upper-middle - 7; and high - 9.

4 A caveat must be noted about the grouping of countries. Since the estimates are based on 10 countries representing the four income groups, there is higher uncertainty for the ranges of financial costs estimated for this SDG target.

The figures in the above table, which are the full capital and operating costs, are used to estimate the annual costs of restoration for each country over the next 10 years in order to achieve their respective targets under two different criteria (see Table 6). For low-income countries, the restoration cost ranges between $8 million and $64 million per year under the proportional rule, and between $35 million to $120 million per year under the Bonn Challenge. India does not show any remediation costs under the proportional rule because the country already met its target based on this criterion. The case is similar for the US given the Bonn Challenge criterion. Brazil has generally lower requirements under the Bonn Challenge because their pledge is lower than the estimated target area under the proportional rule.

Table 6: Additional costs of meeting the targets for restoring degraded agricultural land in selected countries by 2030 (2019 US$ million/year)

Country	Level of income	Under proportional rule			Under Bonn Challenge		
		Low	Average	High	Low	Average	High
Senegal	Low	$8	$9	$9	$35	$38	$41
Uganda	Low	$14	$15	$17	$73	$78	$83
Madagascar	Low	$56	$60	$64	$105	$112	$120
India	Lower-middle	$0	$0	$0	$81	$443	$1,607
Indonesia	Lower-middle	$55	$302	$1,094	-	-	-
Morocco	Lower-middle	$7	$40	$147	-	-	-
China	Upper-middle	$320	$4,982	$18,726	-	-	-
Brazil	Upper-middle	$75	$1,168	$4,388	$13	$200	$752
Australia	High	$166	$4,718	$12,662	-	-	-
US	High	$43	$1,221	$3,278	$0	$0	$0
World	**Mixed**	**$2,115**	**$28,307**	**$114,814**	**$675**	**$9,040**	**$36,667**

Note: "-"means the country does not have a pledge to the Bonn Challenge

3. SAFE WATER AND SANITATION

The goals of safe water and sanitation are stated as SDG6.1 (by 2030, achieve universal and equitable access to safe and affordable drinking water for all) and SDG6.2 (achieve access to adequate and equitable sanitation and hygiene for all and end open defecation). Further details of how these are quantified are given below. Markandya (2020) estimated the increase in natural capital (i.e. clean water) that would result from meeting these targets, in terms of the value of the reduction in lost disability-adjusted life years (DALYs).

The costs of achieving the targets have been estimated in other studies, notably Hutton and Varughese (2016). Their report estimates the costs of achieving both a "basic" level of water supply and sanitation as well as those of "safely managed" levels of these services. Basic services would consist of access to a safe community water source within a 30-minute round-trip; basic sanitation includes an improved toilet and no open defecation.

Safely managed services require an on-plot water supply for every household and for sanitation they include a toilet with safe management of faecal waste. Estimation is based on detailed data collected across developing countries of how much it costs to provide both levels of services. In this report, the costs of meeting the safely managed level of services are considered.

Estimates for the selected countries as annual costs are given in Table 7. Annual costs range from $180 million in Morocco to nearly $18 billion in India. There is also uncertainty about the estimates: the range indicates an upper bound that is 40 per cent higher and a lower bound that is about 30 per cent lower.

In terms of progress towards these goals, Hutton and Varughese (2016) conclude that current levels of financing are sufficient to meet the basic levels of services by 2030 across all countries. This means that additional financing will be needed to attain the safely managed levels over the next decade. Table 7 gives an estimate of the additional funding needed each year over the next 10 years to achieve this goal in each country. The amounts vary considerably. For small countries, such as Senegal and Morocco, the additional finance needed, on average, is around $140 million to $160 million per year; however, for a large country like India the amount is $13.4 billion and for China it is $4.6 billion per year, on average.

Table 7: Additional costs of meeting the safe water and sanitation targets by 2030 (US$ million/year)

Country	Unimproved*		Population** (000)		To connect by 2030 (000)		Annual cost for safe sanitation*** ($Mn/Yr)			Annual cost for safe water*** ($Mn/Yr)			Additional finance to attain safe water and sanitation ($Mn/Yr)		
	Sanitation %	Water %	2015	2030	Sanitation	Water	Mean	Low	High	Mean	Low	High	Mean	Low	High
Senegal	52	21	14,967	18,791	11,607	6,967	108	69	169	96	75	117	155	145	176
Uganda	81	21	39,119	59,961	52,528	29,057	488	312	764	436	341	529	702	658	797
Madagascar	88	48	24,235	33,270	30,362	20,668	282	180	442	252	197	306	406	380	460
India	60	6	1,307,933	1,528,595	1,005,422	299,138	9,336	5,965	14,620	8,343	6,524	10,119	13,442	12,599	15,247
Indonesia	39	13	255,709	277,364	121,382	54,897	1,127	720	1,765	1,007	788	1,222	1,623	1,521	1,841
Morocco	23	15	33,955	36,367	10,222	7,505	95	61	149	85	66	103	137	128	155
China	24	5	1,363,520	1,380,651	344,376	85,307	3,198	2,043	5,008	2,858	2,235	3,466	4,604	4,316	5,222
Brazil	17	2	203,657	222,819	53,784	23,235	499	319	782	446	349	541	719	674	816
Australia	0	0	23,923	25,978	0	0	0	0	0	0	0	0	0	0	0
USA	0	0	322,835	361,029	0	0	0	0	0	0	0	0	0	0	0
World	**32**	**9**	**6,019,453**	**6,950,479**	**3,269,660**	**1,584,648**	**30,362**	**19,400**	**47,545**	**27,133**	**21,216**	**32,906**	**60,002**	**48,157**	**76,727**

Source: * UNICEF and WHO (2015), ** Riahi et al. (2017), * cost estimates are derived from Hutton and Varughese (2016)**

Note: Global population figures exclude countries where no improvements are required.

4. REDUCING GHGS AND CLEAN AIR

SDG13 calls for countries to “take urgent action to combat climate change and its impacts”, while SDG9 aims to “build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”. There is no target value specified in the SDGs although SDG target 9.4 has CO_2 emissions per unit of GDP as an indicator. In Markandya (2020), the goal of the SDGs was translated as ensuring that GHG emissions by 2030 were on track to meet the Paris Agreement of limiting global warming of 2ºC and possibly 1.5ºC. The same link between the overall aims of SDGs 9 and 13 is taken here.

Investments for reducing GHGs

Measures to reduce emissions of GHGs and reorient the economies of countries towards a low-carbon future require not only a change in the types of investment made to increase the supply and efficiency of energy systems, as well as production and consumption systems more widely, but also an increase in the total amount of the investments in these areas.

A large number of studies have modelled the changes required under different assumptions about the role of market-based instruments, such as carbon tax, to incentivize the shift to low-carbon investments. A comprehensive attempt is represented by McCollum et al. (2018), in which the authors use six global modelling frameworks to estimate investments needed to chart a course toward “well below 2ºC” as mandated in the 2015 Paris Agreement, and to pursue the 1.5ºC target. The paper also estimates investments to meet the other SDGs and finds that meeting SDG13 on “limiting warming to well below 2ºC and pursuing efforts for 1.5ºC” also reduces the expenditures needed in meeting the SDG on air pollution, where SDG target 3.9 states, “substantially reduce the number of deaths and illnesses from air pollution”. Box 1 gives some more details of the modelling approach used.

Box 1: Modelling frameworks for estimating energy investments to meet the Paris Agreement

Six global energy-economy models, or integrated assessment frameworks are used in the study. They include AIM/CGE11,12, IMAGE13, MESSAGEix-GLOBIOM14,15, POLES16,17, REMIND-MAgPIE18,19, and WITCH-GLOBIOM20,21. In addition, the authors employ the nationally focused GCAM-USA22,23 model for an analysis of power sector investments. These models span a range, from least-cost optimization to computable general equilibrium models, and from game-theoretic to recursive-dynamic simulation models. Such diversity is beneficial for shedding light on those model findings, which are robust to diverging assumptions and on potential outliers deserving of further investigation.

