Investment Needs to Achieve the Sustainable Development Goals

Understanding the Billions and Trillions

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Abstract: In September 2015, governments adopted the Sustainable Development Goals (SDGs) to guide international cooperation in pursuit of ambitious quantitative goals to be achieved by 2030. This paper reviews the role that global needs assessments play in supporting the SDGs and discusses common criticisms. The paper proposes an analytical framework for SDG needs assessments that translates the 17 SDGs into eleven investment areas. It also integrates investment needs for climate change adaptation and mitigation with the development needs for each investment area. Using this framework, published sector needs assessments are harmonized and consolidated, paying careful attention to differences in methodologies and assumptions. The share of private financing is estimated for each investment area, and overall investment needs are aggregated. The paper then explores the implications of economy-wide studies on synergies and trade-offs in financing the SDGs and outlines priorities and directions for future research. This preliminary analysis of available sector studies shows that incremental spending needs in low- and lower-middle-income countries may amount to at least $_{2013}$1.3 trillion per year ($342 - 355 billion for low-income countries and $903 - 938 billion for lower-middle-income countries). Over the period this corresponds to some 4 percent of these countries' GDP measured in $ PPP and 11 percent of GDP in international dollars. Approximately half of these investments in the SDGs can be privately financed. Domestic resource mobilization can increase significantly leaving an external financing gap of perhaps $133 - 161 billion per year (equivalent to 0.23 percent of high-income countries' GDP) that must be met through international public finance, including Official Development Assistance. Globally an incremental 1.3 – 2.0 percent of world GDP needs to be invested each year by the public and private sectors to achieve the SDGs in every country. These results are preliminary and meant for discussion and improvement.

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Acronyms and Abbreviations

AU	African Union Commission
Capex	Capital Expenditure
CAGR	Compound Annual Growth Rate
CBD	Convention on Biological Diversity
CGE	Computable General Equilibrium
CGIAR	Consultative Group on International Agricultural Research
CSIRO	Commonwealth Scientific and Industrial Research Organization
CMH	Commission on Macroeconomics and Health
COP21	21st Conference of the Parties under the UNFCCC
CPI	Climate Policy Initiative
DBR	Domestic Budget Revenues
DFIs	Development Finance Institutions
EACC	Economics of Adaptation to Climate Change
ECA	Economic Commission for Africa
EIA	United States Energy Information Administration
FAO	Food and Agriculture Organization
FfD	Financing for Sustainable Development
GAFSP	Global Agriculture and Food Security Program
Gavi	Global Alliance for Vaccines and Immunizations
GDP	Gross Domestic Product
GEA	Global Energy Assessment
GEF	Global Environment Facility
GHE	Government Health Spending
GLAAS	Global Analysis and Assessment of Sanitation and Drinking Water
Global Fund	Global Fund to Fight AIDS
GFF	Global Financing Facility in Support of Every Woman Every Child
GNI	Gross National Income
GNP	Gross National Product
GSW	Government Spending Watch
HICs	High-Income Countries
HLP	High-Level Panel on the Post-2015 Development Agenda
HLTF	High-Level Task Force on Innovative International Financing for Health Systems
IAM	Integrated Assessment Modelling
IBRD	International Bank for Reconstruction and Development
ICESDF	Intergovernmental Committee of Experts on Sustainable Development Financing
ICOR	Incremental Capital Output Ratio
ICPD	High-Level Task Force for the International Conference on Population and Development
IDA	International Development Association
IDDRI	Institute for Sustainable Development and International Relations
IEA	International Energy Agency
IFAD	International Fund for Agricultural and Development
ILO	International Labor Organization
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
JMP	Joint Monitoring Programme (for water and sanitation)
LAC	Latin America and the Caribbean
LDCs	Least Developed Countries
LICs	Low-Income Countries
LMICs	Lower-Middle-Income Countries
LPG	Liquefied Petroleum Gas
MAMS	Maquette for MDG Simulations
MDBs	Multilateral Development Banks
MDGs	Millennium Development Goals
MENA	Middle East and North Africa
MICs	Middle-Income Countries
MIV	Microfinance Investment Vehicle
NCAR	National Centre for Atmospheric Research
NCD	Non-communicable disease
NCEC	New Climate Economy Commission
O&M	Operation and Maintenance
ODA	Official Development Assistance

OECD	Organization for Economic Cooperation and Development
OECD DAC	OECD Development Assistance Committee
OOF	Other Official Flows
Opex	Operational Expenditure
OWG	Open Working Group on the Sustainable Development Goals
PGT	Transfer to cover the Poverty Gap
PPP	Purchasing Power Parity
R&D	Research and Development
RMNCH	Reproductive
SDGs	Sustainable Development Goals
SE4All	Sustainable Energy for All
SSA	Sub-Saharan Africa
UHC	Universal Health Coverage
UMICs	Upper-Middle-Income Countries
UN	United Nations
UNCTAD	UN Conference on Trade and Development
UNESCO	UN Educational
UNFCCC	UN Framework Convention on Climate Change
UNICEF	UN Children's Fund
UNTT	UN Task Team Working Group on Sustainable Development Finance
WASH	Water Sanitation and Hygiene
WFP	World Food Program
WHO	World Health Organization

Summary for policymakers

To achieve the Sustainable Development Goals (SDGs) by 2030, countries will need to develop long-term strategies that take the goals seriously as time-bound, quantitative objectives. On current trends the world will miss the goals by a wide margin unless policies are improved, international cooperation is enhanced, and more public and private resources are brought to bear on financing the investments needed to achieve the SDGs. Focusing on the marginal expansion of government services will not be sufficient to reach the SDGs. Instead it will be essential to work backwards from the SDGs to map out the required interventions, policies, and associated investments. This paper analyses the financing implications of taking the SDGs seriously as quantitative objectives to be achieved by 2030.

SDG strategies must include methodologies for working backwards from the goals required to operationalize ambitious long-term goals ("back-castings") and for estimating associated investment needs ("needs assessments"). These were pioneered in the early 2000s for the health sector and later applied to the Millennium Development Goals (MDGs), and now have been developed for most MDG investment areas. Today, each investment area covered by the SDGs has one or more needs assessments. Such sector needs assessments are important (i) to show how the SDGs can be achieved and to identify knowledge gaps in our understanding of implementation strategies or "production functions;" (ii) to understand opportunities for private financing and policies needed to support private investments in the SDGs; (iii) to estimate domestic public financing and residual international co-financing needs; and (iv) to support resource mobilization and provide an accountability framework.

SDG sector needs assessments should employ similar sets of assumptions and generate results that can be compared and aggregated with ease. Success in achieving the SDGs will require higher-quality assessments in many areas as well as a shared understanding of appropriate methodologies. Sound SDG needs assessments must be based on a clear understanding of the nature of interventions and investments that must be delivered to achieve the SDGs (the "SDG production function"); integrate climate change mitigation and adaptation in a consistent and rigorous manner; address gaps, overlaps, and synergies across investment areas; and generate transparent results that can be reviewed by others and can form the basis for an SDG financing strategy.

This paper proposes an analytical framework for conducting and comparing SDG needs assessments and applies it to available sector studies, presenting the first comprehensive needs assessment for the SDGs. The framework translates the 17 SDGs into eleven "SDG investment areas": (i) health, (ii) education, (iii) social protection, (iv) food security and sustainable agriculture, (v) energy access and low-carbon energy infrastructure, (vi) water and sanitation, (vii) transport infrastructure, (viii) telecommunications infrastructure, (ix) ecosystem services and biodiversity, (x) data for the SDGs, and (xi) emergency response and humanitarian work. Investment needs for climate change adaptation and mitigation are integrated into each SDG investment area. The framework identifies appropriate needs assessment methodologies and explains how SDG needs assessments can address other cross-cutting issues, such as ending poverty, gender equality, inequalities, cities and human settlements, sustainable consumption and production, and government functions. The paper then harmonizes assumptions

across the sector needs assessments and – to the extent possible – addresses overlaps, gaps, and synergies across SDG investment areas. Implications of economy-wide effects, such as shifts in real wages or real exchange rates across an economy, on SDG needs assessments are discussed, though not modeled quantitatively.

The quality of available needs assessments varies considerably across the SDG investment areas. Needs assessments in the social sectors – particularly health, but also education – tend to be strongest, while needs assessments for the environment, infrastructure, agriculture, and food security are weakest. Investment needs for social protection remain to be estimated and constitute an important gap in this analysis. Since estimates of financing needs for infrastructure account for the vast majority of total investment needs, their lack of robustness is particularly problematic. The analytical framework also underscores that many SDG needs assessments do not systematically integrate climate change adaptation and mitigation.

On the basis of available needs assessments the study concludes that low- and lower-middle-income countries may need to increase public and private expenditure by some $_{2013}$1.3 trillion per year ($342 – 355 billion for LICs and $903 – 938 billion for LMICs) in order to reach the SDGs.[2] This corresponds to 4 percent of these countries' estimated GDP over the period measured in purchasing power parity (PPP) and 11 percent of GDP in international dollars, or 0.7 – 1.1 percent of world GDP.[3] Table 1 summarizes preliminary investment needs by sector and describes the share of investments that can likely be financed through private resources (41 – 50 percent on average). At the global level an incremental 1.3 – 2.0 percent of world GDP may be required to finance the achievement of the SDGs in all countries.

Low-income countries will require substantial international co-financing to achieve the SDGs, and lower-middle-income countries may need some financial support during the initial SDG period. A preliminary financing analysis suggests that major increases in domestic resource mobilization are possible in developing countries. Lower-middle-income countries have the potential to self-finance the achievement of the SDGs, perhaps requiring some international public co-financing during the early years of SDG implementation. Low-income countries cannot meet the investment needs on their own and may require some $130 – 160 billion in international public co-financing. This corresponds to 0.08 – 0.13 percent of estimated average world GDP over the period or 0.23 percent of high-income countries' estimated GDP averaged over the period. Further analysis is required to confirm these preliminary estimates, which depend heavily on assumptions about future economic growth, and to specify the type of international co-financing required. It is plausible, though, that this financing gap can be met through concessional international public finance, including promised volumes of Official Development Assistance.

[2] These estimates do not include incremental investment needs for social protection systems as well as climate change adaptation and mitigation measures associated with the improved management of ecosystems. Note also that this paper employs a broad definition of "SDG investments" that includes operating expenditures for social services and infrastructure (Box 1, page 26). So the investment shares of GDP cannot be compared with traditional macroeconomic investment ratios that including only expenditures on fixed capital.

[3] See Box 2 on page 100 for how to express SDG investment needs as a share of GDP.

Table 1. Summary of incremental SDG investment needs in low- and lower-middle-income countries (average for 2015 – 2030 in $\$_{2013}$ billion)

Investment area	"Development" investment needs	Incremental climate mitigation and adaptation investment needs	Total investment needs	Private, commercial financing (%)	Private, commercial financing	Public financing
Health	**68 - 87**	**1 - 1.4**	**69 - 89**	**0%**	**0**	**69 - 89**
Education	**194**	**0**	**194**	**0%**	**0**	**194**
Social protection	?	?	?	?	?	?
Agriculture and food security	**[125]**	**[22]**	**[148]**	**[51%]**	**[75]**	**[73]**
Access to modern energy	**257 - 278**	**51 - 55**	**308 - 333**	**[55 - 59%]**	**169 - 196**	**137 - 138**
Access to electricity and clean cooking fuels	54 - 71	10 - 14	64 - 85	[40 - 50%]	26 - 42	38 - 42
Power infrastructure	[203 - 207]	[41]	[244 - 248]	[59 - 62%]	[144 - 154]	[94 - 100]
Access to water and sanitation	**29**	**13 - 16**	**43 - 46**	**[5 - 26%]**	**2 - 12**	**34 - 40**
Basic water supply & adequate sanitation	28	6	34	[0 - 20%]	0 - 7	27 - 34
Water and sanitation infrastructure	[1]	[8 - 11]	[9 - 12]	[24 - 44%]	[2 - 5]	[7]
Telecommunications infrastructure	**[361]**	**[72]**	**[434]**	**[52 - 68%]**	**[225 - 295]**	**[139 - 208]**
Transport infrastructure	**[189]**	**[0]**	**[189]**	**[54 - 84%]**	**[102 - 159]**	**[30 - 87]**
Ecosystems, incl. biodiversity	**[21 - 28]**	**?**	**[21 - 28]**	**[15%]**	**[3 - 4]**	**[18 - 24]**
Data for the SDGs	**0.4**	**0**	**0.4**	**[0%]**	**0**	**0.4**
Emergency response and humanitarian work*	**8 - 23**	**?**	**[8 - 23]**	**[0%]**	**[0]**	**[8 - 23]**
All SDG investment areas**	**1253 - 1316**	**160 - 167**	**1413 - 1483**	**[41 - 50%]**	**577 - 741**	**743 – 836**

Source: Author's calculations and sources identified in the paper.

Note: Numbers have been rounded and may not add up exactly. See tables 14 and 15 for more details.

* Emergency response and humanitarian work will be entirely funded by concessional public international financing and cannot be disaggregated by income group.

** This total excludes several SDG investment needs identified in this paper, including social protection and incremental investment needs for climate change mitigation and adaptation for ecosystems. Total does not equal sum of LICs and LMICs since cost of emergency response and humanitarian work is allocated to total only.

This paper outlines an indicative financing strategy for the SDGs, recognizing the complementarity and limited substitutability between public and private resources for development. While trillions of dollars will be required in incremental investments to achieve all SDGs public financing needs for health, education, and other services are in the order of tens of billions. It is important not to confound these investment needs since each sector will require a different resource mobilization strategy. This paper aims to disentangle the different types of financing needs by presenting tentative estimates of the public and private shares in investments across the different SDG investment areas. It is the first to consider domestic resource mobilization and other financing strategies in the context of the overall SDG investment needs.

The analysis suggests that the SDGs are affordable globally. Financing needs for the SDGs are manageable given the extent of available global savings. Meeting the goals is therefore – first – a moral challenge of re-directing resources towards the societal objectives enshrined in the SDGs and – second – a practical challenge of organization, sound implementation frameworks, and careful implementation.

The health sector demonstrates how SDG needs assessments can play a vital role in addressing both the moral and operational challenges of SDG implementation. Health has successfully used needs assessments and back-castings to operationalize ambitious global health goals and to demonstrate the feasibility of rapid progress in reducing preventable causes of deaths. The sector has been using needs assessments to find answers to the practical challenges of implementation, set global policy standards, and help propagate this learning throughout developing and developed countries. In this process, needs assessments have become increasingly robust, and their findings have been buttressed by implementation lessons. The leading financing institutions in health, including the Global Fund to Fight AIDS, Tuberculosis and Malaria, Gavi, and the recently launched Global Finance Facility have all used needs assessments to make a strong case for investments in health and to mobilize vast increases in domestic and international resources for the sector. A key question for SDG implementation is therefore how lessons from the successes in health can be applied to other SDG priorities.

Four priorities for future research emerge from the analysis presented in this paper. First, sector needs assessments must be strengthened for most SDG investment areas, but particularly for food security and agriculture, infrastructure, and ecosystem services. Remaining gaps, such as investment needs for social protection, must be filled. Second, countries need to develop national SDG needs assessments, which offer a critical opportunity to better understand the impacts of synergies and economy-wide effects. Third, a more robust financing strategy is needed to distinguish between different types of financial flows, their sequencing, opportunities for public and private debt financing, and the role of multilateral development banks and other financing institutions. Finally, the international system should systematically track public and private investments in the SDGs and compare these flows against projected investments needs from SDG needs assessments. This will help refine our understanding of how the SDGs can be achieved, whether the world is on track towards achieving the Goals, and what changes might be needed in implementing the global partnership for the SDGs.

We underscore the preliminary and incomplete nature of this analysis and welcome comments and suggestions for improvement. Such comments should be addressed to info@unsdsn.org.

1. Motivation and organization of this paper

Member states of the United Nations have adopted the Sustainable Development Goals (SDGs) in September 2015. The 17 goals map out ambitious objectives across the three dimensions of sustainable development (economic development, social inclusion, environmental sustainability) to be achieved by 2030. On current trends no country or major region in the world is on track to achieve the SDGs. Some countries have achieved impressive wealth and economic development, but many face growing social exclusion and inequality, and no country has transformed its economy to make it environmentally sustainable. Indeed, business-as-usual pathways are unsustainable for all regions of the world (SDSN 2013). For this reason the SDGs are stretch goals for every country.