Of particular importance for the current study, the six models have broad coverage of different types of energy technologies across the entirety of the global energy system, including resource extraction, power generation, fuel conversion, pipelines/transmission, energy storage and end-use/demand devices, and are therefore well-positioned to assess the evolving nature of the energy and climate mitigation investment portfolio over time. To highlight uncertainties, they make use of both multi-model means and ranges (min/max) when reporting results. Given that the estimates are unable to capture all possible investment outcomes for a particular policy scenario, these means and ranges should be interpreted as being consistent with a middle-of-the-road storyline for population, socio-economic development and technology optimism, all under varying levels of climate policy stringency (see below). Key socio-economic and policy assumptions are harmonized in this study.

Four scenarios are explored in this paper. Current Policies (CPol) serves as each model's reference case (or baseline). The scenario takes into account those energy- and climate-related policies that were already "on the books" of countries as of 2015; in other words, it reflects the early bridges to the low-carbon economy that policymakers have already implemented in various parts of the world. In addition to the reference case, the modelling teams ran three scenarios where policies for low-carbon energy, energy efficiency and climate change mitigation are tightened: Nationally Determined Contributions (NDCs), Well Below 2 Degrees (2°C), and Toward 1.5 Degrees (1.5°C). Population and socio-economic development assumptions across all scenarios are in line with the middle-of-the-road storyline of the Shared Socioeconomic Pathways (SSP2).

Source: McCollum et al. (2018)

Table 8, based on the supplementary materials of their paper, gives the additional investments required per year in the selected countries, both to keep the global economy on track for below 2ºC and 1.5ºC. Investments are based on total estimate to 2030. In the table, the estimates for China, India and the US are directly taken from the paper. Those for Senegal, Uganda and Madagascar are estimated from the paper's total for Africa, allocated to these individual countries based on its share of GHG emissions from the region. Similarly, the figures for Indonesia are estimated as share of the East Asia total, those for Morocco from the Middle East and North Africa total, those for Brazil from the Latin America and Caribbean total, and those for Australia from the OECD total.

The annual amounts of investment, on average, are highest in China, followed by the US and India. Other countries' requirements are an order of magnitude smaller (or even more). Another important observation is the range of costs across the different models. The lower bound is between 70 per cent and 120 per cent lower than the mean, while the upper bound is 80 per cent to 145 per cent greater than the mean. In some cases, the lower bounds are negative, implying the costs of the low-carbon investments to be less than those of the business as usual. Regions with the greatest ranges are Brazil, Australia and the US on the lower bound and the same countries plus India on the upper bound. This means that financial needs depend significantly on the measures in place to encourage low-carbon investments, as well as parameters of the economic structure around which there is still some uncertainty. Globally, costs are estimated at $303 billion a year for the 2ºC target (range is $38 billion to $554 billion) and $458 billion (range $75 billion to $822 billion) for the 1.5ºC target.

Table 8: Projected annual investment gaps to meet different climate targets by 2030 (US$ million/year)

Country	Climate target					
	2ºC			1.5ºC		
	Mean	Low	High	Mean	Low	High
Senegal	$92	$26	$169	$172	$17	$359
Uganda	$186	$52	$343	$349	$35	$726
Madagascar	$66	$18	$121	$123	$12	$256
India	$33,000	$10,000	$81,000	$46,000	$17,000	$108,000
Indonesia	$5,776	$3,004	$9,011	$8,896	$2,311	$18,715
Morocco	$680	$191	$1,254	$1,275	$127	$2,656
China	$113,000	$30,000	$236,000	$166,000	$65,000	$268,000
Brazil	$3,385	-$725	$8,220	$5,802	-$1,209	$13,055
Australia	$2,357	-$309	$5,332	$3,817	$337	$7,156
USA	$38,000	-$3,000	$85,000	$58,000	$8,000	$132,000
World	**$303,000**	**$38,000**	**$554,000**	**$458,000**	**$75,000**	**$822,000**

Source: Adapted from McCollum et al. (2018)

It is also worth noting the huge difference between the investments in countries in sub-Saharan Africa and the big emitters, such as China, India and the US. This reflects the small contribution of that part of Africa to total emissions (around 4 per cent).

Investments for improving air quality

The SDG target here is 3.9 – to substantially reduce the number of deaths and illnesses from air pollution. This is interpreted in Markandya (2020) as reducing concentrations of PM2.5 below 10μg/M3 by 2030 and a similar interpretation is assumed here.

Reductions in GHGs are strongly related to reductions in local pollutants, as many studies have shown (West et al., 2013; Markandya et al., 2018; Shindell et al., 2018). McCollum et al. (2018) estimate the costs of policies to reduce air pollution levels globally in accordance with SDG3.9 at $740 billion for the decade 2020-2030 when no additional measures are taken to accelerate the track to meeting the Paris Agreement targets. If, however, action is taken to meet those targets, specifically the 1.5ºC target, the additional costs decline by 16 per cent, down to $620 billion (i.e. $62 billion a year).

The analysis of the measures undertaken by McCollum et al. to reduce concentrations of harmful pollutants and associated costs is based on a paper by Amann et al. (2011), which uses the GAINS model to estimate the costs and the reductions in concentrations. The modelling is essentially one of looking for the least cost combination of measures that will achieve a given target improvement in air emissions in a given country. They consider two kinds of actions in the air pollution side of the modelling:

1. Behavioural changes such as reduced use of cars, greater use of public transport, walking and cycling. The GAINS model does not internalize such behavioural responses, but reflects them through alternative exogenous scenarios of the driving forces; and
2. A wide range of technical measures developed to capture emissions at their sources before they enter the atmosphere. Emission reductions achieved through these options neither modify the driving forces of emissions nor change the structural composition of energy systems or agricultural activities. GAINS considers about 3,500 pollutant-specific measures for reducing emissions of SO2, NOx, VOC, NH3, PM, CH4, N2O and F-gases.

The modelling is applied to the European countries, where estimates are made for achieving targeted reductions in emissions. It is not possible to conduct, within this study, a detailed analysis of measures for the individual countries to achieve concentrations of pollutants compatible with the SDG. An approximation of the cost by country has been made by allocating the costs in McCollum et al. by country based on the national population that is currently exposed to concentrations of PM2.5 greater than the World Health Organization (WHO) maximum concentration. These populations are given in the World Bank's environmental statistics for all countries.

In 2017, about 6.8 billion of the world's population was exposed to concentrations of this pollutant above the WHO recommended value. If a country share of that total was, say 20 per cent, then 20 per cent of the additional costs reported in McCollum et al. were allocated to that country. This method has some limitations as it does not capture the severity of exposure, which can vary significantly between countries. The choice of PM2.5 for health impacts can be justified as it is by far the most important pollutant as far as health impacts are concerned. The allocation of costs based on shares of populations exposed is, to be sure, an approximation but unfortunately a necessary one.

Table 9 gives the cost estimates for meeting the air quality target for the selected countries: under the assumption that countries follow measures to meet the 1.5ºC target; and that no such measures are undertaken.