Achieving the SDGs – including but not limited to ensuring high-quality education at pre-primary, primary, and secondary levels; universal and affordable access to health systems; universal access to basic infrastructure including for energy, water, sanitation, and transport; sustainable and productive cities; climate change mitigation and adaptation; sustaining ecosystem services; and other investment priorities – will not only require improved policies and effective governance, but also increased public and private investments.[4] Just as investments alone will not deliver the SDGs, neither will improved policies that are not backed up by increased investments.

Experiences from the Millennium Development Goals (MDGs) have sharpened our understanding of the types of financing instruments that are needed for the SDGs. These span the full spectrum of commercial private investments, private financing that is leveraged through public resources, public domestic financing, non-concessional international public financing, including Other Official Flows (OOF), and, where necessary, concessional public international financing, including Official Development Assistance (ODA). Since markets focus only on the first financing instrument (commercial private investments) and since domestic and international public resources alone are insufficient to meet the financing needs for the SDGs, public-private investment partnerships are needed to cover the financing needs (Schmidt-Traub and Sachs, 2015).

To achieve the goals, countries will need to develop long-term strategies that take the goals seriously as time-bound, quantitative objectives. The SDGs call for universal access to basic services and infrastructure instead of a marginal expansion of service coverage. The former will require not only greater financial resources than the latter, but it may also need qualitatively different strategies to reach the unserved and ensure that no one is left behind. By taking the goals seriously, by working backwards from them to map out the required interventions, policies, and associated investments, countries will ask a fundamentally different question than if they focus on the marginal expansion of government services.

[4] This paper uses the term "investments" in the SDGs broadly to include current and capital expenditures needed to achieve the objectives laid out by the Sustainable Development Goals (see Box 1, section 3).

Methodologies for working backwards from the goals required to operationalize ambitious long-term goals ("back-castings") and for estimating associated investment needs ("needs assessments") were pioneered in the early 2000s for the health sector (CMH 2001). Over time they have been developed for most MDG investment areas (UN Millennium Project 2005, Commission for Africa 2005, MDG Africa Steering Group 2008, Bourguignon *et al.* 2008). Today, each investment area covered by the SDGs has one or more needs assessments (section 4).

Yet available needs assessments differ in methodologies, coverage, and assumptions, which makes them difficult to compare. Some are robust and based on years of iterative work involving entire epistemic communities, while others remain "back-of-the-envelope" calculations whose results should be treated with caution. Some needs assessments are goal-based (i.e. they work backwards from quantified, time-bound goals) and consistent with the SDGs. Others extrapolate current trends into the future without regards to whether this will be sufficient to achieve quantified and time-bound goals. Some consider economy-wide effects or the impact of climate change while others do not. Very few distinguish between public and private investments.

Unfortunately, the current public discussion of investment needs for the SDGs and other international policy objectives uses needs assessment results without a clear understanding of how the numbers were derived. A first objective of this paper is therefore to carefully assess available needs assessments and to propose a framework for how to conduct technically sound needs assessments. Where indicated adjustments to available estimates are proposed in order to align them with the SDGs and make them comparable across SDG investment areas. The paper highlights weaknesses in available studies and proposes areas for further research and improvement.

A second objective of this paper is to aggregate the sector investment needs taking account of possible overlaps, synergies, and trade-offs, in order to develop an understanding of total investments needs for the SDG agenda as a whole. Drawing on a large number of sector assessments and several partial aggregations, including Greenhill and Ali (2013), UNTT (2013), and UNCTAD (2014), this study presents the first comprehensive needs assessment for the SDGs, in total and by investment area. The paper highlights caveats, gaps, and weaknesses in available analyses, and describes adjustments made to remove overlaps and to ensure consistency with the SDGs.

A third objective of this paper is to outline an indicative financing strategy for the SDGs. This financing strategy must recognize the complementarity and limited substitutability between public and private resources for development (Schmidt-Traub and Sachs 2015). While trillions of dollars will be required in incremental investments to achieve all SDGs, as shown by the Multilateral Development Banks (AfDB *et al.* 2015), public financing needs for health, education, and other services are in the order of tens of billions of dollars. It is important not to confound these investment needs since each sector will require a different resource mobilization strategy. This paper aims to disentangle the different types of financing needs by presenting tentative estimates of the public and private shares in investments across the different SDG investment areas.

The paper proceeds as follows: Section 2 reviews the case for estimating the financing needs for the SDGs, drawing on lessons from the implementation of the Millennium Development Goals (MDGs); and reviews common arguments against needs assessments and describes how they are addressed in this paper. Section 3 presents the analytical framework for SDG investments and the major investment areas considered in this paper. The section outlines the methodology for identifying appropriate needs assessments, aggregating them, filling gaps, and addressing overlaps. The framework integrates investment needs for climate change adaptation and mitigation into sector investment needs. It further describes how the public and private shares of investments can be estimated. Section 4 considers the investment needs and breakdown by financing instruments for each major SDG investment area. It discusses how investments in other areas affect investment needs for each specific sector. The section also identifies major gaps in available estimates and highlights priorities for future research. It considers alternative methodological approaches and explains the choices made for this paper. The section then aggregates the sectoral estimates for low- and lower-middle-income countries, and approximates incremental global investment needs for the SDGs. Section 5 reviews available economy-wide studies of SDG investment needs and considers implications for the sectoral investment needs identified in Section 4. Next, section 6 outlines an indicative financing strategy for the incremental investments needed in low- and lower-middle-income countries. Section 7 concludes by proposing tentative policy implications and highlighting major areas that require additional research.

The needs assessment results presented in this paper leave room for improvement. Several gaps are identified in the text (e.g. social protection), and still others might need to be filled. A more detailed and robust financing analysis will be presented in separately. Meanwhile, comments and suggestions for improvement of the framework and needs assessment results presented in this paper are welcomed, and should be addressed to info@unsdsn.org. The SDSN will issue updates of the SDG needs assessment on its website.

2. The case for estimating SDG financing needs and common criticisms

This section begins with a review of the principal reasons why needs assessments for the SDGs are an important and useful tool. Section 2.2 provides a typology of the main methodologies used to carry out investment needs assessments, and discusses their limitations as well as advantages. The main criticisms of needs assessments are then discussed in section 2.3 and lessons are drawn for this study.

2.1. The case for SDG needs assessments and criteria for appropriate methodologies

There are four principal reasons why robust needs assessments covering public and private flows must be conducted for the SDGs and why they should be subjected to rigorous academic and public critique to progressively strengthen the analysis:

First, to show how the SDGs can be achieved and to identify gaps in our understanding of implementation strategies or "production functions": Robust needs assessments require a detailed and careful understanding of the underlying interventions needed to achieve the SDGs, the investments needed to provide them at scale, as well as the likely evolution of investment needs as technologies advance and the scale of activity increases. High-quality needs assessments therefore become the final expression or budget for detailed investment strategies that must also consider the impact of policies, such as free access to basic education or quality standards for basic infrastructure.

Some sectors have developed a sophisticated operational understanding of investment needs and supporting policies to achieve global goals. For example, the Commission on Macroeconomics and Health conducted one of the first systematic considerations of investment needs in the health sector (CMH 2001). Since then the health sector has used needs assessments to inventory current knowledge on implementation and to systematically fill knowledge gaps (e.g. WHO 2010a, Jamison *et al*. 2013, Chatham House 2014). Such global needs assessments have informed country health policies and empowered countries to pursue ambitious back-castings and scaling-up strategies, e.g. for HIV/AIDS treatment or malaria control. Over time the improved understanding of health production functions has been spread to most countries in the world, including the poorest ones. (Schmidt-Traub and Sachs 2015).

Needs assessments in other sectors (e.g. food security, some infrastructure areas, ecosystem management) lack equally robust "production functions." If the SDGs are to be achieved, these knowledge gaps will need to be filled over the coming years. Needs assessments provide a framework for systematically identifying knowledge gaps and ways to fill them, as described in more detail in section 4.

Second, to understand opportunities for private financing and policies needed to support private investments in the SDGs: At $22 trillion in global saving[5] (UN 2014), ample private and public resources exist to finance the SDGs, but private financing requires risk-return profiles at market rates. Such risk-return profiles depend on a range of factors, including country risks and the nature of the underlying investment needs. Detailed needs assessments help us understand which investments are attractive to private financing. They also provide a framework for considering public policies and incentives needed to mobilize private financing at the scale required to achieve the SDGs. While private financing cannot be planned, needs assessments are necessary to understand its potential and how that potential can be harnessed.

The distinction between public and private investments is sometimes poorly understood. This can lead to unrealistically high expectations regarding the volume of private financing available or an under-appreciation of the public co-financing needed to mobilize private resources. For this reason section 4 assesses opportunities for private financing for each SDG investment area and aggregates them in Table 14.

Third, to estimate domestic public financing and residual international co-financing needs: The SDGs map out global goals that the international community commits to achieving in their entirety. As agreed in the 2002 Monterrey Consensus (UN 2002) and reaffirmed in the 2015 Addis Ababa Action Agenda (UN 2015), developing countries that implement effective policies and well-designed, transparent, operational programs but lack the domestic resources to finance them should attract greater private resources. When necessary they should also receive international public financing in the form of Official Development Assistance (ODA), Other Official Flows (OOF), and concessional climate finance[6]. To this end, developed countries have committed to provide 0.7 percent in GNI as ODA as well as $100 billion in additional climate finance.

Rigorous needs assessments provide a basis for estimating domestic public resource mobilization and residual international public financing needs after subtracting both private and domestic public financing. Section 6 illustrates how such a financing analysis can be conducted for country income groups. It shows how countries' ability to auto-finance SDG investments rises with income level, and that concessional international public financing should focus on the poorest countries. More detailed financing assessments can be conducted at the country level.

Estimates of domestic public financing needs are often conducted at the sectoral level, and many sectors have ambitious domestic government spending targets (e.g. Abuja Declaration on health spending in Africa, Muscat Agreement on education benchmarks, Maputo Declaration on agriculture spending). However, it is important to consider the overall adding-up constraint in a government's budget, which in turn requires across-the-board needs assessments covering all major areas of public

[5] Unless otherwise noted, the paper uses the shorthand $ to denote US$ in the remainder of this document.

[6] Official Development Assistance (ODA) describes concessional international public finance, as defined by the OECD DAC. Other Official Flows (OOF) denotes non-concessional international public flows, primarily loans by Multilateral Development Banks, Development Finance Institutions, as well as public guarantees, insurance, and export credits.

expenditure. Only by knowing what a government needs to spend to achieve *all* SDGs can one determine whether a financing gap remains that needs to be filled through international public finance.

Fourth, to support resource mobilization and provide an accountability framework: High-quality needs assessments quantify results that can be achieved through a certain level of public and private spending. In this way they constitute an accountability framework that allows taxpayers to track investments against intended results. For example, thanks to detailed needs assessments, the health sector now has widely accepted health benchmarks to be achieved for a certain volume of health spending (Jameson et al. 2013). This information has formed the basis for independent evaluations of international public financing for health and other sectors (Schmidt-Traub and Sachs, 2015).

Global needs assessments have played a central role in the mobilization of health financing during the MDG period. Both the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) and the Vaccine Alliance (Gavi) have used needs assessments to guide their replenishment rounds (Global Fund 2013, Gavi 2014b). The proposed Global Financing Facility in Support of Every Woman Every Child (GFF), which finances interventions in reproductive, maternal, newborn and child health (RMNCH), has also undertaken an evaluation of investment needs (GFF 2015), citing existing needs assessments in the health sector (Stenberg *et al.* 2014, Jamison *et al.* 2013) as the basis of its own evaluations. On the back of these assessments, public financing for health has increased several fold since the early 2000s (Dieleman *et al.* 2014). In contrast, sectors with less robust evidence on how increased financing leads to improved results have seen smaller increases in financing (Schmidt-Traub and Sachs 2015).

2.2. Needs assessment methodologies and approaches

Before considering common criticisms of needs assessments and caveats it is important to review the multitude of available approaches and methodologies (UN Millennium Project 2004, UNTT 2013). In the absence of a commonly accepted typology of methodologies, this paper distinguishes between five types of methodologies:

1. Incremental Capital-Output Ratio (ICOR) estimates and other growth models: One of the first cost estimates for the MDGs (Devarajan *et al.* 2002) draws on the Harrod-Domar growth model (Harrod 1939, Domar 1946) to estimate the incremental capital-output ratio (ICOR), i.e. the economy-wide relationship between aggregate investments and GDP, which is typically obtained through cross-country regressions. The ICOR is then multiplied with a target per capita growth rate (g_Y) needed to achieve a certain level of poverty reduction, which is calculated from poverty-growth elasticities derived from cross-country regressions. Total investment needs (I) can then be estimated using a simple equation, where Y denotes income and p is the population growth rate:

$$I = Y * (g_Y + p) * ICOR$$

This back-of-the-envelope approach is simple to use, but it suffers from several conceptual and practical limitations. ICORs simply extrapolate the past into the future, which is a poor guide for the structural changes that are required to achieve the MDGs and SDGs in most countries. For example, historic investment data cannot anticipate investment needs to respond to new epidemics, such as HIV/AIDS or resurgent malaria in the early 2000s, or to the decarbonization of national energy systems today. As a result, historic poverty-growth elasticities may be inapplicable under a pathway to achieve the SDGs. Moreover, many countries lack adequate data to compute robust ICORs, and obtaining ICORs through cross-country regressions is prone to errors and fails to take into account the specificities of each country.

ICORs are also not an effective tool for mapping out investment needs at the level of detail and specificity that policymakers need. Aggregate investment needs do not help in programming public expenditure, understanding the specifics of private investment opportunities, or providing an accountability framework. ICORs are therefore not suitable for estimating SDG investments needs, a point also emphasized by Devarajan (2015).

2. Simple unit cost estimates or input-outcome elasticities: Some studies apply aggregate unit costs, often drawn from dividing government spending by key output variables. For example, Delamonica *et al.* (2001) compute the average cost of primary schooling per child and multiply this cost with the target population. Similarly, some biodiversity needs assessments compute the average cost of maintaining protected areas per square kilometer and multiply this value with the target area for protected areas (CBD 2012a, 2012b).

Simple descriptive models that link a certain level of investments to certain target variables, such as economic growth, are variants on this approach. For example, some econometric models (e.g. Bhattacharya et al. 2012; Fay et al. 2011; Foster and Briceño-Garmedia 2010) include regressions of economic growth on infrastructure investments and other relevant variables. The resulting coefficients can then be used to project aggregate infrastructure investment levels for a target rate of GDP growth or other target variables.

Such methodologies have the benefits of being simple and easy to apply to a large number of countries, but just like ICORs they are entirely based on projecting current expenditures into the future. If the composition of investment needs changes (e.g. by including new interventions or by focusing on harder-to-reach populations) these unit costs will no longer apply. Average unit costs are therefore a poor guide to the investments needed to reach unserved populations, as marginal costs may rise. Moreover, aggregate unit costs lack the level of detail required to guide the programming of public and private resources – a key objective of a robust SDG needs assessment. Finally, just like intervention-based needs assessments, back-of-the-envelope unit cost estimates do not take into account synergies, trade-offs, and other economy-wide effects of SDG investment programs. On balance, this methodology may therefore have its uses for providing a first set of investment needs estimates, but more detailed estimates and/or integrated modeling approaches are required to help guide implementation.

3. Intervention-based needs assessments: An extension of unit cost estimates are intervention-based needs assessment, as employed by the UN Millennium Project (2005) and most recent assessments in health, education, and other key sectors (see section 4). Such intervention-based tools specify the interventions needed to achieve certain outcome objectives and can be disaggregated by population, geography (e.g. urban/rural), and other dimensions, which allows them to serve as an accountability framework. They then project the capital and operating expenditure needed to deliver these interventions to the target populations. Unit costs may change with changing coverage (e.g. as populations become harder to reach), and the ratio of capital to operating expenditure will evolve over time as countries expand their capital stock. As a result marginal investment needs for expanding social services and providing access to infrastructure services change over time. Since intervention-based tools are often designed in the form of spreadsheets, they are comparatively transparent and easy to use.

A downside of this approach lies in the lack of dynamic cross-sectoral assessments of synergies and trade-offs. Some intervention-based needs assessments therefore assume changes to wages and other key parameters that may be derived from separate economy-wide models (e.g. UNESCO 2015b). Such changes are exogenous and may therefore require careful iteration with economy-wide tools. An extension of intervention-based needs assessment tools are engineering system models, such as MESSAGE, MARKAL or TIMER. These models provide detailed representations of the respective sectors and can be coupled with dynamic equilibrium and other economy-wide models (UNTT 2013).

In summary, intervention-based tools can offer a transparent approach to mapping out investment needs at a high level of disaggregation and in a format that can be made consistent with medium-term expenditure programming and budgeting processes. They are particularly well suited to social sectors and access to basic infrastructure since replicable interventions in these areas can be specified in significant detail. Any use of intervention-based tools needs to be complemented by a discussion of economy-wide effects.

4. Computable General Equilibrium (CGE) Models: CGEs consist of aggregate production and utility functions that are combined to depict an economy in equilibrium. Changes can then be introduced into the system to estimate the investment needs for different policy options. One of the first CGE models applied to the MDGs was developed for Niger by Agénor (2005a, 2005b). This tool includes highly stylized MDG production functions.

A widely-used CGE model applied to the MDGs is the World Bank's Maquette for MDG Simulations (MAMS) developed by Lofgren and Diaz-Bonilla (2008, 2013) and Lofgren *et al.* (2013). MAMS models subsets of key MDG sectors (primary education, health, water and sanitation) and combines them with a generic economic model. This enables MAMS to address several important questions that are outside the scope of intervention-based needs assessments, including (i) interactions between investments in specific SDG sectors and policies designed to achieve them; (ii) interactions between investments in SDG outcomes and the wider economy (i.e. the private sector) through changes in the price and supply of specific factors, such as skilled labor; (iii) the impact of resource inflows (e.g. in the form of Official Development Assistance) on the real exchange rate, which might shift resources from the tradable to

the non-tradable sector and reduce export-led growth (an effect sometimes called “Dutch disease”); and (iv) the inter-temporal equilibrium consistency to ensure that financing needs, debt accumulation, and fiscal policies are consistent over time (Bourguignon *et al.*, 2008).

Given the need for country-specific modeling of MDG outcomes and the relationship with the wider economy, MAMS was designed so that it could easily be applied to multiple country databases (Lofgren *et al.* 2013, Bue and Klasen 2012). Between 2006 and 2013, 65 MAMS applications were conducted for 45 countries (Lofgren *et al.* 2013, table 4.18, pages 247 – 250). More recent examples include Kinnunen (2015), Lenhardt (2015), Levin (2015a, 2015b). Drawing on MAMS, the World Bank has recently started a series of country development diagnostics for the SDG period (Gable *et al.* 2014, 2015) that assess countries’ ability to achieve certain SDG outcomes under a range of scenarios.

MAMS and similar models are an important tool for understanding how certain SDGs can be achieved, but they also suffer from a number of shortcomings. MAMS uses highly stylized Cobb-Douglas production functions for development outcomes in education, health, and other areas that are parametrized using historic data and allow for non-constant returns to scale (Lofgren and Diaz-Bonilla, 2008). These functions are too stylized to understand the investment needs in individual sectors – particularly if the composition of these investment needs changes over time (e.g. due to new technologies, the emergence of new types of investment needs such as anti-retroviral treatment for HIV/AIDS in the early 2000s) – or to guide budgetary processes. The computational complexity and data requirements limit the models’ scope to a subset of MDG/SDG sectors. For example, most MAMS applications do not include the investment needs for AIDS treatment, secondary education, natural resource sectors, and other major investment areas.

Another structural weakness of CGE models is that they do not adequately account for market externalities. By design, CGE models project that the introduction of an explicit or implicit carbon price leads to a negative economic shock without considering the societal cost of climate change. The tools are also ill-suited to incorporating physical boundaries, such as the planetary boundaries proposed by Rockström *et al.* (2009) and Steffen *et al.* (2015). These issues are particularly important for the SDGs, which include a focus on the environment and climate change. They are reviewed by Stanton and Ackerman (2009) and IDDRI and SDSN (2014).

In view of the relative strengths and weaknesses of CGE models and bottom-up sector needs assessments, we concur with Bourguignon *et al.*’s (2008) assessment that “MAMS does not replace detailed sector studies, but instead complements [them].” In particular, MAMS and similar models allow policymakers to embed sector investments in an economy-wide framework, but on their own they do not provide sufficient granularity to understand sector investment needs. The discussion of economy-wide effects of SDG investments and the financing strategies in sections 5 and 6 respectively includes these tools.

5. Integrated Assessment Models (IAMs): Integrated Assessment Models provide an analytical framework for incorporating information from a range of fields in a consistent and dynamic manner, typically with a focus either on detailed sectoral descriptions or on interaction terms across sectors (UNTT 2013). A large range of IAMs exists, covering a broad spectrum of economic, environmental, and social investment needs such as DICE (Nordhaus 2008), PAGE (Hope 2006), notably used in the Stern Review (2007), AIM (Matsuoka *et al*. 2001), IMAGE (PBL 2015) and MESSAGE (Messner and Strubegger 1995).

Compared with CGEs, IAMs provide a more flexible approach to modeling dynamic systems, which is particularly useful for understanding how environmental objectives can be achieved. They are also an effective tool for understanding interactions across sectors and the evolution of complex systems over relatively long periods of times. IAMs have been used successfully in estimating investment needs for specific targets with particular attention to cross-sectoral effects. Yet, most IAMs are not primarily designed for estimating investment needs and therefore do not produce budgets that can be tied directly to inputs, outputs, and longer-term outcomes – the essence of goal-based budgeting.

One challenge with IAMs is that they tend to be difficult to interpret, even for experienced experts. The assumptions about which targets should be achieved, and how to achieve them, often vary in subtle ways between different IAMs, but these differences are hard to detect since assumptions can be deeply embedded in the models. Moreover, IAMs employ a range of methods to estimate investment needs, including direct computation through in-built optimization models, ex-post allocation techniques to determine investment needs in key sectors, and simple "back-of-the-envelope" calculations for sectors that are not modeled in detail (UNTT 2013).

2.3. Common criticisms of needs assessments

Needs assessments for global goals are controversial in the policy as well as academic communities. Several criticisms have been leveled against the idea of needs assessments, their methodologies, and results. This section distinguishes between five main groups of criticisms and discusses their implications for this working paper.

1. Policies and good governance are more important than investment needs: Some analysts (e.g. ERD 2015) argue that needs assessments fail to address the critical role of policies, and that policies take primacy over investment needs (Devarajan 2015). Yet this criticism misses two important points about goals-based needs assessments. First, virtually all needs assessments are explicitly based on key sector policies. For example, SDG-consistent health needs assessments (e.g. WHO 2010, Jamison *et al*. 2013, Chatham House 2014) model the impact of the phasing out of user fees for primary health care, national policies on preventative medicine, and behavior-change programs (e.g. to reduce the risk of childhood obesity or to lower the incidence of smoking and alcohol abuse). Needs assessments for education, energy access, agriculture, and other areas also require assumptions about public subsidies, building standards and codes, regulatory frameworks, and other policy variables.

Second, needs assessments focus on the resources *necessary* to achieve the SDGs, but money alone will of course not be sufficient to achieve ambitious long-term targets (Clemens *et al.* 2007). It is beyond any doubt that good governance is necessary for rapid improvements in economic, social, and environmental outcomes. Investing large volumes of money in poorly governed, corrupt, or organizationally ineffectual systems will not generate adequate results. Yet the reverse is also true, and too often overlooked in the discussion on needs assessments: good policies and sound governance that are not backed up by adequate resources cannot achieve the SDGs either.

A related criticism is that needs assessments are too focused on ODA and underplay the role of domestic resource mobilization. In reality, SDG needs assessments are agnostic to the sources of financing – they simply determine overall financing needs. A financing strategy should start first with private and domestic public resources before turning to international public finance to fill remaining investment gaps (c.f. UNESCO 2015a for education, Jamison *et al.* 2013 and Chatham House 2014 for health). Indeed, needs assessments show that some developing countries that currently receive substantial volumes of aid do not need such ODA (see section 6).

2. Needs assessment fail to consider absorptive capacity constraints: It is sometimes argued that needs assessments, which work backwards from ambitious long-term goals, fail to consider that developing countries' ability to use or "absorb" aid effectively is limited (e.g. Clemens *et al.* 2007). In the technical literature absorption refers to the process of turning aid flows into an increase in net exports (Greenhill *et al.* 2015). A less abstract definition of absorption might consider countries' ability to scale up investments efficiently. It is useful to distinguish between absorption at the sector and at the macroeconomic level.

At a sector level, many countries lack adequate human resources, management systems, or basic infrastructure to rapidly scale up public investments. Such capacity constraints are real in many countries, but they can be overcome through sustained and targeted investments in human resources including training, management systems, monitoring and evaluation, etc. over an extended period of time, provided of course that countries put in place adequate supportive policies (Greenhill *et al.* 2015). For example, the health sector has shown how even the most impoverished countries can scale up their ability to deliver costly and complex control and treatment programs for infectious diseases (WHO 2010, Jamison *et al*. 2013, Chatham House 2014). Indeed, detailed needs assessments are necessary to help us understand absorptive capacity constraints in each sector, and ways in which they can be mitigated through a gradual scaling-up of services and investments.

The macroeconomic absorption of large inflows of foreign reserves raises important questions of macroeconomic management. In perhaps the most detailed assessment of the macroeconomic implications of massive increases in external resource flows to achieve the MDGs in low-income countries, the IMF has prepared "Gleneagles scenarios" for a number of African countries (Christensen 2008, Mongardini and Samake 2009). The Fund concluded that the adverse macroeconomic consequences of increased aid flows can be contained through prudent macroeconomic management and predictable resource inflows. Well-managed increases in resource flows pose no fundamental

barrier to achieving the MDGs, particularly since many of the planned investments reduce supply-side constraints. Consequently, concerns about Dutch disease are not an argument against needs assessments. Instead, detailed SDG needs assessments are a prerequisite to understanding how countries that will require substantial inflows of public and private external resources need to adjust their macroeconomic frameworks to mitigate adverse consequences from appreciating real exchange rates. Section 5 considers the macroeconomic implications of aid inflows in greater detail.

3. Needs assessment methodologies and their results are too unreliable: Many observers have criticized MDG needs assessments for applying unrealistic unit costs and top-down "technocratic approaches" (e.g. Reddy and Heuty, 2005, 2006). Some of these criticisms are justified for weak needs assessments, as underscored in section 4, but they should spur greater efforts in improving methodologies, data, and analyses. When unit costs are too unreliable, then we should try to improve them. This is how the health sector has moved from having no shared understanding of investment needs to achieve key health outcomes at the turn of the Millennium towards a robust and widely shared view on the investments needed to achieve key health outcomes (e.g. CMH 2001, WHO 2010, Jamison *et al.* 2013, Global Fund 2013, Chatham House 2014, Gavi 2014b, GFF 2015).

Some analysts (e.g. ERD 2015 in the case of education) cite large discrepancies in the results of sectoral needs assessments as evidence of major weaknesses in the approach. But these discrepancies are typically the results of different assumptions about what to include in the analysis. For example, some studies focus only on capital expenditure while others also include operating expenditure and ancillary costs, such as sanitation facilities in schools and school feeding programs. Similarly, needs assessment results in the education sector depend on key policy parameters, such as student-teacher ratios and whether school books and other learning materials are paid for by parents or by the government.

In this way needs assessments force critical questions about the nature and type of interventions to include, as well as key policy choices. Once these issues have been settled, most needs assessment results, particularly in the social sectors, tend to converge towards shared headline needs – see for example Jamison *et al.* (2013) for health and UNESCO (2015a, 2015b) for education. As underscored in section 4, even the best available estimates are incomplete and imperfect, which should mobilize each technical community to improve its understanding of the investment needs to achieve the SDGs by reviewing assumptions and estimation methodologies.

4. Needs assessments neglect economic growth: It is sometimes argued that needs assessments miss the most important development priority, which is to sustain economic growth (e.g. Easterly 2001, 2005, 2006a and 2006b). The argument is that economic growth leads to improved social, economic, and (possibly) environmental outcomes, so the focus should be on policies to promote growth instead of mapping out sector investment needs.

There are three ways to respond to this concern. First, sustained economic growth is critical for achieving the SDGs (and is the focus of SDG 8). Yet it is the result of long-term increases in the stock of capital, which in turn derive from sound policies combined with targeted investments in human capital,

business capital, natural capital, and other forms of capital. Needs assessments ask the question of what some of these investments should be (they typically exclude business capital), and how they can be programmed. Since some of the causality runs from targeted investments to improved outcomes and economic growth, needs assessment are fully consistent with a central focus on economic growth.

Second, economic growth raises countries' abilities to mobilize domestic public resources and private financing from both domestic and international sources, which in turn reduces reliance on international public co-financing. In this way, assumptions about economic growth play an important role on the financing side of SDG needs assessments. They should therefore be detailed in any SDG needs assessment and be subject to periodic review (section 6).

Third, a number of objectives enshrined in the SDGs are poorly correlated with economic growth. These include investments in maternal mortality, education of marginalized children, gender equality, public investments in rural infrastructure, and many more. Since these investments will be underprovided through strategies focusing on growth alone, they must be pursued in parallel. SDG needs assessments help specify, program, and monitor such investments.

5. Global needs assessments are of limited use – the focus should be on national-level estimates: Many SDG investments are highly co-dependent. For example, increased investments in rural infrastructure, including access to clean energy, safe water, and sanitation, affect projected health investment needs. Such synergies and trade-offs are not always well understood and are difficult to quantify. Global sectoral needs assessments for health, education, and other areas tend not to address such co-dependencies in a structured manner. This fact, coupled with the realization that implementation modalities and associated investment needs differ across countries, has led some observers to discount the utility of global or regional needs assessments by sector, and to focus instead on integrated national or sub-national assessments (Kharas *et al.* 2014).

National needs assessments and budgeting processes are clearly required for the operational planning of public and private expenditures. However, global or regional needs assessments play several important and complementary roles. First, they provide orders of magnitudes of required investment needs that constitute measures of success for the international financing frameworks, as well as for resource mobilization at national and international levels. Global assessments also help advance the international community's understanding of how priority goals can be achieved and how progress can be tracked through rigorous monitoring and evaluation (M&E) and strict accountability. Perhaps most importantly, widely shared global needs assessments empower countries and civil society to be more ambitious in the design of national implementation strategies. For example, the CMH (2001) and initial design documents for the Global Fund were critical in encouraging governments in Africa and elsewhere to put forward vastly more ambitious national strategies for health and the fight against infectious diseases. For all these reasons global needs assessments are an important tool for operationalizing ambitious global goals, and complements national and sub-national analyses of investment needs.

3. Analytical framework for an SDG needs assessment

A global analysis of public and private investment needs for the SDGs must proceed sector by sector in order to capture the full breadth and depth of the information needed to understand public-private SDG investment needs. An analytical framework for conducting an SDG needs assessment must address complex methodological questions, including: How to define the major investment areas? How to deal with cross-cutting issues such as climate change adaptation and mitigation? How to quantify investment needs for ending extreme poverty? How to aggregate results taking account of gaps, overlaps, and synergies? How to deal with economy-wide effects? How to aggregate assessments across countries? How to reconcile different methodologies across a broad spectrum of SDG investment needs?

To lay the groundwork for addressing these questions sequentially, the papers proceed in four steps outlined in the next subsections. Box 1 summarizes key terms and concepts used in the remainder of the paper.

Box 1: Key terms and concepts for SDG needs assessments

Capital expenditures (capex) denote investments in fixed capital formation, such as infrastructure investments, that amortize over time.

Incremental SDG investment needs are SDG investments that are additional to baseline SDG investments, defined as today's expenditure levels. Usually, incremental SDG investment needs assume best practice in terms of targeting and effectiveness of public and private expenditure, but they do not correct baseline spending for inefficiencies. Care must be taken to harmonize the definition of incremental investment needs across SDG investment areas in order to facilitate comparisons.

Operating expenditures (opex) describe current expenditures, such as salaries, medicines, and other consumables.

SDG interventions describe the provision of goods, services, and infrastructure needed to achieve the SDGs.

SDG investments describe operating and capital expenditures required to deliver the SDG interventions in order to achieve the SDG outcomes. Since operating expenditures contribute to expanding the physical, human, business, and natural capital required to achieve the SDGs they are included as investments. Sometimes the text will use SDG expenditure as a synonym for SDG investments.

SDG investment areas describe the eleven clusters of SDG interventions that form the basis for organizing needs assessments into discrete and non-overlapping areas (section 3.1).

Total SDG investment needs combine baseline and incremental investment needs (capex and opex) for the SDGs. When they are estimated by adding incremental SDG investment needs to baseline SDG expenditure, they do not account for ineffective targeting and inefficiencies in baseline spending.