Table 9: Additional costs of meeting air quality standards by 2030 (US$ million/year)

Country	Population > WHO Std. (%)	Population (Million)	Population > WHO Std. (Million)*	Cost to meet air quality target ($Mn/Year)	
				With 1.5°C climate target	With no additional climate investment
Senegal	100	15	15	$139	$165
Uganda	100	39	39	$358	$427
Madagascar	99	24	24	$220	$262
India	100	1,311	1,311	$12,027	$14,354
Indonesia	89	258	229	$2,103	$2,510
Morocco	34.4	100	34	$316	$377
China	100	1,371	1,371	$12,578	$15,012
Brazil	56	208	116	$1,067	$1,274
Australia	0	24	0	$0	$0
USA	9	321	29	$265	$317
World	**92**	**7,347**	**6,759**	**$62,000**	**$74,000**

Sources: McCollum et al. (2018) and World Bank (2017)

* This number is the product of "% Population > WHO Std." and "Population"

5. MATERIALS USE IN PRODUCTION AND CONSUMPTION

The main SDG related to materials is SDG12 on sustainable production and consumption and SDG target 12.2, which states sustainable management and efficient use of natural resources. Indicators include: 12.2.1 (material footprint, material footprint per capita, and material footprint per GDP) and 12.2.2 (domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP). The precise target increase in efficiency of materials use is based on work by the Organisation for Economic Co-operation and Development (OECD) and United Nations Environment Programme (UNEP) as explained below.

There are four categories of materials normally considered when analysing material use: biomass (which constitutes wood, crops feedstock and plant-based materials); non-metallic materials (such as sand, gravel and limestone); fossil-fuels; and metals.

According to the OECD, global primary materials use is projected to almost double from 89 gigatons (Gt) in 2017 to 167 Gt in 2060. Non-metallic minerals represent the largest share of total materials use and are projected to grow from 44 Gt to 86 Gt between 2017 and 2060. Metal use is smaller when measured in weight, but is projected to grow more rapidly, and metal extraction and processing is associated with large environmental impacts (OECD, 2019). Growth in materials is expected to be less than growth in GDP, indicating an increase in efficiency. This is greatest for fossil fuels and biomass at around 2 per cent per year, 1.4 per cent per year for non-metallic minerals, and least for metals (0.75 per cent/year).

Given the significant environmental impacts of material extraction and production, and scarcity of some minerals raising concerns that overuse could lead to future limits to growth, SDG12 looks to increase materials efficiency even further. UNEP and the International Resources Panel (IRP) published a Global Resources Outlook (UNEP and IRP, 2019), in which they claim that “concerted resource-efficiency and sustainable resource-management measures can reduce resource extraction by 25 per cent, significantly mitigate negative impacts and boost the economy by 8 per cent by 2060”. The 25 per cent reduction is relative to an historical trend scenario that has a total of 187 Gt in 2060, with a different breakdown between the four categories of materials from the OECD study.

In determining the targets and estimating the costs of reductions in materials use by country and globally, the following assumptions are made. They are based on taking the UNEP targets for 2060 and calculating the reductions from the business as usual estimates for that year as derived by the OECD:

- Biomass use can be reduced from the OECD estimate of 37 Gt to the UNEP/IRP target of 32 Gt by 2060.
- Metal use can be reduced from the OECD estimate of 19.5 Gt to the UNEP/IRP target of 9.4 Gt by 2060.
- The non-metallic minerals target for 2060 are the same in the OECD and UNEP/IRP projections so no change is expected there.

- Country reductions are based on OECD estimates for 2060, with reduction targets proportional to the global target. The OECD report gives estimates for major countries, including the following in our set: Australia, Brazil, China, India, Indonesia and the US. Figures for the smaller countries have been estimated based on the figures for the regions. So for Madagascar, Senegal and Uganda, the estimates are the share of the country's GDP as a per cent of the GDP for sub-Saharan Africa (excluding South Africa for which the OECD makes a separate estimate). For Morocco, the estimate is based on the share of that country's GDP as a per cent of the GDP for the Middle East and North Africa.
- Changes in intervening years to 2060 are in proportion to the changes for 2060.
- Reductions in fossil fuel use are not assessed under this section, as they are costed as part of the reduction targets for GHGs.

Data on costs are quite limited. In the International Energy Agency (IEA) report on materials efficiency (IEA, 2019), some cost data are given in terms of the cost per ton CO_2 abated by reducing materials use. The report refers to a study by Material Economics, which notes that strategies accounting for a considerable portion of material demand reduction in the Clean Technology Scenario are estimated to have positive although moderate costs, such as EUR 50 (euros) per metric ton (t) of carbon dioxide (CO_2) abated for buildings reuse and EUR 60/t for reducing steel fabrication losses. Other strategies that account for a substantial portion of the additional material demand reductions in the material efficiency variant are at the higher end of the cost curve, such as EUR 85/t abated for material efficiency in buildings design and construction, and EUR 100/t for vehicle light weighting. All strategies in the Material Economics analysis have abatement costs no higher than EUR 100/t.

To convert these costs into cost per metric ton of materials, such as metals, a link between materials use and CO_2 emissions is required. In the UNEP report cited above, the extraction and processing of metals make up about 10 per cent of total GHGs. In 2017, these emissions were estimated at 53.5 $GtCO_2e$, including from land-use change (UNEP, 2018). Thus, the share that is attributed to metals is 5.35 $GtCO_2e$. Metal use in production in 2017 globally was 8.63 Gt. Thus, emissions per metric ton of metals were 620kg CO_2. Costs of reduction of CO_2 per ton abated according to the IEA report lie in the range of €50-100/t CO_2 abated. An average of €75/t is used, which was equal to $82.5/t CO_2 at the exchange rate of the year of the estimate (2015). This implies that the cost per metric ton of metal reduced is $51.2. This figure is used (with the ranges of $34.1 to $68.2) in estimating the costs of metal materials reduction measures.

The other category of materials for which there is an efficiency target is biomass. The UNEP and IRP (2019) report estimates the share of emissions from this sector at 17 per cent of global emissions, equal to 9.10 $GtCO_2$ in 2017. Biomass use in 2017 globally was 21.5 Gt. Thus, emissions per ton of biomass were 423 kg. Measures to improve crop efficiency and land use management would include increased grassland management, improved agronomy practices, and dietary additives and feed supplements to reduce emissions from livestock. McKinsey (2007) estimates that the average cost per ton CO_2 abated is around €1, equal to $1.4 at the exchange rate of the time of estimation.

This would imply a cost of $0.6/t of biomass abated. A range of +/-25 per cent is taken based on the MACC curve in the McKinsey paper, given a cost range of $0.45 to $0.75 per metric ton. The above cost estimates for metals and biomass targets should be considered preliminary. As the IEA report notes, further analysis is required in this area.

These estimates, combined with the targets for reductions in metals and biomass use form the basis of the estimates given in Table 10, which gives the reduction in Gt of metals and biomass over the decade 2020-2030, as well as cost estimates per year over this period to achieve these reductions. It should be noted that these are averages over the decade. As reductions and costs increase over time, one can expect lower costs in the initial years and higher ones later. Globally, the costs range from $45 billion to $91 billion a year over the next decade, with the largest amount required in China (around a third of the total), followed by India and the US (10 per cent and 8 per cent, respectively, of the total). Most of the costs are for reducing the use of metals in production; costs of biomass reduction only make up 0.5 per cent of the total. Given the programme identified here has not yet started, one can assume that these expenditures represent additional financing that will be needed over the coming decade.

Table 10: Costs of achieving materials efficiency in selected countries by 2030 (US$ million/year)

Country	Metals				Biomass				Total cost ($Mn/Year)**		
	Reduction 2020–2030 (Gt)*	Annual cost ($Mn/Year)**			Reduction 2020–2030 (Gt)*	Annual cost ($Mn/Year)**					
		Average	Low	High		Average	Low	High	Average	Low	High
Senegal	0.007	$28	$19	$37	0.003	$0	$0	$0	$28	$19	$38
Uganda	0.013	$57	$38	$76	0.006	$0	$0	$0	$57	$38	$76
Madagascar	0.005	$20	$13	$27	0.002	$0	$0	$0	$20	$13	$27
India	1.531	$6,531	$4,350	$8,699	0.668	$33	$25	$42	$6,564	$4,375	$8,741
Indonesia	0.556	$2,374	$1,581	$3,163	0.243	$12	$9	$15	$2,387	$1,590	$3,178
Morocco	0.015	$65	$43	$86	0.007	$0	$0	$0	$65	$43	$87
China	5.172	$22,069	$14,698	$29,396	2.231	$112	$84	$139	$22,180	$14,782	$29,536
Brazil	0.399	$1,701	$1,133	$2,266	0.172	$9	$6	$11	$1,710	$1,139	$2,277
Australia	0.235	$1,001	$667	$1,334	0.102	$5	$4	$6	$1,006	$671	$1,340
USA	1.263	$5,388	$3,588	$7,177	0.545	$27	$20	$34	$5,415	$3,609	$7,211
World	**15.916**	**$67,909**	**$45,228**	**$90,457**	**6.475**	**$324**	**$243**	**$405**	**$68,233**	**$45,471**	**$90,861**

Sources: *OECD (2019), and UNEP and IRP (2019)

**Own calculations

6. TERRESTRIAL ECOSYSTEMS

The target year in SDG15 for losses of terrestrial and freshwater inland ecosystems is 2020, but that is obviously unrealistic, so 2030 has been adopted as the target date. In addition, the target reduction of losses for forests (15.2), wetlands and protected areas (15.1) are not specified in the SDG, but they are stated in the Aichi Targets that were adopted as part of the Convention of Biological Diversity's Strategic Plan for Biodiversity 2011–2020. The Aichi Targets are closely related to the SDGs; hence it is reasonable to adopt them.

The relevant ones for this exercise are: halving the rate of loss of forests and wetlands; and ensuring that at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved. There has, however, been a push to raise the protected areas together from 27 per cent to 30 per cent (Waldron et al., 2020). If each target were raised in proportion, that would make the terrestrial target 18.9 per cent and the marine 11.1 per cent.

There is no formal statement, however, in the literature setting these as the new targets and so the report has retained the original Aichi Targets. Conservation is undertaken through effectively and equitably managed, ecologically representative and well-connected systems of protected areas, other effective area-based conservation measures, and integration into the wider lands.

Reducing the rate of deforestation

Data on the rate of deforestation is taken from the World Development Indicators (World Bank, 2017). To estimate the costs of halving the rate of loss, only one study – undertaken by the Secretariat of the Convention on Biological Diversity (CBD, 2013) – was available. It estimated the costs of this target, assuming the programme was initiated in 2013 and completed in 2020, by which time the rate of loss would be halved if the programme was successful.

In terms of what has been achieved since 2013, there are divergent views. One comes from Global Forest Watch (GFW) compiled from satellite images by the World Resources Institute (WRI, 2020). It estimates the decline in tree cover last year at 29.4 million hectares, almost 50 per cent more than in 2015. That analysis is supported by on-the-ground observations, especially in Southeast Asia, where forest continues to be converted to oil palm. If true, it would indicate that the programme has not worked so far.

The other source is the Global Forest Resources Assessment (FRA), compiled from government inventories by the UN Food and Agriculture Organization (FAO). It estimates the annual net loss, once forest regrowth is taken into account, at barely a tenth as much: just 3.3 million hectares and says deforestation rates have declined by more than 50 per cent in the past decade.

The difference is not resolved, but the discussions on the topic suggest that GFW, based on satellite data and not dependent on national reporting of registered land use, is possibly closer to the right figure. In any event, neither measure would claim that deforestation rates were halved between 2013 and 2020. In this analysis, it is assumed that the target of reducing the rate of deforestation by 50 per cent relative to 2020 levels remains in place, to be achieved by 2030.

The estimates of the costs are based on work done by the Convention for Biological Diversity (CBD) Secretariat. They include preparation of biodiversity inventories, setting up monitoring systems, training and education of professional officers, law enforcement and the creation of enabling conditions (financial incentives which counter illegality). The global cost was estimated at $10.5 billion in investments over three years and $83.1 billion in recurrent costs over eight years. These costs are in 2012 prices: to convert to 2020 prices they are raised by a factor of 1.129, making a total cost of $105.6 billion over 8 years. So as to be consistent with the other programmes, these costs are spread out for the coming programme over 10 years.

To link this to a cost per hectare, an estimate of the level of deforestation was taken at the start of the period (2012-2013). As noted, there are very different opinions of the rate at that time. The GFW figure for that period was 22 million hectares while the FAO figure was around 3.3 million hectares. Based on these, the costs of the CBD programme work out between $4,804/ha and $32,028/ha spread over 10 years. These estimates are in 2020 prices.

The resulting costs for the selected countries and the whole world are given in Table 11, both for the whole period 2021-2030, as well as an average annual cost over that period. Global costs amount between $19 billion and $128 billion, implying an average cost of between $1.9 billion and $12.7 billion a year. The highest costs (nearly half the total) are in Brazil, with Indonesia next. Large countries, such as China and India, that have high costs of other SDGs do not need finance for this SDG, as they are not facing deforestation.

Table 11: Costs of reducing deforestation by half in 2021-2030

Country	Deforestation rate (% per year)	Forest area (ha)	Based on GFW data		Based on FAO data	
			Cost of halving loss ($Mn)	Annual cost ($Mn/Yr)	Cost of halving loss ($Mn)	Annual cost ($Mn/Yr)
Senegal	0.5	8,299,000	199	19.93	1,329	132.90
Uganda	4.1	2,090,400	412	41.17	2,745	275
Madagascar	0.3	12,454,800	179	17.95	1,197	120
India	-0.5	70,757,400	-	-	-	-
Indonesia	0.6	90,962,400	2,622	262.19	17,480	1,748
Morocco	-0.8	5,619,600	-	-	-	-
China	-1.1	208,413,600	-	-	-	-
Brazil	0.4	493,122,000	9,476	947.58	63,175	6,317
Australia	0.2	124,448,400	1,196	119.57	7,972	797
USA	-0.1	310,083,300	-	-	-	-
World	**0.1**	**3,995,776,400**	**19,196**	**1,919.57**	**127,977**	**12,798**

Sources: The deforestation rate is from World Bank (2017), reporting average figures from 2000 to 2015 (the negative numbers indicate an increase in forest areas); data for forest areas are for 2015 and obtained from World Bank (2017); costs are based on CBD (2013)

Reducing the rate of loss of wetlands

One of the Aichi targets is to halve the rate of loss of wetlands, where feasible bring it to zero, and significantly reduce degradation and fragmentation. The original date for achieving this was 2020, but as that has not been met, a new date was set at 2030. The baseline for this is difficult as not all countries have up to date figures. The global baseline estimate is for 2015. Costs of achieving the goal as estimated by the CBD were between $290 and $323 billion over eight years in 2012 prices. Updating to 2020 prices gives a range of $327 billion to $365 billion. The total area of wetlands on which the estimate was based was 1,213 million ha, facing a loss of 19.4 million ha a year or 155 million ha over the eight years. The costs related to that loss rate are $1,598-2,349 per ha spread over 8 years originally, but to be consistent with the other programmes the costs are spread over 10 years (2021-2030).

The figures for individual countries are calculated using this cost range, but applied to the loss rates relevant to the individual countries. Estimates of these were difficult to obtain in some cases and the figures used are from various sources as cited in Table 12. Further work is needed to get better estimates, especially for Brazil, Senegal, Indonesia and Morocco. Given this limitation, the table provides an estimate of total costs of meeting the wetland target. Globally, the figures are $248 billion to $365 billion, or $25 billion to $36 billion a year. Large outlays will be needed in Indonesia, India, China and Brazil. Some small countries with a high loss rate and a high level of wetland area, such as Uganda, will also need significant amounts of finance; in its case the figures indicate an annual amount of $85 million to $124 million a year.

Increasing protected areas

The Aichi targets for protected areas state that such areas should account for at least: 17 per cent of terrestrial and inland water areas; and 10 per cent of marine and coastal areas. Since then, there has been a strong push in the post-2020 global biodiversity framework to increase protected areas coverage coverage to 30 per cent for terrestrial areas and marine areas taken together (Waldron et al., 2020).