The distinction between incremental and total SDG investment needs is central to the analysis in this paper. As described in section 4, most sector needs assessments focus on incremental investment needs, partly because it is difficult to assess public and particularly private baseline expenditure on the SDGs. Since baseline SDG investments are imperfectly targeted and inefficient in many countries, focusing on incremental investment needs ignores opportunities for greater efficiency in today's spending, and may therefore inflate overall resource needs even if incremental government spending is projected to be efficient. Moreover, baseline expenditure scenarios are not defined consistently across studies, which makes them difficult to compare. To the extent possible this paper adjusts estimates to make them consistent. Later work will attempt to arrive at total investment needs for the SDG.

3.1. Step 1: Define eleven integrated SDG investment areas

Just like the MDGs, the SDGs describe broad outcome objectives that require a multitude of inputs. In a series of many-to-many relationships, achieving each SDG requires large numbers of inputs, and each input may contribute to more than one SDG. For example, access to safe water contributes *inter alia* towards the goals on water, health, nutrition, and gender equality. The UN Millennium Project (2005) has mapped out these many-to-many relationships for the MDGs (UN Millennium Project 2005, Annex 2). An equivalent table for the SDGs would be conceptually similar, though far more complex. It is therefore impossible to organize an SDG needs assessment by outcome goals since this would lead to double-counting of investment needs for inputs that contribute to more than one goal.

To solve this problem, the UN Millennium Project rearranged all interventions into discrete investment areas to yield many-to-one relationships that avoid overlaps and repetition of inputs (UN Millennium Project 2005, Annex 1). Applying this approach to the SDGs yields a minimum of eleven SDG investment areas that require significant volumes of public co-financing (excluding areas that can be entirely financed through private commercial investments, such as industrial development):

1. Health
2. Education
3. Social protection
4. Food security and sustainable agriculture
5. Energy access and low-carbon energy infrastructure
6. Water and sanitation
7. Transport infrastructure
8. Telecommunications infrastructure
9. Ecosystem services and biodiversity
10. Data for the SDGs
11. Emergency response and humanitarian work

Reported ad memorandum:

- Sub-total climate change mitigation
- Sub-total climate change adaptation

Since the SDGs describe an integrated agenda, a needs assessment must make choices about how to capture a number of cross-cutting issues. These include poverty, climate change mitigation and adaptation, gender equality, reducing inequalities, cities and human settlements, sustainable consumption and production, government functions, operating the international system, security and peacekeeping. The remainder of this sub-section describes how these issues can be addressed in an SDG needs assessment and summarizes remaining gaps.

Climate change adaptation and mitigation

Tackling climate change by limiting the rise in average global temperatures to less than 2°C compared to the pre-industrial baseline will be key to achieving the SDGs (HLP 2013, SDSN 2013). Many investments in mitigation and adaptation – such as a low-carbon energy plant or climate-resilient infrastructure – are operationally indistinguishable from investments in "development" and must be structured and executed together. Maintaining a separation between "climate" and "development" investments is analytically unsound and would be counterproductive to the integrated strategies for sustainable development that the world needs (Schmidt-Traub and Sachs 2015).

The need to integrate climate and development investments becomes particularly important in poor countries that face substantial gaps in development outcomes. Adaptation and mitigation will increase the capital and operating expenditures of many "development" activities, so unmet investment needs must be taken into consideration when estimating incremental adaptation or mitigation expenditure. If a country is underspending relative to the investments needed to achieve the SDGs, then stand-alone estimates of adaptation and mitigation expenditures will also underestimate true needs. For example, if a country faces a major investment shortfall in the construction and maintenance of irrigation systems, then adaptation needs should cover incremental financing needs for both the existing stock of irrigation infrastructure and the additional irrigation systems that need to be built in order to achieve the SDGs. Yet, most adaptation estimates ignore this gap. Similarly, adaptation cost estimates tend not to address overlaps between incremental investments for adaptation and "development," which can give rise to double-counting (Fankhauser and Schmidt-Traub 2011). For example, countries may need to improve water management systems for agriculture to increase agricultural productivity ("development") or to adapt to climate change. Estimating these investment needs separately may lead to double counting.

For these reasons this paper follows the analytical framework developed by Fankhauser and Schmidt-Traub (2011) and discusses incremental investment needs for climate change adaptation and mitigation inside each major SDG investment area in order to stay within 2°C warming. This will allow for an estimate of investment needs that account for incremental costs dedicated to mitigation and adaptation for, say, agriculture or health. To substantiate calls for increased climate finance under the UNFCCC, climate finance needs are aggregated and reported separately. Such *pro forma* separation serves primarily accounting purposes and should not deflect from the need for integrated investment strategies.

Poverty reduction

Reducing poverty (SDG 1) has a complex production function that includes many policies and a broad range of investments, including in social capital (health and education), physical capital (infrastructure), business capital (smallholder farms, artisanal fishing, small enterprises, manufacturing), and other forms of capital. Some analysts propose to estimate direct investments needed to end poverty. In addition to the ICOR-based cost estimates for reducing poverty discussed in section 2.2 (Devarajan *et al.* 2002), several back-of-the-envelope estimates exist for the cost of direct income transfers to end extreme income poverty, measured as living on $1.25 a day. For example, a widely cited study by Chandy and Gertz (2011) estimates that $66 billion might be required annually to end extreme income poverty.

Estimates for direct income transfers to end extreme poverty or aggregate ICORs will overlap with other investments considered under SDG investment areas. Recognizing this point, Devarajan *et al.* (2002) present their needs assessment for poverty and the separate analysis for sector investment needs as two alternative MDG costings. Since the SDGs aim for universal coverage of health, education, and basic infrastructure they cover a major share of investments needed to end extreme poverty. Residual direct income transfers and other social protection measures are captured in section 4.3.

Gender equality

Grown *et al.* (2006) have reviewed investment needs for gender equality under the MDGs, which correspond broadly to the priorities identified in SDG 5 (see also Arutyunova and Clark 2013; Sen and Mukherjee 2013; ICPD 2015). As shown in that paper, the bulk of investment needs for achieving gender equality must be included in gender-sensitive sector investments, including in education, health, and access to basic infrastructure services. The authors then identify the remaining interventions needed to achieve gender equality, including access to sexual and reproductive health and rights, reducing gender equality in employment, increasing women's political participation, combating violence against women, and various capacity-development interventions.

A large share of the investment needs for the "remaining gender interventions" is included in the SDG needs assessments considered in the next section. Interventions to tackle violence against women, support victims, and – possibly – specific training programs can be included under social protection, but no reliable assessments could be found to estimate associated investment needs, in spite of their importance for achieving the SDGs. The analysis in Grown *et al.* (2006) shows, however, that the associated investment needs are relatively modest, so their exclusion in this preliminary assessment of SDG investment needs does not materially alter overall results.

Inequalities

Reducing inequalities (SDG 10) will require targeted investments in providing basic infrastructure and public services to marginalized populations that must be included under each investment area. Indeed, the universal coverage objectives enshrined in the SDGs will go a long way towards reducing inequalities. Reducing inequalities will also require improved policies to ensure equality of opportunity and to allow for income redistribution consistent with a country's needs and its social objectives. Such

policies will require comparatively modest investments. In spite of their importance for achieving the SDGs, such policies will therefore not be considered in this investment analysis.

In addition to redistributive policies and universal coverage of basic infrastructure and social services, social safety nets will be required to address the special needs of disabled and chronically sick people, underemployed families, single-parent households, victims of violence, and other marginalized populations. Such SDG investments in social protection may serve consumption needs of households (e.g. through work-for-food programs, disability benefits, other stipends) and/or support the achievement of SDG outcomes (e.g. conditional cash transfers to increase school attendance and improve child health outcomes). They are discussed under SDG investment area 3 below.

Cities and human settlements

Achieving SDG 11 on cities and human settlements will require vast investments in urban infrastructure, social services, resilience and environmental protection, and economic development. Urban investment needs in social services and infrastructure are covered under the respective investment areas, which also include investments in climate change adaptation or resilience as well as mitigation. A substantial share of urban environmental investment needs is covered under water supply and sanitation as well as energy systems, although urban transport systems may require investments additional to those reported in this paper. Needs assessments for additional urban services (e.g. waste collection and public transport) are not included, which may constitute a significant gap in the SDG needs assessment (though some urban services should be largely financed through targeted levies and user fees). Public investments in urban housing constitute a potentially significant gap in the analyses presented in this paper, yet MDG needs assessments (e.g. UN Millennium Project 2004) have assigned relatively low public investment needs to urban housing. Although minor relative to other urban investments, capacity building will also likely be required for municipal authorities to develop and implement sustainable development plans.

Sustainable consumption and production

Sustainable consumption and production (SDG 12) is another major cross-cutting priority of the SDG agenda. A large number of associated investment needs are covered under the eleven investment areas, particularly sustainable agriculture and nutrition, sustainable energy, water and sanitation. Additional investment needs are hard to quantify since they largely require changes in privately owned production processes combined with effective government policies and regulation (UNEP 2012). Revised and expanded SDG needs assessments should consider such residual investment needs for sustainable consumption and production.

Government functions and operating the international system

The SDGs will require strengthened central and local government functions, including the judiciary, public administration, and the police force. Investment needs for government functions that are not directly associated with the eleven investment areas identified above can be substantial, but no global studies could be found on how to quantify them. They should be considered as part of more detailed national analyses of SDG investment needs.

This assessment does not include the incremental costs of operating international organizations and other mechanisms designed to support the achievement of the SDGs. This may include increased operating costs of the UN system as well as intergovernmental bodies, such as the World Trade Organization.

Security and peacekeeping

SDG 16 focuses on the need for peace and security. This requires humanitarian assistance as well as investments in security and peacekeeping. This paper addresses humanitarian assistance and emergency response under SDG investment area 11. The analysis does not cover expenditures for security and peacekeeping, which are traditionally separated from development expenditures.

3.2. Step 2: Harmonize and aggregate investment needs across the eleven investment areas

The second step is to review the latest needs assessments available for each major SDG investment area; identify incremental investment needs for climate change mitigation and adaptation; consider synergies with investment needs in other areas; discuss necessary adjustments to harmonize results; consider opportunities for private financing; and summarize gaps in understanding and opportunities for further research (section 4).

Comparison of available needs assessment studies and results

To facilitate the comparison of needs assessment studies, each study is summarized in standardized tables considering the following dimensions:

- **Coverage and development outcomes:** Which interventions and development outcomes are assessed in the study?
- **Relationship to SDGs:** How do these outcomes relate to the SDGs?
- **Key gaps:** Which major intervention areas of relevance to the SDGs are missing from the analysis?
- **Methodology:** Which needs assessment methodology is used (see section 2.2)?
- **Incremental vs. total investment needs:** Do the assessments estimate the total investment needs of achieving the outcomes, including current expenditures, or do they only consider incremental costs? If incremental investment needs are considered, what is the baseline scenario and how can these be made comparable?

- **Expenditure types:** Do the needs assessments consider capital and operating expenditures? To ensure comparability across different pathways it is important that both sets of expenditures be considered. This applies particularly in the case of energy infrastructure where low-carbon technologies may present higher upfront capital costs, but operate at much lower annual costs (Nelson *et al*. 2014).

- **Consideration of climate change mitigation and adaptation:** Do the assessments consider incremental investment needs for climate change mitigation and/or adaptation?

- **Consideration of economy-wide effects:** Which, if any, economy-wide effects are considered in the assessments (e.g. changes in real wages)?

- **Geographical resolution and scope:** Is the analysis broken down by countries, regions, or other dimensions? Which countries or regions are covered in the assessment?

- **Period covered:** Which time period is covered in the assessments?

- **Relationship to other studies and observations on methodology:** Do the assessments represent an update on earlier work or do they draw on previous assessments?

- **Base year:** What is the base year for investment needs, expressed in constant $?[7]

- **Annual investment needs in billions (start year/end year):** How do investment needs evolve over time?

- **Period average in billions per year (years):** What are average investment needs over the time period considered in the study?

- **Comments on results:** Additional observations on the results of the needs assessment.

- **Other adjustments made:** Which other adjustments were made to results of the assessments included in this study?

- **Robustness of estimates:** How suitable is the methodology used in the needs assessment for the purposes of costing SDG investment needs? How robust are the numbers?

[7] Unless otherwise noted, estimates of investment needs reported in the tables are not adjusted and are expressed in constant dollars for the base year used in the study.

Available needs assessments for the major SDG investment areas differ in the countries they cover. Some include all countries, while others consider only investment needs in a subset of developing countries. This analysis is limited to developing countries with a particular focus on low-income and lower-middle-income countries. This choice is motivated by the fact that (i) achieving many SDGs in high-income countries will largely require shifting expenditures, and greater efficiency in public/private investments (although important exceptions are sustainable consumption and infrastructure), and (ii) high- and upper-middle-income countries will be able to meet their financing needs without resorting to concessional international co-financing. Section 4.13 then estimates incremental SDG investment needs at the global level.

As shown in section 4, needs assessments are harder to conduct in some areas than in others. In particular, education, health, and other social sectors have made great strides in developing robust needs assessments, while our understanding of investment needs in infrastructure, food security, and ecosystem services remains much less robust and complete. The paper endeavors to assess the quality and robustness of each set of investment needs in the sectoral summary tables in section 4, highlighting gaps that need to be filled through future work. Estimates that seem incomplete or insufficiently robust are presented in square brackets in the summary Table 14.

Additional investment needs for climate change mitigation and adaptation under a 2°C pathway

Pursuant to the discussion under Step 1 above, incremental investment needs for climate change adaptation and mitigation are considered under each investment area. A first critical question concerns the global warming pathway assumed to scale investment needs in both adaptation and mitigation. The available literature (e.g. Stern 2007, UNFCCC 2007, World Bank 2010, ECONADAPT 2015) assumes different pathways that often exceed the 2°C limit adopted formally by member states of the UNFCCC in Cancùn in 2010. Since the science and the politics of climate change converge on limiting the rise in average global temperatures to less than 2°C (IDDRI & SDSN 2014, IPCC 2014) SDG needs assessments should consider the IPCC (2014) carbon budget that gives a likely chance of staying within 2°C as the outer boundary of permissible greenhouse gas emissions.

Adaptation scenarios for higher temperature increases can be useful to illustrate the sensitivity of investment needs in adaptation to increases in global average temperatures. For example, modeling by Bruin (2014) found that investment needs for adaptation are likely to be twice as great if the average global temperature rises to 4°C. Yet, these analyses tend to hide substantial regional variation, and under a 4°C scenario it seems likely that adaptation will become impossible in several regions (IPCC 2014).

Our principal source for adaptation investment needs is the World Bank's Economics of Adaptation to Climate Change (EACC) synthesis report (World Bank 2010) and a recent review of adaptation needs assessments by the ECONADAPT (2015) project. This latest report compares two climate scenarios where global temperatures increase by 2°C with sectoral baseline scenarios by 2050. These are selected to present a wide range of potential, one extremely "wet" (i.e. with high precipitation rates) from the

National Centre for Atmospheric Research, and another "dry", developed by the Commonwealth Scientific and Industrial Research Organization. Adaptive measures to return to pre-climate change levels of welfare are then identified and costed. All investment needs are expressed as *additional* to the baseline investment needs of development measures.

The World Bank EACC underestimates overall investment needs for a number of reasons (ECONADAPT 2015). First, opportunity and transaction costs are not factored into the analysis. Similarly, the challenges of poor governance, high management costs, and failures of adaptation measures in many fragile and/or poor countries are not taken into account. Second, its coverage of sectors and impacts is only partial, and the report considers primarily "hard" options (e.g. infrastructure solutions like dams or irrigation) over "soft" options (e.g. warning systems, watershed management and community preparedness programs) because their investment needs are more easily quantified. Despite these limitations, and in the absence of more recent global estimates of adaptation costs, the paper draws on the report to account for investment needs in adaptation. When estimates of incremental investment needs for adaptation expressed as percentage "mark-ups" are available, they are applied to development estimates in order to identify a range of potential investment needs.

Sources for investment needs in climate change mitigation focus largely on the energy system and are described in the corresponding sub-sections in chapter 4. Once again, key weaknesses of available studies are inconsistent assumptions regarding carbon budgets, and a focus on global studies that lack the granularity needed to map out the transformation of national energy systems needed to stay within 2°C, a gap that the Deep Decarbonization Pathway Project (IDDRI & SDSN 2014) and the recently announced project *The World in 2050* seek to close.[8]

Overall, assessments of financing needs for climate change mitigation and adaptation are based on a heterogeneous and inconsistent set of assumptions, which makes it difficult to compare results. It also makes it difficult to determine the investment needs for a sustainable development pathway consistent with achieving the SDGs by 2030, including staying within the 2°C limit. Available data are impossible to harmonize across studies, so highlight differences and key methodological assumptions are highlighted in section 4 in the hope that this will spur greater harmonization, including a shared focus on a 2°C pathway in all future work on the economics of climate change mitigation and adaptation.