As noted in the introduction to this section, however, the 30 per cent overall figure does not separate the marine and terrestrial targets and so it has not been adopted for the purpose of this report. The *Protected Planet Report 2016* (UNEP-WCMC and IUCN, 2016) puts the current terrestrial protected areas at 14.7 per cent and marine ones at 10.1 per cent each as a share of the extent of its ecosystem. In terms of hectares, the report states that to meet the target an additional 3.1 million km^2 would need to be protected globally. For marine and coastal areas, the same report states that the 10 per cent target has been met globally, but not for all countries. This arises because a few countries have coverage well in excess of 10 per cent. Estimates of the additional areas needed to be protected for the selected countries are taken from the Protected Planet dashboard.

The costs of meeting the goals are spread over 10 years (2021–2030). For terrestrial areas, the unit costs are taken from Hussain et al. (2011). The cost of converting land to protected areas is considerable. Hussain et al. carried out a detailed survey of the different components of the cost, which include transfer of property rights in some cases, establishing and maintaining networks of areas, transactions costs and, most importantly, opportunity costs of the alternative use of the land. Costs per hectare turn out to be in the range of $2,792 to $11,869 (the original figures have been adjusted for inflation to get them into 2020 prices). The CBD (2013) study also makes some estimates, with even wider ranges, but with less detail on method, so the Hussain et al. estimates have been used. For marine sites, the CBD study has been used. It estimates the costs of meeting the 10 per cent target between $16.3 billion and $39.4 billion (prices adjusted for inflation to get them into 2020 prices). The amount of land they would protect is estimated at 1,097 million ha, given a cost per hectare of between $15 and $36.

In addition to these costs, Waldron et al. (2020) estimate an additional annualized cost for meeting the 30 per cent combined target at between $78.7 billion and $153.7 billion, of which $43.1 billion is additional funding required to make existing protected areas effectively protected. The total cost estimates from that study for new areas cannot be converted into a cost per hectare as the additional terrestrial and marine areas protected are not specified in the paper. The costs of upgrading management for existing sites, however, can be converted into a cost per hectare as current areas are given as 19.8 million km^2 (terrestrial) and 14.9 million km^2 (ocean). Together they imply an additional $12.4/ha. As this is not included in the other sources used, it has been added to the cost data.

Table 13 gives the estimates of the finance needed over 10 years to meet the targets for protected areas. Global costs per annum amount to $87 billion to $369 billion – a very wide range. Most of this is for terrestrial areas, with largest shares going to the US and India, followed by China and Indonesia. Even a small country like Madagascar, however, would need in the range of $1.6 billion to $6.8 billion. Further work is needed to pin these estimates down more accurately.

Table 12: Costs of reducing loss of wetlands by half in 2021–2030

Country	Inland wetlands (000 ha)*	Coastal wetlands (000 ha)*	Total wetlands (000 ha)**	% Loss per year***	Protection target by 2030 (000 ha)	Cost of both targets 2021-2030 ($Mn)		Annual cost of targets 2021-2030 ($Mn/Year)	
						Low	High	Low	High
Senegal	146	41	157	-1.6%	20	$32	$47	$3	$5
Uganda	2,631	0	2,631	-2.5%	529	$846	$1,243	$85	$124
Madagascar	1,944	151	2,095	-1.6%	268	$429	$630	$43	$63
India	10,557	4,743	15,300	-2.5%	3,077	$4,918	$7,230	$492	$723
Indonesia	16,950	22,650	39,600	-1.6%	5,069	$8,101	$11,909	$810	$1,191
Morocco	14	302	316	-1.2%	30	$48	$71	$5	$7
China	42,870	10,550	53,420	-1%	4,274	$6,830	$10,040	$683	$1,004
Brazil	6,346	20,448	26,794	-1.6%	3,430	$5,481	$8,058	$548	$806
Australia	3,320	4,980	8,300	0%	0	$0	$0	$0	$0
USA	2,400	42,200	44,600	0%	0	$0	$0	$0	$0
World	**1,128,090**	**84,910**	**1,213,000**	**-1.6%**	**155,264**	**$248,154**	**$364,780**	**$24,815**	**$36,478**

Sources: Davidson et al. (2018); Senegal, Madagascar, Morocco - Ramsar (2020); Uganda - Government of Uganda (2016); India - Bassi et al. (2014) and Prasher (2018); Indonesia - Margono et al. (2014) and Sulaiman et al. (2019); China - Meng et al. (2017); Australia - Australian Government, Department of Agriculture, Water and the Environment (2013); USA – U.S. Fish and Wildlife Service (2011); and World - Ramsar Convention on Wetlands (2018)

* The respective inland and coastal wetlands area of Senegal and Madagascar are based on Davidson et al. (2018), where they estimate that globally, inland is 92.8% and coastal is 7.2% of total continental wetlands.

** In total wetlands area, Ramsar Sites are used for Senegal, Madagascar, Morocco and Brazil due to lack of data for the individual countries.

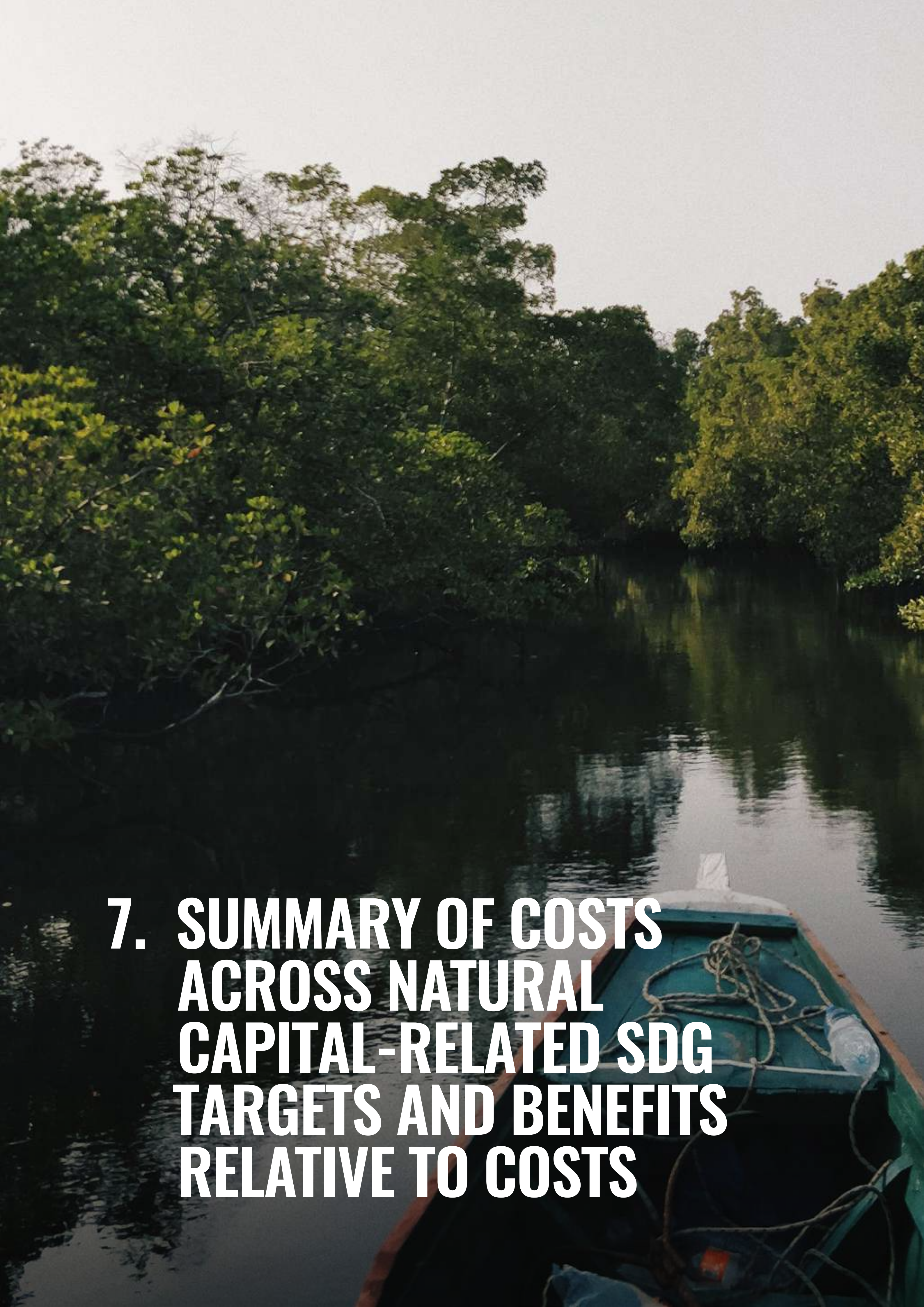
*** The global average loss per year is 1.6%. This estimate was used for Senegal, Madagascar, Indonesia and Brazil because data are not available for these countries. In the case of Australia and the US, no additional costs are involved as current programmes meet the target. Costs are based on CBD (2013).