Synergies with investment needs in other sectors

As emphasized throughout this paper, outcomes in one investment area are co-dependent on policies and investments in other areas. Synergies and trade-offs are widespread and may have a significant impact on outcomes and overall investment needs. The distinction between synergies in outcomes and synergies in investment needs is important, since the latter describe a more reduced set of

[8] Several research institutions have recently announced the launch of *The World in 2050*, a long-term modeling effort to develop integrated sustainable development pathways through to 2050 that show how the SDGs can be achieved. The initiative will provide regionally down-scaled pathways to assess how major world regions can enter a sustainable development pathway. The initiative is led by the Earth Institute of Columbia University, the International Institute for Applied Systems Analysis (IIASA), the Stockholm Resilience Center at Stockholm University, and the Sustainable Development Solutions Network (SDSN).

relationships. For example, good education outcomes require, *inter alia*, access to safe water and improved sanitation, but improved access to safe water and sanitation will not have a significant impact on the cost of running an education system.

A detailed discussion of how outcomes in one area depend on investments elsewhere is beyond the scope of this paper. The focus in section 4 is therefore on the synergies and trade-offs across sectors that will significantly affect the volume of investments in any given investment area.

Adjustments made for this paper

We summarize adjustments made to ensure comparability across sector needs assessments and to facilitate their aggregation across the eleven SDG investment areas. Such adjustments can include the geographic scope, the nature of interventions considered (to avoid overlaps and gaps across investment areas), the inclusion of capital vs. operating expenditure, etc. Where needs assessments discount future investments (e.g. as part of cost-benefit analyses) or spread financing over several years (e.g. to account for amortization) the results are converted into annual non-discounted cash-flows, which can be compared across studies.

Opportunities for public and private financing

The financing strategy for the SDGs is considered in section 6. Opportunities for private financing of the SDGs differ markedly across SDG investment areas. For ease of presentation, opportunities for private financing are therefore considered under each investment area in section 4.

Aggregation of results

Based on a careful analysis of interventions covered in each sector needs assessment; an assessment of major synergies in investment needs; and a number of adjustments made to harmonize results between studies, section 4.12 then aggregates the investment needs across the eleven major SDG investment areas. To the extent possible, the synthesis identifies gaps and overlaps in available SDG needs assessments to help guide future research.

3.3. Step 3: Consider economy-wide effects on SDG investment needs

Section 5 draws on economy-wide models and integrated assessment tools to consider economy-wide effects. Available studies provide a good indication of which economy-wide effects of investments in the SDGs, such as changes in real wages, are quantitatively important. Since the focus is on aggregating sector needs assessments, and since available economy-wide tools tend to cover relatively small subsets of SDG investments (section 2.2), consideration of economy-wide effects remains conceptual and illustrative. This area warrants further and more detailed work.

3.4. Step 4: Explore public-private financing strategy for SDG investments

Section 6 summarizes the financing strategy for the projected SDG investments in low- and lower-middle-income countries. Priority is given to private investments where they can reasonably be mobilized without compromising on the achievement of the SDGs. The remaining public financing needs should be met, where possible, through domestic resource mobilization, which in turn depends on

countries' per capita income and overall investment needs. Many sector studies estimate domestic resource mobilization potential for their sectors, but they typically do so without considering overall public investment needs for the SDGs. As a result, sector spending objectives can add up to more than a country can reasonably finance through its own resources (Hagen-Zanker and McCord 2011; Schmidt-Traub and Sachs, 2015). For this reason it is critical that domestic resource mobilization be considered in the context of overall SDG investment needs, as this paper does for the first time. The section concludes by considering how the remaining financing gap can be financed through concessional and non-concessional international finance.

4. Overview of investment needs for the SDGs

This section identifies the major investments needed for each of the eleven priority investment areas presented in section 3. It synthesizes the results of available needs assessment studies, describes any adjustments made to ensure coherence and avoid overlaps with the results from other sectors, and considers the major synergies with other investment areas, i.e. how investments in other investment areas may affect the level of investment needed in a given investment area.[9] Additional investment needs for climate change adaptation and mitigation are considered in each investment area and consolidated at the end of this section. It then assesses the potential for private financing of the required capital investments and operating expenditure. The discussion of each investment priority concludes with a summary of knowledge gaps and areas for future research.

4.1. Health

The health SDG and associated targets (OWG 2014) focus on tackling the major infectious diseases, non-communicable diseases, child and maternal mortality, sexual and reproductive health, as well as providing universal health coverage (UHC). The SDG agenda for health is considerably broader than the MDG agenda, notably through its focus on universal access to health systems and the inclusion of non-communicable diseases. Good health outcomes depend on sound policies and investments that address the clinical, environmental, and social dimensions of health, including healthy diets and healthy behaviors. This in turn requires improved policies and investments in many areas outside the health system, including education, gender equality, water and sanitation, clean energy, and environmental management (Jamison *et al.* 2013, Agyepong *et al.* 2014, Murray *et al.* 2015).

Available needs assessments studies and results

The WHO Commission on Macroeconomics and Health (CMH 2001) undertook the first major needs assessment for health. This was followed by the publication of an updated and expanded needs assessment for the health MDGs by the UN Millennium Project (2005). In 2010, the High-Level Task Force on Innovative International Financing for Health Systems (HLTF) (WHO 2010a) was tasked to provide inputs on the incremental investment needs to reach MDGs in low-income countries, including the investment needs associated with strengthening health systems. This analysis was then updated by Chatham House (2014). In parallel, the Lancet Commission on Investing in Health (Jamison *et al.* 2013) prepared country-level needs assessment estimates. The focus is on the three studies prepared after 2010, which are summarized in Table 2. This paper retains the estimates from Jamison *et al.* (2013) since they are disaggregated to the country level with wide geographic coverage; include some of the cost of achieving universal health coverage (UHC) through health systems strengthening; and cover the whole SDG period through to 2030 and beyond.

[9] As described in section 3, this paper focuses only on synergies in investment needs instead of the broader questions of how changes in one area affect outcomes in another.

These needs assessments do not cover investment needs for non-communicable diseases (NCDs), which have been included in the SDGs. NCDs are responsible for over 68 percent of deaths worldwide in 2012, 40 percent of which were premature (WHO 2014). An early needs assessment for key NCD interventions was carried out as part of the Lancet NCD Series for 23 low- and middle-income countries (Beaglehole *et al* 2008). This was later expanded to 42 countries accounting for 77 percent of the global NCD burden (WHO 2011). A more recent analysis (Nugent 2015) focuses on a much narrower set of interventions, so this paper retains the results from WHO (2011). Even this study considers only a sub-set of NCDs, so likely underestimates the projected investment needs. Given the vast scope of NCDs and the extremely high costs of treating some conditions, every country will need to make a decision on which NCDs and types of diagnostics and treatment should be included in the country's strategy to achieve the SDGs.

Additional investment needs for climate change mitigation and adaptation

Recent reports by the Lancet Commission on Health and Climate Change and the Lancet Commission on Planetary Health warn that unmitigated climate change will significantly affect human health and is effectively threatening to reverse the progress made in the past few decades (Watts *et al.* 2015, Whitmee *et al.* 2015). Rising average temperatures and more pronounced temperature spikes will directly increase mortality risks from heat waves, although some areas will experience lower mortality from cold weather. Climate-induced changes in disease vectors and food availability will also affect the burden of disease, particularly from vector- and water-borne diseases, such as malaria, dengue fever, schistosomiasis, and diarrhea (Bosello *et al.* 2006, Watts *et al.* 2015).

The EACC report estimates the investment needs for adapting to climate change in the health sector to be in the range of $\$_{2005}$1.5 - 2 billion per year for low- and middle-income countries, depending on the climate scenario considered (World Bank 2010). In a background discussion paper to the synthesis report, Pandey (2010) similarly estimates investment needs for adaptation in the health sector in developing countries to be around $2 billion per year between 2010 and 2050. This analysis focuses on malaria and diarrheal disease, and the great majority of these incremental investment needs are incurred in tackling the increased incidence of the latter. Incremental investment needs for adaptation are calculated compared to a baseline incidence of disease without climate change. In order to account for climate adaptation costs in health, additional investments as reported by the EACC report are included to the range reported by Jamison *et al.* (2013).

These estimates are much lower than earlier figures, which calculated the cost of adaptation as reaching between $4 and $12 billion in the year 2030 (Ebi 2007). The reduction in investment needs for adaptation results primarily from projected falls in the baseline incidence of these diseases by 2050, which in turn will require greater investments in health systems, as described above.

Table 2. Needs assessment studies for health

Study	Jamison *et al.* (2013)	Chatham House (2014)	WHO (2010a)	WHO (2011)
Coverage and development outcomes	Universal Health Coverage (UHC) and a "Grand Convergence" in health (Reduction in the burden of infections and RMNCH disorders in most high-mortality LICs and LMICs down to the rates presently seen in the best performing MICs).	Universal Health Coverage (UHC).	Achieving MDG health targets; investments in health systems strengthening.	Core set of "best buy" interventions against NCDs, as defined by WHO (2010b).
Relationship to SDGs	Addresses SDG3 - reduce burden of RMNCH disorders and communicable diseases (3.1, 3.2 and 3.3), and reach UHC (3.8). The control and treatment of NCDs (3.4 and 3.6) are not included.	Addresses SDG3 - Achieving MDG targets for RMNCH disorders and communicable diseases (3.1, 3.2 and 3.3) and contributes to reaching UHC (3.8) through health systems strengthening.	Addresses SDG3 - Achieving MDG targets for RMNCH disorders and communicable diseases (3.1, 3.2 and 3.3) and contributes to reaching UHC (3.8) through health systems strengthening.	Achieving SDG3 – partly addresses target 3.4 (NCDs).
Key gaps	Non-communicable diseases; epidemic preparedness and response plans.	Non-communicable diseases only partially addressed; epidemic preparedness and response plans.	Non-communicable diseases only partially addressed; epidemic preparedness and response plans.	Not all NCDs are included (notable gaps include renal and intestinal diseases, gastrointestinal diseases, neurological diseases and mental disorders).
Methodology	**Intervention-based needs assessment** (Bottom-up analysis of investment needs with the OneHealth Tool: for country-level scenario planning for maternal and child health, HIV and malaria control). Projections for investment needs for health systems strengthening, neglected tropical diseases, and tuberculosis interventions draw on other sources and estimates: respectively from the HLTF, WHO/World Bank/Ghana Ministry of Health, and WHO Stop TB Department).	Updates the WHO (2010a) per capita estimate from $\$_{2005}$ to $\$_{2012}$, taking into account changes in exchange rates and inflation.	**Intervention-based needs assessment** (Country estimates were based on an assessment of current levels of coverage of the interventions being costed and the current status of the health system infrastructure and personnel. Based on this, the marginal impact of scaling up coverage of proven interventions was estimated).	**Intervention-based needs assessment** (country estimates are based on a WHO financing tool).
Incremental vs. Total costs	**Incremental** (to a "status quo" spending scenario, assuming constant coverage of interventions over time).	**Total** (per capita only).	**Incremental** (to a business as usual "no-change" spending scenario, representing the sum of spending from domestic, private and external sources based on current 2008 government and private spending to GDP ratio and 2007 ODA to GDP, projected forward using predicted GDP growth rates).	**Incremental** (to current spending levels).

Study	Jamison *et al.* (2013)	Chatham House (2014)	WHO (2010a)	WHO (2011)
Expenditure types	**Capex + Opex** (Scaling up programmatic investment in current interventions in family planning, maternal and newborn health, immunization, treatment of childhood illness, malaria, tuberculosis, HIV/AIDs, health systems strengthening, and scaling up new tools).	**Capex + Opex** (WHO 2010a "minimum package of services," "representing the minimum expenditure required to ensure priority services for everyone in the context of LICs," used as a proxy for UHC).	**Capex + Opex** (Scaling up a "minimum package of services" to achieve the MDGs (tackling maternal and child health, HIV/AIDs, TB and malaria); expanding access to the management of chronic diseases, mental health, and neglected parasitic diseases; Increasing access to affordable essential medicines for some chronic diseases, cancer, neglected tropical diseases and general care; tobacco control; reduction of salt in foods; health systems strengthening, including human resources, logistics and supply chain, health information system, health systems financing, leadership and governance).	**Capex + Opex** (population-based measures to address NCD risk factors (tobacco use, harmful alcohol use, unhealthy diets and physical inactivity) through tax increases and public awareness campaigns and individual-based interventions to address NCDs in primary care (cancer, cardiovascular diseases and diabetes) through prevention and treatment measures).
Consideration of climate change mitigation and adaptation	No	No	No	No
Consideration of economy-wide effects	Includes annual 4% increase in non-commodity costs to account for rising wages and other unit cost increases resulting from a large scaling up of investments in health. However, authors note that the full elasticity of costs is likely not adequately captured by the analysis.	None	None	None
Geographical resolution and scope	**Country level** (34 LICs + 48 LMICs).	**Country level** (LICs, LMICs and UMICs).	**Country-level** (49 LICs - GNI per capita < $935).	**Country-level** (13 LICs, 13 LMICs and 16 UMICs, extrapolated to all LICs and MICs).
Period covered	2015 – 2035	Not specified	2009-2015	2011 – 2025
Relationship to other studies and observations on methodology	Update of the WHO (2010a) study.	Updates per capita estimate by WHO (2010a). Methodology detailed in McIntyre & Meheus (2014).	n/a	Builds on prior work presented by Beaglehole *et al.* (2008).
Base year	2011	2012	2005	2008
Annual investment needs in billions $ (start year)	$57 (2015) Breakdown: LICs $24 (2015) + LMICs $33 (2035)	n/a	$19 (2009)	n/a

Study	Jamison *et al.* (2013)	Chatham House (2014)	WHO (2010a)	WHO (2011)
Annual investment needs in billions $ (end year)	$91 (2035) Breakdown: LICs $30 (2015) + LMICs $61 (2035)	n/a	$37 (2015)	n/a
Period average in billions $ per year (years)	**$61 (2016-2025) - $80 (2026-2035)** Breakdown: LICs: $23 (2016-2025) - $27 (2026-35) + LMICs: $38 (2016-2025) - $53 (2026-2035)	n/a	**$32 (2009 - 2015)**	**$11.4 (2011 – 2025)** Breakdown: $0.7 in LICs, $3.7 in LMICs and $6.9 in UMICs
Comments on results	The study provides per capita costs of $22 (2016-2025) - $23 (2026-35) for LICs and $14 (2016-2025) - $18 (2026-2035) for LMICs. Investments in strengthening health systems account for some 80% of health investment needs in LICs.	The study provides a per capita total health spending target (representing minimum investment needs) of $86. The authors also suggest a target for health spending of at least 5% of GDP for countries with larger budgets.	The study provides a per capita figure of $54 for total investment needs and $25 for incremental investment needs. Investment needs are broken down by (i) capital and recurrent cost, (ii) upfront and continued costs, (iii) input, (iv) disease and health system building block, (v) level of care and (vi) geographic area (regions).	Countries covered in the study account for 90% of the NCD burden in developing countries and 77% of the global NCD burden. The average per capita cost reported by the study is $1 in LICs, $1.5 in LMICs and $3 in UMICs.
Adjustments made	Rebased to $\$_{2013}$ and, yielding development investment needs of $63-83 billion (LICs: $24-28 billion, LMICs: $39-55 billion). Adaptation investment needs of $\$_{2005}2$ billion per year (rebased to $\$_{2013}$) from Pandey (2010) are added. Combined with WHO (2011), this yields a total of **$69-89 billion (LICs: $25-29 billion, LMICs: $44-60 billion).**	Rebased to $\$_{2013}$ and retained as a reference for health needs assessments.	Results have not been retained for this paper.	Rebased to $\$_{2013}$ yielding total investment needs for LICs and LMICs of $5 billion per year (LICs: $1, LMICs: $4). In the absence of available data on incremental health costs from climate change impacts on NCDs, no adaptation investment needs are added. Results are combined with Jamison *et al.* (2013).
Robustness of estimates	Methodology suitable and numbers are robust.	Methodology suitable and numbers are robust.	Methodology suitable and numbers are robust.	Methodology suitable and numbers are robust.

Source: Author's analysis, based on Jamison *et al.* (2013), Chatham House (2014), McIntyre & Meheus (2014), WHO (2010a), WHO (2011) and Pandey (2010).

Needs assessments for adaptation in the health sector are limited, since they only include a sub-set of vector- and water-borne diseases. Moreover, the impact of climate change on health systems is highly sensitive to projected temperature changes. All available estimates for adaptation needs project that temperatures do not rise beyond 2°C above pre-industrial levels. Any further increase in global mean temperatures would likely impose significantly higher investment needs on the health sector.