Table 13: Costs of meeting the protected areas targets by 2030

Country	Terrestrial target by 2030 (000 ha)	Marine target by 2030 (000 ha)	Cost of terrestrial target 2021-2030 ($Mn)		Cost of marine target 2021-2030 ($Mn)		Cost of both targets 2021-2030 ($Mn)		Annual cost of both targets 2021-2030 ($Mn/Year)	
			Low	High	Low	High	Low	High	Low	High
Senegal	0	1,410	$0	$0	$38	$68	$38	$68	$4	$7
Uganda	229	0	$641	$2,716	$0	$0	$641	$2,716	$64	$272
Madagascar	5,704	10,988	$15,996	$67,772	$299	$531	$16,295	$68,303	$1,630	$6,830
India	33,274	22,621	$93,315	$395,349	$616	$1,092	$93,930	$396,442	$9,393	$39,644
Indonesia	9,209	41,279	$25,825	$109,413	$1,123	$1,994	$26,948	$111,407	$2,695	$11,141
Morocco	5,185	2,571	$14,540	$61,602	$70	$124	$14,610	$61,726	$1,461	$6,173
China	12,919	3,970	$36,230	$153,498	$108	$192	$36,338	$153,690	$3,634	$15,369
Brazil	0	0	$0	$0	$0	$0	$0	$0	$0	$0
Australia	0	0	$0	$0	$0	$0	$0	$0	$0	$0
USA	49,445	0	$138,664	$587,484	$0	$0	$138,664	$587,484	$13,866	$58,748
World	**310,000**	**82,839**	**$869,369**	**$3,683,289**	**$2,254**	**$4,001**	**$871,623**	**$3,687,289**	**$87,162**	**$368,729**

Sources: CBD (2013), Hussain et al. (2011), and UNEP-WCMC and IUCN (2016)

Notes: The world figure for marine areas only covers the selected countries. Targets are estimated from the Aichi Targets as explained in the text. Marine costs are based on CBD (2013). Other costs are from Hussain et al. (2011). There are no targets for Australia and Brazil because they have expanded their protected area networks since 2016.



7. SUMMARY OF COSTS ACROSS NATURAL CAPITAL-RELATED SDG TARGETS AND BENEFITS RELATIVE TO COSTS

Summary of costs

The cost estimates across all the SDGs that are directly linked to enhancing natural capital in the selected countries are summarized in Table 14, which gives the average annual costs of meeting the relevant SDG targets in the next 10 years. China appears to require the largest total investment cost at about $163 billion per year, followed by India ($91 billion/year) and the US ($80 billion/year). The bulk of the investments in the three countries are for measures that will reduce greenhouse gas emissions.

There are SDGs for which some countries do not need to invest, mainly because the targets have already been met. For instance, water and sanitation targets are already met in the industrialized countries (Australia and the US). Australia has also already met its targets with respect to air pollution, wetlands and protected areas. The US has met its targets for restoration of degraded agricultural land and wetlands. In terms of deforestation, four countries (India, Morocco, China and the US) do not have investment costs to address the SDG target because they have positive annual rates of change in their forest areas.

Globally, it is estimated that about $774 billion per year is required to meet the selected SDG targets by 2030. This compares to an estimated $2.5 trillion per year, on average, for all 17 SDGs across all developing countries in UNCTAD (2020) and $2.5 trillion to $3 trillion per year in UN (2019).

Table 14: Average costs of meeting the selected SDG targets by 2030 (US$ million/year)

Country	Agricultural land remediation*	Water and sanitation	Climate change**	Air pollution	Material efficiency	Deforestation***	Wetlands	Protected areas	All targets
Senegal	$38	$155	$92	$139	$28	$133	$4	$5	$594
Uganda	$78	$702	$186	$358	$57	$275	$104	$168	$1,928
Madagascar	$112	$406	$66	$220	$20	$120	$53	$4,230	$5,226
India	$443	$13,442	$33,000	$12,027	$6,564	-	$607	$24,519	$90,603
Indonesia	-	$1,623	$5,776	$2,103	$2,387	$1,748	$1,001	$6,918	$21,555
Morocco	-	$137	$680	$316	$65	-	$6	$3,817	$5,020
China	-	$4,604	$113,000	$12,578	$22,180	-	$844	$9,501	$162,707
Brazil	$200	$719	$3,385	$1,067	$1,710	$6,317	$677	$0	$14,075
Australia	-	$0	$2,357	$0	$1,006	$797	$0	$0	$4,161
USA	$0	$0	$38,000	$265	$5,415	-	$0	$36,307	$79,988
World	**$9,040**	**$60,002**	**$303,000**	**$62,000**	**$68,233**	**$12,798**	**$30,647**	**$227,946**	**$773,665**

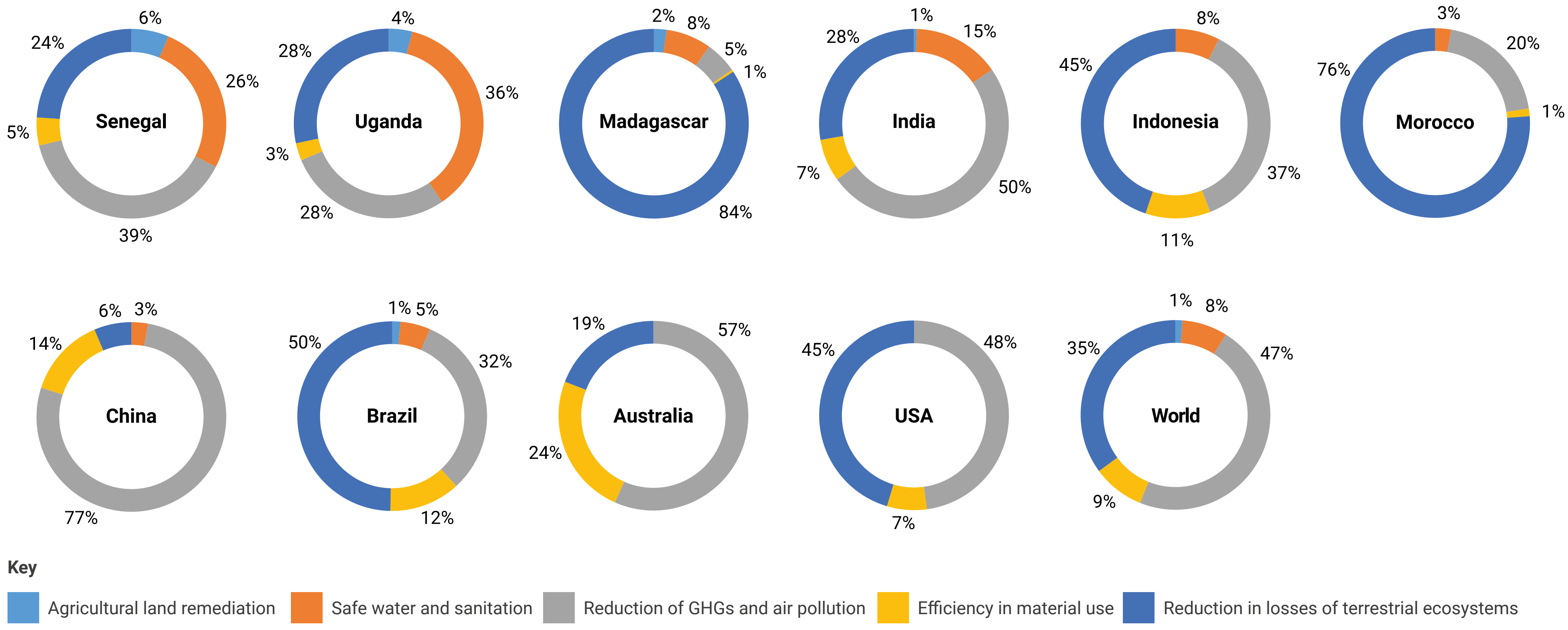
* Agricultural land remediation is based on estimates of remaining pledge under the Bonn Challenge. Countries with “-” did not commit to the Bonn Challenge. US costs are zero because they have already met their pledge.