The health sector does not contribute significantly to climate change mitigation. For this reason health investments for climate change mitigation are not included in this analysis

Synergies with investment needs in other sectors

As underscored by Jamison *et al.* (2013) and Murray *et al.* (2015), policies and investments in many other areas contribute to improving or worsening health outcomes. Illustrative examples include: safe water and improved sanitation to lower diarrheal diseases and improved nutrition, access to clean cooking fuels to lower pulmonary infections and related non-communicable diseases, reductions of deaths and injuries from road accidents, healthier diets, transport infrastructure and services to improve access to health facilities, gender equality to improve women's and children's health outcomes, and many more.

Neither the Lancet Commission nor the HLTF have included major investments outside the health system in their needs assessments. Since the SDGs aim for universal access to basic infrastructure – including clean energy, safe water, and sanitation – a comprehensive SDG needs assessment will include all major investments outside the health sector that are needed to achieve the SDG health outcomes.

Available health needs assessments also do not discuss or quantify the extent to which investments in other sectors may alter investment needs for the basic health package. Strong evidence exists that investments in clean energy may drastically lower mortality and morbidity from air pollution (e.g. van Vliet *et al.* 2011, Shindell *et al.* 2012, NCEC 2014a). These effects feed mostly into non-communicable diseases, which are not fully covered in available needs assessment. As a result, the health investment needs (as opposed to health outcomes) reported in this paper are reasonably invariant to the volume of investments in some of the other investment areas. This will of course change substantially once non-communicable diseases are included in an expanded health needs assessment.

Adjustments made for this paper

Results from Jamison *et al.* (2013) are rebased from $\$_{2011}$ to $\$_{2013}$ and combined with the rebased estimates for NCDs from WHO (2011). This yields incremental annual "development" investment needs of \$67 – 87 billion in total each year for the period 2015 to 2030 (see the numbers for health in Table 14). The breakdown of investment needs for LICs (\$25 – 29 billion) and LMICs (\$43 – 59 billion) is reported as in Jamison *et al.* (2013) after being rebased.

Investment needs for adaptation from World Bank (2010) are rebased from $\$_{2005}$ to $\$_{2013}$ and added to the overall range, resulting in a total of $69 – 89 billion per year. Incremental needs for adaptation in the health sector are scaled down to country income groups on a per capita basis.

Opportunities for public and private financing

In both developed and developing countries, the private sector plays a major role in the delivery of health services; but financing UHC is a different matter. While private health insurance and out-of-pocket expenditure can make significant contributions to health financing in high-income and upper-middle-income countries, experience shows that investments in UHC in most developing countries will need to be publicly financed. The evidence on user fees in developing countries shows that out-of-pocket expenditures lead to drastically lower utilization of health services and fail to generate substantial revenues. For this reason, the consensus in the international health community is that UHC-related investments and operating expenditures need to be publicly financed (Moreno-Serra and Smith 2012, Savedoff 2012, Yates 2009, Jamison *et al.* 2013, Agyepong *et al.* 2014). This assumption is extended to the financing of the NCD interventions since they constitute a limited sub-set of "best buy" conditions and treatment options, which can be considered as part of a package of essential health interventions central to achieving UHC (WHO 2011, WHO 2010b). It would be useful to conduct a more detailed financing analysis on NCDs.

Of course substantial private investment does occur in developing countries, including for advanced medical treatment for the wealthy. In combination with unsustainable user fees, such investments account for some 20 percent of all health expenditure in developing countries (UNCTAD 2014). Yet since such investments are either incompatible with achieving UHC or beyond the scope of the primary health care focus of the post-2015 agenda, the private sector will likely not contribute to the financing gap for the health SDG. Even if there is some private co-financing, the public finance needs reported in current needs assessments strike us as conservative, since they exclude the investment needs for controlling and treating non-communicable diseases and therefore understates overall needs.

Robustness of available assessments and avenues for further research

Overall, the health needs assessments have improved substantially since the first global assessment prepared by the Commission on Macroeconomics and Health (CMH 2001). They have become robust and are broadly consistent across studies. Many needs assessments have been validated *ex post* by the investments made through some of the world's leading health financing mechanisms – as can be seen from the needs assessments in Global Fund (2013), Gavi (2014a), and GFF (2015). The needs assessments demonstrate that the health sector has developed a robust and widely shared production function for achieving the principal SDG outcomes.

It would be very helpful to gain a better understanding of how investments (or the lack thereof) in other areas, such as water, sanitation, and energy, affect investment needs in the health sector. Such work would require broad integrated modeling across a broad spectrum of SDG investment needs.

Another important line of future inquiry concerns the potential of modern technologies, including information and communication technologies (ICTs), to make health systems more effective and efficient. In particular ICTs can lower the cost of providing health services, and facilitate access through initiatives like the expansion of smartphone-equipped Community Health Workers in rural areas. They can also make spending on health systems more transparent to reduce waste.

4.2. Education

The SDGs include a strong focus on quality education at pre-primary, primary, secondary, and post-secondary education, including adult literacy. This represents a substantial broadening of the education agenda compared with the MDGs, which focused on enrolment in primary schools. Moreover, the focus is shifting towards education outcomes since it has been consistently shown that enrolment alone does not necessarily lead to adequate results (UNESCO 2010, 2014). Most countries will need to strengthen their education systems to achieve these ambitious goals, through improved policies and increased investments in infrastructure and operating expenditure, including teachers' salaries. Good education outcomes also depend on improvements beyond the education sector, as reviewed below.

Available needs assessments studies and results

The most recent Education for All Global Monitoring Report (UNESCO 2015a, 2015b, Wils 2015) estimates investment needs for the education SDG, and currently represents the most comprehensive and up-to-date estimates of annual financing gaps in the education sector, at $\$_{2012}22$ billion between 2015 and 2030. This estimate was expanded in the July 2015 update of the reports background policy paper on "Pricing the Right to Education," to include investment needs for upper-secondary education, raising the total annual financing gap to $39 billion between 2015 and 2030 (UNESCO 2015b). These headline investment needs take into account projected increases in domestic spending on education as a result of GDP growth and increased budget allocations to education. In order to maintain consistency with the needs assessment used in other SDG investment areas, incremental investment needs over current spending are reported in summary tables 14 and 15.

These estimates update and replace earlier needs assessments conducted by UNESCO (2012, 2013), and no other comprehensive analyses of investment needs are available for the education sector, so these figures are used in this paper's analysis of overall investment needs in education. Table 3 provides an overview of the most recent UNESCO (2015b) estimates.

The gradual refinement of the UNESCO estimates, and their use by other organizations such as the Malala Fund to inform their own work (Results for Development 2015), is a positive example of how needs assessments can improve over time, yielding increasingly detailed and operational evaluations of financing requirements to achieve goals.

Table 3. Needs assessment studies for education

Study	UNESCO (2015a, 2015b)
Coverage and development outcomes	Achieving universal pre-primary, primary, lower and upper secondary education of good quality.
Relationship to SDGs	Addresses SDG4 – not including tertiary education, skills for work, adult literacy and scholarships.
Key gaps	Tertiary education; skills for work; adult literacy; scholarships; teacher training.
Methodology	**Intervention-based needs assessment** (Calculates investment needs to meet the targets using a projection model incorporating a "basic expenditure function," and a number of key targets including student:teacher ratios, school attendance; as well as assumptions about population trends, evolution of teacher salaries. Uses the latest available national data to update estimates of the financing needs and gaps, after factoring in expanded domestic resource mobilization for education).
Incremental vs. Total costs	**Incremental** (to current spending and additional domestic spending, assuming increased domestic tax revenues as a share of GDP and budget allocations to education in excess of 20%).
Expenditure types	**Capex** (14% for classroom construction) + **Opex** (82%, three-quarters of which are for teacher salaries, the rest for instruction materials, teacher training and school management reforms) and catering to the marginalized (4%).
Consideration of climate change mitigation and adaptation	n/a
Consideration of economy-wide effects	The model assumes a long-term relationship between teacher salaries and GDP per capita, and that countries will gradually converge at average salaries.
Geographical scope and resolution	**Country level** (81 LICs + LMICs).
Period covered	2015-2030
Relationship to other studies and observations on methodology	Follows methodology of UNESCO (2010), with adjustments (expanded geographical scope and period covered). Methodology detailed in UNESCO (2015b).
Base year	2012
Annual investment needs in billions $ (start year)	n/a
Annual investment needs in billions $ (end year)	n/a
Period average in billions $ per year (years)	Total costs**: $340 (2015-2030)** Breakdown by interventions: Pre-primary, primary and lower-secondary education: $242 (2015-2030) + Upper-secondary education: $97 (2015-2030) Breakdown by income group: LICs: $50 + LMICs: $289 Increase in total costs: **$191 (2015-2030)** Breakdown by income group: LICs: $36 + LMICs: $155 Financing gap: **$39 (2015-2030).** Breakdown by interventions: Pre-primary, primary and lower-secondary education: $22 (2015-2030) + Upper-secondary education: $17 (2015-2030) Breakdown by income group: LICs: $21 + LMICs: $18
Comments on results	n/a
Other adjustments made	Rebased to $\$_{2013}$, yielding **$194 billion (LICs: $37 billion; LMICs: $157 billion)** in investment needs incremental to total spending. Climate change related investments are assumed to be zero.
Robustness of estimates	Methodology suitable and numbers are robust.

Source: Author's analysis, based on UNESCO (2015a, 2015b). Note: Numbers have been rounded and may not add up exactly.

Additional investment needs for climate change mitigation and adaptation

While education curricula will need to evolve in response to climate change, and some school buildings might need to be upgraded to better deal with temperature and weather extremes, any incremental investment needs for adaptation in the education sector will be very small (IPCC 2014, Hughes *et al.* 2010). Similarly, the education sector does not contribute significantly to climate change mitigation. Incremental investment needs for climate change adaptation and mitigation therefore are not included in this paper.

Synergies with investment needs in other sectors

Good education outcomes depend not only on functioning education systems, but also on progress in other sectors (UNESCO 2015a). Improved access to water, sanitation, transport services, modern energy, and other infrastructure services increase attendance of children, especially of girls in middle school. In particular, access to electricity and lighting has been shown to increase education outcomes by enabling children to do homework after dusk (Modi *et al.* 2006). A major drag on education outcomes in developing countries stems from poor child health, particularly inadequate nutrition (Bhutta *et al.*2013). Greater gender equality, particularly the education of mothers, has also been shown to improve learning outcomes among children UNESCO (2010). Changes in the population of school age children – a major driver of investment needs in education (UNESCO 2015b) – can also be altered by rising incomes, improved reproductive health, and gender outcomes such as later age of marriage (UN Population Division 2011). Such effects may have a significant effect on per capita education expenditure towards the end of the SDG era.

While education outcomes depend significantly on progress in other areas, the investment needs in education systems are largely invariant to these changes. For example, improved school attendance owing to better child health and reduced seasonal demand on child labor will not have a significant impact on the capital and operating costs of education systems. For this reason, the education co-benefits from investments outside the education system will not materially alter the results of education needs assessment, as presented in UNESCO (2015b).

Investment needs for education may change substantially through the increased use of modern information and communication technologies. Such technologies hold the promise of making high-quality education content available at low marginal cost even for hard-to-reach children; increasing transparency and accountability in the education sector; and improving the tracking of education outcomes (Schmidt-Traub and Sachs 2015). To date, the education sector has been slow in the adoption of modern technologies, and their impact has not been considered in available education needs assessments.

Adjustments made for this paper

Results from the Education for All Global Monitoring Report (UNESCO 2015a, 2015b) are rebased from $\$_{2012}$ to $\$_{2013}$. The breakdown of costs for LICs and LMICs is reported as in the original study. No further changes were made to the estimates since they do not overlap significantly with the needs assessments for other investment areas.

As noted above, UNESCO's (2015a, 2015b) headline investment needs describe the financing gap remaining after projected increases in domestic spending. To ensure consistency with other sector studies, Table 14 reports incremental needs relative to current spending levels, i.e. $194 billion per year ($37 billion in LICs and $157 billion in LMICs).

Opportunities for public and private financing

Just like in the health sector, private expenditure on education in developing countries accounts for a significant share of total investments. Estimates vary from 15 percent (UNCTAD 2014) to some 30 percent (UNESCO 2015a). In part, these expenditures reflect user fees for primary and lower secondary education that are inconsistent with the objective of universal access and completion rates (UNESCO 2013). They also cover school fees paid by wealthy households for higher-quality private schooling, which are outside the scope of the SDGs. For these reasons, financing for the education SDG will need to be overwhelmingly public, even as the private sector continues to offer fee-based services.

Robustness of available assessments and avenues for further research

The most recent estimates for investment needs in the education sector are comprehensive and cover the principal SDG priorities, with the exception of adult literacy, skills for work, and the expansion of post-secondary education. They need to be scrutinized closely by the education community to ensure their robustness and to confirm the underlying production function for the education SDG. Meanwhile, a promising area for future research is the potential use of modern information and communication technologies to expand the reach and quality of education systems and to reduce the cost of service delivery.

4.3. Social Protection

As described in section 3.1, the universal access to basic infrastructure and social services prescribed by the SDGs will make a major contribution to ending extreme poverty in all its forms. Access to health and education in particular will need to be free for the poor and marginalized groups to use these social services (sections 4.1 and 4.2). Universal Health Coverage provides an important insurance mechanism against unforeseen shocks, including injury and severe illness. Similarly, free education helps reduce the likelihood that children, particularly girls, stop going to school in response to an economic shock suffered by the family (ILO 2014).

Social protection systems targeting such needs can take a variety of forms, such as work-for-food programs, direct cash transfers, social insurance, etc. (Development Initiatives 2015, Greenhill *et al*. 2015). The International Labor Organization (ILO 2014) estimates that close to three-quarters of the global population lives without adequate social protection coverage.

Investments across the SDGs will increase economic growth and household incomes, insure against shocks, and raise the incomes of the poor, but they are not enough on their own to ensure that no one is left behind. A number of social protection measures will be required to target specific groups and needs. These include but are not limited to the special needs of the disabled; victims of violence (including sexual violence); single-parent households and orphans; long-term support for communities exposed to disasters beyond initial humanitarian assistance (section 4.11); demobilization of combatants; victims of discrimination and exclusion; and families lacking any source of income. In addition, some countries provide conditional cash transfers to promote healthy and sustainable behaviors by families and specific groups. ILO (2014), Greenhill *et al.* (2015), and Development Initiatives (2015) review the evidence on the effectiveness of social protection programs.

Available needs assessments studies and results

Three factors make it hard to conduct a global needs assessment for social protection: (i) the context-specificity of social protection programs and their dependence on societal norms and levels of income; (ii) the need to target them to specific groups, which differ across countries; and (iii) the substantial overlap with investment needs for social services and basic infrastructure.[10] Most available studies therefore focus on individual countries or small sub-sets of countries, a point underscored by Development Initiatives (2015). For example, ILO (2005, 2008, 2014) analyzes social protection spending needs for a number of low-income countries, focusing on age-old and disability pensions, basic child benefits, essential health care, and social assistance/employment schemes. The ILO studies do not aggregate across low-income and lower-middle-income countries, and their estimates exhibit a high degree of variation across countries. This makes it difficult to extract implications for global SDG investment needs.

Other analyses provide estimates for the cost of social safety nets by estimating the direct transfers needed to lift incomes of the extremely poor to at least $1.25 PPP per day. Greenhill *et al.* (2015) estimate that annual spending needs for social protection floors, including health insurance, cash transfers, and pension systems, would require incremental public investments to the tune of $42 and $40 billion per year in low- and lower-middle-income countries, respectively. These estimates include 15 percent administrative costs and assume 75 percent leakage to account for the difficulty of targeting income transfers to the extreme poor. Using a similar methodology, Development Initiatives (2015)

[10] For example, parts of the investment needs to achieve Universal Health Coverage (UHC) can be used to finance conditional cash transfers in countries where these are indicated. Similarly, countries can use work-for-food programs to build roads and other infrastructure projects. The associated investment needs are included in the infrastructure needs assessments.

arrive at estimates of investment needs for social protection of $44 billion for low-income countries and $61 billion in middle-income countries. Due to the methodological similarities between Development Initiatives (2015) and Greenhill *et al.* (2015), Table 4 compares ILO (2008) with Greenhill *et al.*, who provide the more detailed description of methodology and assumptions.