** Estimates are for the 2ºC target.

*** Deforestation is based on FAO data; “-“ means that the forest area is increasing in the country.

Figure 1 below presents the cost of meeting each SDG target, as a proportion of the total cost, in the selected countries. Note that the SDG target for terrestrial ecosystems in the figure is a combined target to reduce the rates of deforestation and loss in wetlands, and to increase protected areas. Reduction of GHG emissions and improvement of air quality comprise more than one-third of investment costs in six countries – Senegal (39%), India (50%), Indonesia (37%), China (77%), Australia (57%) and the US (48%). In low-income countries, investments in safer water and sanitation are in the top two relative to other SDG targets – Senegal (26%), Uganda (36%) and Madagascar (8%). Globally, the share of costs is highest for investments in GHG emission reduction and cleaner air (47%), followed by reduction in losses of terrestrial ecosystems (35%), efficiency in material use (9%), safer water and sanitation (8%) and land remediation (1%).

Figure 1: Cost shares (%) of meeting natural capital-related SDG targets with respect to total costs in selected countries by 2030



A summary of cost ranges in meeting the SDG targets are provided in Appendix 2. Across all targets, the high estimate is about four times the low estimate, which is substantial. The range varies considerably across the eight natural capital-related SDGs. The ratio of high cost estimate to low estimate is less than two for water and sanitation, air pollution, materials efficiency and wetlands; about four for protected areas, seven for reducing deforestation, 14 for climate change and 54 for land remediation. The SDGs with the high ranges point in part to the need for more detailed investigation of the costs at the country level than is available in the literature. In the case of climate change (and partly for other SDGs as well), they also indicate that the costs depend significantly on the policies and measures undertaken to achieve the goal. For countries seeking to conduct similar estimates the data sources and methodology are provided in Appendix 3.

It must also be noted that the assessment of SDG15 in this report mainly covers forests, wetlands and protected areas, although the targets under SDG15 are much broader. Therefore, the findings presented above are likely to be an underestimate of the total financing needed to achieve all targets under SDG15.

Benefits relative to costs

The costs of attaining the SDGs can be compared to the increase in natural capital generated by their implementation. These benefits were estimated in Markandya (2020), taking the present value of the additional flow of ecosystem services that meeting the SDGs would provide. As the benefits were only estimated at a global level, the comparison can also only be made at that level and not for individual countries. A discount rate of 4 per cent was used in the calculation, which is a common discount rate employed in wealth accounting for natural assets (Kunte et al., 1998; Lange et al., 2018; Markandya, 2019). The present value of the costs is estimated similarly over the period 2021–2030 (10 years). In both cases, there is a considerable range so both lower and upper bounds are reported. Table 15 gives the summary values, along with the ratio of the increase in the value of natural capital relative to the present value of the costs.

Table 15: Present value of costs and value of increase in natural capital (US$ billion)

SDG sector	PV costs			Increase in natural capital			BCR		
	LB	Mean	UB	LB	Mean	UB	LB	Mean	UB
Degraded areas	$5.5	$73.3	$297.4	$13,700.0	$21,650.0	$29,600.0	2500.9	295.3	99.5
Water and sanitation	$390.6	$486.7	$622.3	$1,500.0	$1,500.0	$1,500.0	3.8	3.1	2.4
Climate change	$308.2	$2,457.6	$4,493.4	$1,600.0	$8,450.0	$15,300.0	5.2	3.4	3.4
Air pollution	$502.9	$502.9	$600.2	$5,100.0	$5,100.0	$5,100.0	10.1	10.1	8.5
Material efficiency	$368.8	$553.4	$737.0	$2,600.0	$6,500.0	$10,400.0	7.0	11.7	14.1
Deforestation	$15.6	$103.8	$103.8	$3,800.0	$8,250.0	$12,700.0	244.1	79.5	122.3
Wetlands	$201.3	$248.6	$295.9	$100.0	$3,950.0	$7,800.0	0.5	15.9	26.4
Protected areas	$707.0	$1,848.8	$2,990.7	$120.0	$165.0	$210.0	0.2	0.1	0.1

Note: LB: lower bound; UB: upper bound; PV: present value; BCR: benefit-to-cost ratio

Decisions on the SDGs are not based on a comparison of the benefits in terms of natural capital increases against the costs. Nevertheless, it is useful to know where the increases are greatest relative to the costs. Based on mean values, the greatest gains come from investments in land remediation, followed by avoided deforestation, wetlands, materials efficiency and air pollution reduction, in that order. In all cases, the increases in natural capital exceed the costs of the programmes, with the exception of protected areas where the measured increase in natural capital is less than the cost. Knowledge of these gains in natural capital can also be important in securing financing for the associated projects in the first place.

The ranking changes a little with the use of low and high estimates, but the broad conclusions remain the same. It is also important to note that the benefit-to-cost ratios are based on global estimates and so the ranking will not apply in all countries. Individual estimates need to be made at the country level. Furthermore, downscaling further, there will be a range of ratios of increases in natural capital to cost within the country. Thus, while protected areas have a ratio of benefits to costs of less than one on average globally, individual sites in countries may have ratios well above one.

8. CONCLUSIONS AND NEXT STEPS

In this paper, a review has been carried out of the additional financial resources required to meet selected SDG targets. The natural capital approach in Markandya (2020) is used to estimate the natural capital gaps that are needed to meet related SDG targets. Based on that, the paper has appraised the financial costs to close the said gaps. Estimates of these costs have been made at the global level as well as for selected countries that represent a diverse geographical range and different levels of development. The methods involved a bottom-up or top-down approach, bringing together estimates from different studies and reporting costs figures in comparable units (2019 US dollars).

Globally, it is estimated that, additionally, about $774 billion per year is required to meet the selected targets for the eight natural capital-related SDGs by 2030. This compares to an estimated $2.5 trillion per year, on average, for all 17 SDGs across all developing countries in UNCTAD (2020) and $2.5 trillion to $3 trillion per year in UN (2019). The methodologies and SDGs addressed in the two UN studies and this report differ, but a common message comes across, and that is regardless of the methodology used, the scale of meeting the SDGs is immense.

The share of costs is highest for investments in GHG emissions reduction and cleaner air (47%), followed by reduction in losses of terrestrial ecosystems (35%), efficiency in material use (9%), safer water and sanitation (8%) and land remediation (1%). Looking at costs in individual countries, reduction of GHG emissions and improvement of air quality comprise more than a third of investment costs in six countries. In low-income countries, investments in safer water and sanitation are in the top two relative to other SDG targets.