Given the difficulty of deriving robust estimates for social protection expenditure from top-down "sectoral" needs assessments, country-level analyses of social protection spending can provide useful benchmarks. This overview paper cannot review the literature on available country-level assessments, but substantial evidence is becoming available. As one example, Development Initiatives (2015) shows that Ethiopia currently spends $103 million per year on social protection. Using latest available spending data from 2013/2014, this corresponds to $46 per beneficiary, assuming a leakage rate of 75 percent and 20 percent program management cost (Marcus Manuel, *personal communication*). Some of these funds finance public infrastructure works programs, so care must be taken to avoid double-counting with infrastructure investments.

Table 4. Needs assessment studies for social protection

Study	Greenhill *et al.* (2015)	ILO (2008)
Coverage and development outcomes	A "Basic Social Compact" comprising basic social protection, universal health care coverage and universal primary and secondary education.	A "Basic Social Security Floor" comprising old-age and disability pensions, basic child benefits, essential health care, and social assistance/employment schemes.
Relationship to SDGs	Addresses SDGs 1, 3 and 4 directly, but will also have impacts on a wider range of goals, including notably SDGs 2, 5, 6, 10, 11, 16.	Addresses SDGs 1, 3 and 4 directly, but will also have impacts on a wider range of goals, including notably SDGs 2, 5, 6, 10, 11, 16.
Key gaps	The study does not consider social protection needs of groups other than the extreme poor, with the exception of universal free access to health and education. See below and text for comments on methodology.	Projected investment needs are very broad and do not specify individual interventions. This makes it difficult to identify gaps and overlaps with other SDG investment areas. Moreover, the projected investment needs cannot be applied across country groups due to high inter-country variation in projected needs.
Methodology	Investment needs in social protection estimates as the equivalent income-transfers needed to bridge the poverty-gap (i.e. ensuring that income of each person living in extreme poverty is increased to $1.25 PPP per day). The estimate includes leakage rates of 75% (175 transfers for every 100 beneficiaries being targeted) and administrative costs of 15%. Education estimates are based on UNESCO (2015) country estimates and health estimates on Chatham House (2014) target. The financing gap is calculated based on projected increases in tax capacity and existing aid allocations.	Costing model projects evolution of investment needs for each of the four components of the basic social security floor in a number of low-income countries. Each country assessment is developed around a set of assumptions about GDP growth, government expenditure and revenues, administrative costs, basic health costs (e.g. medical staff wages), child benefit/income support levels, etc.
Incremental vs. Total costs	**Total.**	**Total**.

Study	Greenhill *et al.* (2015)	ILO (2008)
Expenditure types	Social protection includes both cash transfers and social insurance.	Expenditures modeled cover (i) universal basic old-age and disability pensions, (ii) basic child benefits, (iii) universal access to essential health care and (iv) social assistance/100 day employment scheme.
Consideration of climate change mitigation and adaptation	Recognized but not quantified.	No
Consideration of economy-wide effects	Absorption constraints.	Social protection and health care costs (such as medical staff wages) are projected as a function of GDP per capita growth.
Geographical resolution and scope	**Country level** (89 LICs and MICs).	**Country level** (7 African countries and 5 Asian countries – including both LICs and LMICs).
Period covered	2011 - 2030	2010 - 2030
Relationship to other studies and observations on methodology	The methodology is outlined in Manuel and Hoy (2015).	Modeling methodology based on ILO (2005) and Mizunoya *et al*. (2006).
Base year	2013	n/a
Annual investment needs in billions $ (start year)	n/a	n/a
Annual investment needs in billions $ (end year)	n/a	n/a
Period average in billions $ per year (years)	Total costs of the "Basic Social Compact" in LICs: **$148 (2011 – 2030)**. Breakdown: $42 for basic social protection + $32 for education + $74 for health. Total costs of the "Basic Social Compact" in LMICs: **$478 (2011 – 2030).** Breakdown: $40 for basic social protection + $169 for education + $269 for health.	The cost of the overall social protection package ranges between 3% and 10% of GDP depending on the country considered.
Comments on results	The study also provides estimates for MICs as a whole.	Access to health care and child benefits account for the majority of costs in all countries.
Adjustments made	Investments needs for health and education are covered in the corresponding SDG investment areas. For the reasons discussed in text, this preliminary SDG needs assessment does not report investment needs for social protection.	Investments needs for health and education are covered in the corresponding SDG investment areas. For the reasons discussed in text, this preliminary SDG needs assessment does not report investment needs for social protection.
Robustness of estimates	The poverty-gap approach to estimating investment needs does not take adequate account of (i) other SDG investments that reduce expenditure needs for the extreme poor, and (ii) opportunities for economic growth to lift the incomes of the extreme poor. Social protection is a central component of the SDGs, so more detailed assessments are needed to quantify the corresponding investment needs.	The ILO methodology focuses on very broad expenditure categories without defining the underlying interventions. Investment needs for several social protection areas are approximated as average shares of GDP. As a result it is impossible to identify overlaps and remaining gaps with regards to other SDG investments considered in this paper.

Source: Author's analysis, based on Greenhill *et al* (2015), Manuel and Hoy (2015) and ILO (2008).

Additional investment needs for climate change mitigation and adaptation

The predicted increase in extreme weather events due to climate change will have a significant impact on livelihoods. This will disproportionately affect the poor, notably due to their reliance on climate-sensitive sectors such as small-scale agriculture, animal husbandry, and artisanal fishing. Moreover, many developing countries are located in the tropics, where the effects of climate change will be felt most strongly (Mendelsohn *et al*. 2006), while the poor within them tend to live in locations that are more exposed to and less resilient to storms, droughts and other natural hazards (Béné *et al.* 2014, Kuriakose *et al*. 2012). In order to prevent increased vulnerability from climate change, social protection programs may need to be expanded by focusing on sustaining livelihoods and reinforcing adaptive capacity (Kuriakose *et al*. 2012).

Kemeny (2010) estimated the cost of scaling-up social protection as part of the World Bank (2010) Economics of Adaptation to Climate Change report. Based on evaluations of four active social protection programs (in Ethiopia, India, Malawi and Bangladesh), the author conclude that climate change will have very uneven effects on the cost of social depending on the local policy context and social protection program considered. Kemeny (2010) also points out that the difficulty of predicting extreme weather events and how their impact will be distributed among the population, particularly on long time scales, makes additional investment needs for climate change adaptation in this area highly uncertain.

Given the difficulties of integrating available estimates of investment needs for social protection with other SDG needs assessments, discussed below, investment needs for social protection are not adjusted for climate change adaptation. This gap needs to be filled through more detailed country-level analyses.

Synergies with investment needs in other sectors

Available needs assessments for social protection floors overlap directly with other SDG investment areas considered in this paper. ILO (2008) and Greenhill *et al.* (2015) both include the cost of running health and education systems under social protection floors. These investment needs are covered under the corresponding SDG investment areas in this paper and should therefore be excluded from further consideration in this SDG investment area.

The evidence reviewed by ILO (2008, 2014), Development Initiatives (2015), and Greenhill *et al.* (2015) in support of targeted social transfer payments is compelling and supports the inclusion of targeted social protection payments as part of an SDG needs assessment. However, available needs assessments methodologies for social protection payments that are based on broad-based income transfers to the extreme poor raise three sets of conceptual and methodological issues.

First, other SDG investments described in this paper (e.g. health, education, support for smallholder farmers, basic infrastructure, and humanitarian work) will partly replace direct expenditures by the extreme poor. Overlaps with needs assessments for food security and sustainable agriculture (FAO *et al.* 2015, covered in section 4.4) will be particularly significant, since the latter already includes “Transfers

to cover the Poverty Gap" (PGT) to raise incomes in rural areas and end hunger in the short term. Available data makes it impossible to quantify the extent of overlaps, but they are likely to be very substantial.

Available global needs assessments for social protection reviewed in Table 4 and the above-cited example of the Ethiopian social protection program underscore the fungibility of SGD investment across program types. Each country needs to decide whether and how to use public budgets for infrastructure works and other programs to promote social protection programs. Similarly, some education funding may be used to finance conditional cash transfers that improve health or education outcomes without passing through the national health or education budgets. In other words, countries may reassign parts of the investment needs assigned to infrastructure, health, education, and other SDG investment areas to social protection programs without significantly affecting overall SDG investment needs. The high-level SDG needs assessment conducted in this paper seeks to ensure that all SDG investment needs are included. The programming of such funds may differ significantly from one country to the next.

Second, the SDG investments outlined in this paper will significantly accelerate economic growth[11] with a strong poverty focus owing to the universal coverage requirement for social services and access to basic infrastructure. Over time per capita incomes at the bottom of the income distribution will rise sharply under a sustainable development pathway. This in turn will obviate the need for across-the-board social transfer payment schemes that target all households below the extreme poverty line. Some residual social transfer payments may be needed towards the end of the SDG period to lift every household above the extreme poverty line, but the magnitude of these payments is uncertain and will be much lower than the figures reported by Greenhill *et al.* (2015) as well as FAO *et al.* (2015) for rural areas. Countries may of course decide to pursue social transfer payments out of their own volition and finance them through their own resources, but it is difficult to see how they should be a necessary part of achieving the SDGs that require international public co-financing when domestic resources are insufficient.

Finally, cash transfers can play a significant role in humanitarian work and responses to disasters, covered in section 4.11. This overlap would need to be considered as part of an integrated analysis of SDG investment needs.

A strong case exists for including targeted social transfer payments to specific groups as part of the SDG investment areas. However, the SDGs do not call for minimum income levels to be guaranteed by governments over the short term, so different needs assessment methodologies are needed to fill this important gap in our understanding of how to achieve the SDGs.

[11] See Mongardini and Samake (2009) for a detailed assessment of the impact of MDG investments on economic growth. Note that the SDG investments described in this paper cover a broader set of interventions and should therefore accelerate economic growth further.

Adjustments made for this paper

In the absence of a clear approach for adjusting available needs assessments for social protection, the Greenhill *et al.* (2015), Development Initiatives (2015), and ILO (2008) estimates are not included in the summary tables 14 and 15, in which question marks remain. This should not be wrongly interpreted as suggesting that social transfer payments pay no role in achieving the SDGs. The opposite is the case, but better numbers are needed.

Opportunities for public and private financing

Social transfers do not generate a financial return and therefore cannot be financed through commercial private financing.

Robustness of available assessments and avenues for further research

As described above, available estimates for social transfer payment schemes overlap too much with other SDG investment needs and do not adequately take into account the effect of economic growth on household incomes to warrant inclusion in the SDG investment needs alongside other SDG investments outlined in this paper. However, this does not diminish the importance of targeted social transfer payments to meet the needs of specific groups.

Future research should therefore focus on filling this important gap by proposing methodologies for assessing investments needs for narrowly targeted social transfer payments. Given the country-specificity of such investment needs it appears most promising to pursue such studies at the national level.

Second, country-level, economy-wide models are required to assess the impact of SDG investment on economic growth and national poverty rates. These will help determine residual investment needs for social protection to meet the full set of SDGs.

A third line of future inquiry may focus on the substitutability of social transfer payments and direct investments in social services, support to smallholder farmers, and infrastructure. Countries may differ in their preferences for direct public investments in public services and infrastructure or providing cash payments to individuals. Once more, robust answers to these questions will require country-level estimates, and it may be difficult to transfer lessons from one country to another.

4.4. Food security and sustainable agriculture

The SDGs emphasize the need to ensure food security and improved nutrition, as well as guarantee incomes for small-scale farmers through sustainable agricultural practices. Some necessary investments are investments in eliminating hunger, including responses to emergencies; improving nutrition; meeting the special needs of smallholder farmers or artisanal fishermen; maintaining and restoring

productive soils; rural infrastructure; increasing the productivity and sustainability of commercial agriculture; reducing greenhouse gas emissions from agriculture; and increasing the resilience of agriculture to climate change (see for example Dobermann *et al.* 2013). Another important spending priority is research and development (R&D) for agriculture and food security, which has been leveling off globally since the 1980s and has even declined in sub-Saharan Africa since the 1990s (Schmidhuber and Bruinsma 2011).

Available needs assessments studies and results

The most recent assessment of investment needs for food security and agriculture was conducted by the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD) and the World Food Program (WFP) (FAO *et al*. 2015). With food expenses accounting for 50 to 70% of spending by people living under the $1.25-a-day poverty line, action to eradicate hunger is closely related to ending extreme poverty, so the report's approach is to estimate the investments needed to lift all extreme poor to at least the $1.25 line. Two types of investments to achieve this are costed: (i) a social protection measure called "Transfer to cover the Poverty Gap" (PGT) that serves to raise incomes and end hunger in the short-term, and (ii) pro-poor investments that contribute to raising people out of poverty in the medium to long term, gradually replacing the PGT. The former essentially represents the income transfers needed to raise everyone's per capita income to at least $1.25 per day. The latter are calculated using aggregate ICORs that are then assigned to investment areas based on the current composition of agricultural investments. Both these methodologies have major limitations, as reviewed in section 2.2, and do not provide a strong basis for SDG needs assessments.

In addition, three other major studies are reviewed (Table 5). Schmidhuber *et al.* (2009) estimate investments needed to increase agricultural productivity, while Schmidhuber and Bruinsma (2011) estimate investment needs for ensuring food security and achieving "zero hunger." FAO *et al.* (2015) build on and update these two studies. Rosegrant *et al.* (2015) estimate investment needs for food security with a particular focus on minimizing food loss and waste.

For the SDG needs assessment the paper uses the results reported in the most recent and most comprehensive assessment (FAO *et al.* 2015), which broadly includes the investments assessed by Rosegrant *et al.*'s (2015). As described below, the methodologies used in the paper have major limitations, so the results need to be treated with caution, but no other comprehensive estimates are available at this stage. The FAO *et al.* numbers include global spending on R&D to which the CGIAR plans to contribute 10 percent, which would require raising the annual CGIAR budget from $1 billion today to some $1.6 billion by 2025 (CGIAR 2011).

Owing to the broad scope and methodological choices made in this study, significant adjustments are made to the results included in the summary tables 14 and 15. These adjustments are detailed below.

Table 5. Needs assessment studies for agriculture and food security

Study	Schmidhuber & Bruinsma (2011)	Schmidhuber *et al.* (2009)	Rosegrant *et al.* (2015)	FAO *et al.* (2015)
Coverage and development outcomes	Reaching "zero hunger," defined as less than 3% of population as undernourished.	Producing the total amounts of crops and livestock products projected in FAO's long-term outlook to 2030 and 2050.	Reductions in post-harvest losses (including production, processing, distribution and retailing stages).	Reaching "zero hunger," defined as less than 5% of the population as undernourished and ending extreme poverty.
Relationship to SDGs	Addresses SDG2: achieving zero hunger (2.1), through increases in productivity and income (2.3), by investing in sustainable agricultural systems (2.4), and rural infrastructure and technology development (2.a).	Addresses target 2.3 of SDG2: increasing output and productivity (to almost double) with investment in maintaining and augmenting capital stock (partly addresses 2.a).	Reducing food waste is a component of achieving zero hunger (2.1). Also includes investments in rural infrastructure and technology development (2.a).	Addresses SDG1: eradicating extreme poverty (1.1) and implementing social protection systems (1.3); and SDG2: achieving zero hunger (2.1) through increases in productivity and income (2.3) by investing in sustainable agricultural systems (2.4), the preservation of genetic resource diversity (2.5), and rural infrastructure and technology development (2.a).
Key gaps	Addressing micro-nutritional needs; maintaining genetic diversity of seeds; climate-resilient agriculture; elimination of agricultural export subsidies; investment needs for commercial agriculture.	Addressing nutritional needs; agricultural research; rural infrastructure; safety nets; maintaining genetic diversity of seeds; climate-resilient agriculture; eliminating agricultural export subsidies.	Addressing nutritional needs; safety nets; maintaining genetic diversity of seeds; climate-resilient agriculture; elimination of agricultural export subsidies.	Addressing micro-nutritional needs; climate-resilient agriculture; elimination of agricultural export subsidies; investment needs for commercial agriculture.
Methodology	**Incremental Capital-Output Ratio (ICOR) estimate** (Estimates the investments needed to raise the average dietary energy supply (DES) by 2025 to ensure chronic undernourishment at less than 3% of the population. As DES is a function of the incremental income generated by investments, the study used ICORs (set by country income: ICOR=3 if country GDP per capita < $2000, ICOR=4 if country GDP per capita < $4000, and ICOR=5 if country GDP per capita > $4000) to express the overall share of investments in GDP, and estimates of the share of agricultural GDP (AGDP) in total GDP, to then evaluate the	**Incremental Capital-Output Ratio (ICOR) estimate** (Long-term projections of 40 agricultural production activities (to reflect changes in technologies used), each of which is linked to a number of current inputs and capital stock services. The evolution in value of capital stock is modeled for 26 capital items based on specific unit costs and item lifetimes to account for replacements. Both the unit costs and the capital items lifetime were computed with regional averages).	**Econometric modeling**: grouped logistic regression used to identify key variables and map the relationship between infrastructure development and losses, from which investment needs estimates were derived. Five scenarios considered (a baseline scenario and four others differentiated by the targets assumed and geographic scope covered). Cost-benefit analysis conducted using the IFPRI IMPACT 3 model (a partial equilibrium model).	Two mechanisms are costed: first "Transfer to cover the Poverty Gap" (PGT) and then pro-poor investments to gradually replace the PGT. 1. The PGT is estimated as the average increase in income required to lift each person living under $1.25/day PPP to the poverty line. A 20% markup is added for administrative and leakage costs. 2. Pro-poor investments are measured with reference to an Incremental Capital-Output Ratio (ICOR) estimate. It is assumed that 5% of the population