Comparing the costs of meeting the SDGs against the increase in natural capital they would generate, the greatest gains come from investments in land remediation, followed by avoided deforestation, wetlands, materials efficiency and air pollution reduction, in that order. In all cases, the increases in natural capital exceed the costs of the programmes, with the exception of protected areas where the measured increase is less than the cost.

It is also important to note the high level of uncertainty in the costs. Across all targets, the high estimate is about four times the low estimate. There is also considerable variation across the eight SDGs. The ratio of high cost estimate to low estimate is less than two for water and sanitation, air pollution, materials efficiency and wetlands; about four for protected areas, seven for reducing deforestation, 14 for climate change and 54 for land remediation.

The SDGs with the high ranges point in part to the need for more detailed investigation of the costs at the country level than is available in the literature. In the case of climate change (and partly for other SDGs as well), cost estimates also indicate that they depend significantly on the policies and measures undertaken to achieve the goal.

Focusing on the selected SDG targets related to natural capital, this paper estimated the cost of meeting these targets globally and in 10 selected countries. Limited data, however, introduce uncertainties in the cost ranges estimated. The next steps of the study are to: apply the methodology to 10 additional countries, aiming that altogether the 20 countries would represent about two-thirds of the world economy as well as significant biodiversity; compare the country level costs with the benefits in terms of natural capital at the country level; compare the estimates of required finance against the rate of actual investment to see where there is a gap and how big it is; and identify actions that can accelerate the mobilization of finance where the gap is greatest and where the need in terms of meeting the SDGs has highest priority.

APPENDICES

Appendix 1: Estimated agricultural areas to be remediated in selected countries by 2030 (thousand hectares)

Country	Remaining area to be remediated by 2030*		Share of ag. land**	Agricultural area to be remediated by 2030	
	Under prop. rule	Under Bonn Challenge		Under prop. rule	Under Bonn Challenge
Senegal	451	2,000	52%	234	1,040
Uganda	487	2,448	87%	424	2,129
Madagascar	2,130	4,000	77%	1,640	3,080
India	-2,108	11,189	72%	-1,518	8,056
Indonesia	13,376	-	41%	5,484	-
Morocco	876	-	84%	736	-
China	28,518	-	72%	20,533	-
Brazil	15,037	2,575	32%	4,812	824
Australia	25,925	-	75%	19,444	-
USA	8,832	-1,959	57%	5,034	-1,117
World	**307,157**	**165,533**	**54%**	**165,865**	**89,388**

Source: FAOSTAT Land Use

* From Table 4
** Agricultural land as percentage of total agricultural land and forest land by country

Appendix 2: Cost ranges of meeting SDG targets in selected countries by 2030

Country	Ag Land Remediation* ($)		Water & Sanitation ($)		Climate Change** ($)		Air Pollution*** ($)		Material Efficiency ($)		Deforesta-tion**** ($)		Wetlands ($)		Protected Areas ($)		All Targets ($)	
	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
Senegal	35	41	145	176	26	169	139	165	19	38	20	133	3	5	4	7	391	733
Uganda	73	83	658	797	52	343	358	427	38	76	41	275	85	124	64	272	1,369	2,396
Madagascar	105	120	380	460	18	121	220	262	13	27	18	120	43	63	1,630	6,830	2,427	8,003
India	81	1,607	12,599	15,247	10,000	81,000	12,027	14,354	4,375	8,741	-	-	492	723	9,393	39,644	48,966	161,316
Indonesia	-	-	1,521	1,841	3,004	9,011	2,103	2,510	1,590	3,178	262	1,748	810	1,191	2,695	11,141	11,985	30,619
Morocco	-	-	128	155	191	1,254	316	377	43	87	-	-	5	7	1,461	6,173	2,144	8,052
China	-	-	4,316	5,222	30,000	236,000	12,578	15,012	14,782	29,536	-	-	683	1,004	3,634	15,369	65,992	302,143
Brazil	13	752	674	816	-725	8,220	1,067	1,274	1,139	2,277	948	6,317	548	806	0	0	3,664	20,461
Australia	-	-	0	0	-309	5,332	0	0	671	1,340	120	797	0	0	0	0	482	7,469
USA	0	0	0	0	-3,000	85,000	265	317	3,609	7,211	-	-	0	0	13,866	58,748	14,741	151,276
World	675	36,667	48,157	76,727	38,000	554,000	62,000	74,000	45,471	90,861	1,920	12,798	24,815	36,478	87,162	368,729	308,200	1,250,260

* Agricultural land remediation is based on estimates of remaining pledge under the Bonn Challenge. Countries with "-" did not commit to the Bonn Challenge.

** Estimates are for the 2ºC target.

*** Lower bound is with 1.5ºC climate target. Higher bound is without additional climate investment. Negative figures imply that the costs of the low-carbon investments are less than those of the business-as-usual investments.

**** Lower bound is based on GFW data and higher bound is based on FAO data; "-" means that the country is not facing deforestation.

Appendix 3: Data, sources and methodology for estimating the costs of meeting the SDG targets

SDG	Key data			Methodology
	Data	**Source**	**Additional notes**	
(Agricultural) land degra-dation	Total degraded land area, hectare (TOTAL)	Sutton et al. (2016)	Data includes degraded agricultural and forest lands	(1) TARGETPROP = 0.13 x TOTAL (2) REMAINDERi = TARGETi - RESTORED, where i is PROP or BONN (3) Annual remediation cost of degraded agri-cultural land in the next 10 years = (REMAINDERi x AGLAND x COST) / 10 years
	Target to be remediated (TARGET): Propor-tional Rule - 13% of national degraded land, hectare (PROP)	Authors' estimate	Of the 2.74 billion ha total degraded area in the world, the Bonn Challenge is to restore 350 million ha by 2030, which is 13% of the total	
	Target to be remediated (TARGET): Bonn Challenge pledge, hectare (BONN)	IUCN (2020a)		
	Total area restored, hectare (RESTORED)	IUCN (2020b)	Achievement of countries with pledges as of 2018	
	Agricultural land as percentage of total agri-cultural and forest land (AGLAND)	FAO (2020)		
	Remediation cost (US$/ha) by income level (COST)	Authors' estimate, see Table 5 in report	Costs are estimated for country classifications by income level (low, low-middle, upper-middle, high) and ranges (low bound, average, high bound); costs include investment and technical assistance	
Water and sanitation	Percentage of unimproved water and sanita-tion services	UNICEF and WHO (2015)		
	Population in 2015 and 2030	Riahi et al. (2017)		
	Cost for safe sanitation and safe water	Hutton and Varughese (2016)		

SDG	Key Data			Methodology
	Data	Source	Additional Notes	
Climate change	Climate target - 1.5°C	McCollum et al. (2018)		
	Climate target - 2°C			
Air pollution	% Population > WHO Standard	World Bank (2017)		
	Population	World Bank (2017)		
	Cost to meet air quality target - with 1.5°C Climate Target and without additional climate investment	McCollum et al. (2018)		
Material efficiency	Reduction in use of metals and biomass, gigatons	OECD (2019); UNEP and IRP (2019)		
Deforestation	Deforestation rate, % per year	World Bank (2017)	Average figures from 2000 to 2015	
	Forest area, hectare	World Bank (2017)	Data are as of 2015	
	Cost of halving the rate of deforestation	CBD (2013)		
Wetlands	Inland and coastal wetland areas	National government report; Ramsar (2020)	Data may be obtained from a country report or Ramsar site	
	Global average loss per year (1.6% per year)	Ramsar Convention on Wetlands (2018)	Additional data can be obtained from country reports	
	Cost of halving the loss of wetlands	CBD (2013)		
Protected areas	Terrestrial target by 2030, hectare	UNEP-WCMC and IUCN (2016)		
	Marine target by 2030, hectare			
	Cost of terrestrial target	Hussain et al. (2011)		
	Cost of marine target	CBD (2013)		

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