Study	Schmidhuber & Bruinsma (2011)	Schmidhuber *et al.* (2009)	Rosegrant *et al.* (2015)	FAO *et al.* (2015)
	investments in agriculture needed to achieve the 3% target).			will continue to require PGT to sustain themselves.
Incremental vs. Total costs	**Incremental** (to a baseline scenario where 9.1% of developing country populations (approx. 591 million people) would be chronically undernourished in 2025).	**Incremental** (to the value of inputs and capital stock services, calculated year-on-year; i.e. the gross investment in any year is the net increase in the value of capital stock + stock replacement cost in the same year).	**Incremental** (to a baseline scenario using standard IFPRI IMPACT 3 model yield projections).	**Incremental** (to a business as usual scenario where 635 million people are still undernourished by 2030)
Expenditure types	**Capex + Opex** (Investments designed to create new income opportunities for the rural poor and direct assistance for rural and urban poor unable to purchase food with their own assets, including rural infrastructure and market access; natural resource development; rural institutions; research, development and extension; expenditure for safety nets).	**Capex** (26 capital items: 14 related to primary agriculture, e.g. irrigation, development of grazing land, or mechanization + 12 to the agricultural downstream sector, e.g. dry storage, investments in milk production/processing, milling of cereals).	**Capex + Opex** (Infrastructure development and maintenance - for electricity, paved roads, rail capacity and road capacity; technologies for best practice in post-harvest management; and agricultural R&D).	**Capex + Opex** (Investments designed to create new income opportunities for the rural poor and direct assistance for rural and urban poor unable to purchase food with their own assets, including rural infrastructure and market access; natural resource development; rural institutions; research, development and extension. Expenditure for social protection programs plays a major role).
Consideration of climate change mitigation and adaptation	No	No	No - constant 2005 climate assumed	No
Consideration of economy-wide effects	Investment needs considered on an economy-wide basis, using ICORs and AGDP/GDP shares to express influence of agricultural investments on income per capita.	Investment needs considered on an economy-wide basis, using ICORs and AGDP/GDP shares to express influence of agricultural investments on income per capita.	GDP growth and population projections are the IPCC medium projection on socioeconomics (SSP2) to 2050.	Pro-poor investment needs in agriculture considered on an economy-wide basis, using ICORs and AGDP/GDP shares to express influence of agricultural investments on income per capita.
Geographical resolution and scope	**Country level** (93 countries in SSA, LAC, MENA, S. Asia and E. Asia. Covers LICs and LMICs, and some MICs and HICs, notably Brazil, Costa Rica, Colombia, Cuba, Dominican Rep, Chile).	**Country level** (93 countries in SSA, LAC, MENA, S. Asia and E. Asia. Covers LICs and LMICs, and some MICs and HICs, notably Brazil, Costa Rica, Colombia, Cuba, Dominican Rep, Chile).	**Regional level** (Africa, Asia, MENA, LAC, Developed Countries, and Others). Scope varied according to scenario (either "Global" or "Developing Countries").	**Country level** (Global scope: all countries including 97 "developing countries" covering 31 LICs, 30 LMICs, 29 UMICs and 6 HICs + Taiwan).
Period covered	2005 - 2025	2005/07 - 2050	2014-2029	2016-2030
Relationship to other studies and observations on methodology	Builds on the FAO Anti-Hunger Program (FAO 2003). Also fills key gaps identified in Schmidhuber *et al.* (2009).	n/a	n/a	Builds on and complements the methodology of Schmidhuber and Bruinsma (2011).
Base year	2009	2009	Unspecified	2013

Study	Schmidhuber & Bruinsma (2011)	Schmidhuber *et al.* (2009)	Rosegrant *et al.* (2015)	FAO *et al*. (2015)
Annual investment needs in billions $ (start year)	n/a	n/a	n/a	n/a
Annual investment needs in billions $ (end year)	n/a	n/a	n/a	n/a
Period average in billions $ per year (years)	**$50.2 (2005-2025)**	**$210 (2006-2050)**	**$7-32 (2014-2029)** + $0.7 (2014) - $8 (2025-2050) for agricultural R&D	**$245 (2016-2030)** Breakdown: $100 for PGT + $145 for pro-poor investments in agriculture
Comments on results	The study provides a breakdown by region (SSA: $13; MENA: $2; LAC: $7; South Asia: $18; East Asia: $10) and by investment area (infrastructure: $19; Natural resource development: $9; Institutions: $6; R&D: $6; Safety nets: $10). Results include some $2.2 billion in R&D expenditure (compared with some $1 billion spent today).	The replacement of depreciated capital stocks accounts for 62% of costs.	The range of investment needs indicated excludes scenarios with a global scope, keeping only estimates for developing countries. The large range in investment needs estimates is due to the study's scenario approach. The lower end of the range is due to cost allocation scenarios where only 25 or 50% of investment needs are directly attributed to post-harvest loss reduction measures, rather than the development of infrastructure and technology for other purposes.	The numbers cited in this table are for LICs and LMICs only and are therefore lower than the study's headline number of $267, which includes UMICs and HICs. The study also reports separate estimates for rural areas only.
Adjustments made	Results have not been retained for this paper.	Results have not been retained for this paper.	Results have not been retained for this paper.	Investments in the PGT ($100 billion) and for rural electrification and roads ($20 billion) are removed. The total is disaggregated by income group based on country-level data provided in the study, for total "development" needs of $125 billion per year (LICs: $61, LMICS: $64). A 2% mark-up is applied for incremental climate change adaptation needs (UNFCCC 2007), and $35 billion for mitigation ($15 for CO_2 removal by sinks + $20 for reducing non-CO2 emissions from agriculture by 10%) added, yielding a total of **$148 billion per year (LICs: $67, LMICs: $80)**
Robustness of estimates	Methodology not suitable for detailed SDG needs assessments.	Methodology not suitable for detailed SDG needs assessments.	Methodology not suitable for detailed SDG needs assessments.	Methodology not suitable for detailed SDG needs assessments.

Source: Author's analysis, based on Schmidhuber and Bruinsma (2011), Schmidhuber *et al*. (2009), Rosegrant *et al.* (2015), FAO *et al*. (2015) and UNFCCC (2007).

Additional investment needs for climate change mitigation and adaptation

Climate change will have a significant impact on the investment needs for food security and sustainable agriculture by influencing where crops can be grown and livestock reared. Depending on the local context, yields may be affected both negatively (from increased weather variability and extremes, reductions in rainfall, the appearance of pests) and positively (through lengthened growing seasons and CO_2 fertilization), but overall, the IPCC predicts that agriculture will be negatively affected in most regions in the longer term (IPCC 2014). It appears that developing countries in lower latitudes (i.e. closer to the equator) will suffer earlier and greater damage to agriculture (Mendelsohn *et al.* 2006). As a result, the development of irrigation and access to new drought-resistant or flood-tolerant crops will become essential to maintain agricultural productivity in many parts of the world (World Bank 2010).

Two major studies of investment needs for adaptation to climate change in agriculture are available: the EACC synthesis report (World Bank 2010) and UNFCCC (2007). The EACC report estimates investment needs for adaptation in the agricultural sector between $\$_{2005}$2.5 – 3 billion. These numbers correct estimates of $\$_{2000}$7.1 - 7.3 billion by Nelson *et al.* (2010). The latter study considers the difference in investments under the scenario with climate change and adaptation, compared to the scenario with climate change but no adaptation. This methodology differs from the one employed by the EACC report, which compares investment needs between a scenario with no climate change with a scenario with climate change and full adaptation.

The World Bank (2010) excludes a number of adaptation needs and assumes, somewhat unrealistically, that losses in agricultural productivity due to climate change can overwhelmingly be covered through increased imports. This paper instead follows Fankhauser and Schmidt-Traub (2011) in using the UNFCCC (2007) approach of adding a 2 percent mark-up to annual investment needs, which the authors recognize is optimistically low, since it is limited to additional investments in expanded irrigation, the relocation of industries such as pulp and paper manufacturing facilities, and the development of larger agricultural areas to cope with falling crop yields. Applying it to estimates for low- and lower-middle-income countries only results in incremental investment needs for climate change adaptation of $\$_{2013}$2.5 billion per year. As underscored below, these estimates should be considered preliminary and are in urgent need of refinement. It should also be noted that the climate scenario underlying the UNFCCC (2007) figures do not correspond to a 2°C pathway. It assumes a trajectory where emissions fall back to 2004 levels by 2030, which is highly likely to lead to warming in excess of 2°C.

Just like the ICOR-based needs assessments for food security and agricultural productivity, the state of the art in estimating incremental investment needs for adaptation measures remains unsatisfactory and incomplete. Moreover, agriculture is particularly dependent on the level of projected average temperature increases (IPCC 2014), so countries should consider investment needs under a range of assumptions for global warming. Given the vital importance of agriculture to food security, poverty reduction, and economic development – particularly in developing counties – these questions should be addressed urgently.

Agriculture accounts for 10 to 12 percent of global greenhouse gas emissions (IPCC 2014), notably through methane emissions from livestock and rice paddies, as well as nitrous oxide from the use of fertilizer. Changes in consumption patterns will have to play a significant role for mitigation in agriculture, but interventions are also possible at the production stage. These include new low-emitting production systems, particularly through avoided deforestation and improved livestock, paddy rice and nitrogen fertilizer management. UNFCCC (2007) estimates that global additional financing and investment needs will need to rise by $35 billion by 2030 per year, of which $15 billion would be directed to CO_2 removal by sinks, such as agroforestry, and the remaining $20 billion to reducing non-CO_2 emissions from agriculture by 10 percent. While the investment needs for agroforestry are not disaggregated by country-category, the study estimates that approximately 65 percent of the annual financial flows for non-CO_2 emission reductions, or $13 billion, would be needed in developing countries.

Synergies with investment needs in other sectors

Agriculture, nutrition, and food security are among the investment areas that exhibit the strongest synergies with other investment areas, as food production and consumption affects water and land resources, biodiversity, health, and climate (Dobermann *et al.* 2013, Foley *et al.* 2011). As discussed above, agriculture and agriculture-related land-use change are one of the biggest contributors to greenhouse gas emissions. At the same time agriculture is very vulnerable to climate change, so major investments will be required to make food systems climate-resilient (FAO 2012).

Investments in improved education and health can have a significant impact on nutrition outcomes, including through healthier diets; but their impact on investment needs for the interventions considered under food security will likely be minor, and have therefore not been considered in this paper.

Investment needs in agriculture will, however, change significantly if agricultural production systems shift towards healthier diets that rely less on meat and more on nuts, fruits, vegetables, which would also have substantial climate and land-use benefits (Wirsenius *et al.* 2010). Lower meat consumption will reduce the need for grain production and corresponding agricultural investments. At the same time, a shift towards higher-value crops will require more agricultural investment. It is unclear whether the net effect of such changes will require more or less investment in agriculture.

Adjustments made for this paper

Several substantive adjustments are made to the results obtained by FAO *et al.* (2015) to avoid double-counting with other investment areas. As reviewed in section 2.2, stand-alone estimates of income transfers needed to end extreme poverty overlap significantly with investment needs in other SDG investment areas. For example, a substantial share of poor households expenditure needs are accounted for by health, education, water, and energy supply. These investment needs are projected to be covered through public expenditure (at least for the extreme poor). For this reason the social protection estimate is excluded from the investment needs reported in tables 14 and 15, leaving some $145 billion in annual pro-poor investments. Complementary direct and indirect income transfers, including for emergency and other humanitarian situation, should be addressed in sections 4.3 (social protection) and 4.11 (emergency response and humanitarian work).

The remaining investments in increasing rural incomes include a number of items that are also covered elsewhere. The estimated $\$_{2013}$7 billion needed for rural electrification is removed, and another $13 billion is included for rural roads in low- and lower-middle-income countries, as these are covered under sections 4.5 (access to modern energy) and 4.7 (transport infrastructure).[12] The overall funding needs for food security and agriculture are therefore reduced by another $20 billion, down to $125 billion.[13] This estimate is presented for LICs and LMICs by aggregating country-level costs provided in the FAO *et al.* report (2015, Appendix 4).

Table 14 therefore reports total annual investment needs for food security and agriculture of $125 billion every year from 2015 to 2030, of which $61 and $64 billion are needed in LICs and LMICs, respectively. The inclusion of incremental investment needs for climate change adaptation and mitigation raises the total to $148 billion ($67 billion in LICs and $80 billion in LMICs) per year. As described above and in section 2.2, the methodologies underpinning these estimates are ill-suited for SDG needs assessments. For this reason the results should be considered preliminary and are placed in square brackets.

Opportunities for public and private financing

FAO *et al*. (2015) estimate that 60 percent of investments in rural productivity need to be publicly financed. In comparison, UNCTAD (2014) projects that 75 percent of agricultural investments can be privately financed. This much higher estimate of private investment share results from the fact that the bulk of UNCTAD's investment needs cover investments to increase the productivity of commercial agriculture, which should indeed be overwhelmingly privately financed. Since investment needs identified in this section focus primarily on the needs of the extreme poor, the FAO *et al*. estimates of

[12] FAO *et al.* (2015) estimate investment needs for rural electrification and roads in low- and middle-income countries that amount to some $11.3 and $22.7 billion respectively ($34 in total). These are scaled down to low- and lower-middle-income countries on a per capita basis. This yields investment needs of $5 billion for LICs and $15 billion for LMICs (representing 15 and 43 percent of total developing country population covered in the study respectively).

[13] These estimates do not take into account incremental needs for climate adaptation and mitigation.

the public investment share are retained. If investments in rural infrastructure (roads and electrification) are removed from the analysis, the public share of investments falls to just under half, at about 49 percent. Applying this share to the $_{2013}$125 billion incremental financing needs for additional pro-poor investments yields private financing needs of some $64 billion.

Robustness of available assessments and avenues for further research

As described, the needs assessments retained for the summary table use methodologies based on ICORs, which are unsatisfactory for the reasons outlined above and in section 2.2. Moreover, available studies do not adequately cover interventions to improve nutrition and reduce agriculture's environmental impact. Climate change mitigation and adaptation are also not adequately integrated into the assessments. Overall, these gaps show that needs assessments for agriculture and food security are not underpinned by a robust production function for the achievement of the corresponding SDG. These gaps must be closed if the sector is to attract the large increase in resources that it requires according to the preliminary needs assessments available.

In view of the gaps, the limited robustness of ICOR-based assessments, and the difficulty of translating the results into operational investment frameworks, the investment needs for sustainable agriculture and food security should be considered preliminary. They likely underestimate investment needs, including for emergency food assistance. For all these reasons the results are placed in square brackets in tables 14 and 15.

A key priority for future research is therefore to develop more disaggregated needs assessment methodologies for agriculture that are interventions-based or draw on integrated assessment tools. In view of the tremendous heterogeneity of agriculture investment needs across and within countries, it may be necessary to focus future research on detailed country-level assessments. Such revised assessments must endeavor to cover the full range of investments required to achieve SDG 2, including improving nutrition, developing climate-resilient agricultural practices, maintaining the genetic diversity of seeds, and eliminating agricultural export subsidies. They should also promote integrated assessment of investment needs in agriculture that include climate change mitigation and adaptation. Moreover, Rosegrant *et al.* (2015) highlight the contribution that curtailing food loss and waste can make towards improving nutrition outcomes and ensuring food security. These drivers require more careful consideration in future studies.

A major knowledge gap concerns the net impact of shifts towards healthier diets and more environmentally sustainable production techniques on investment needs in agriculture and food security. The relationships underlying these investments are multiple and complex. Understanding them better likely requires broad integrated assessment models. Finally, more work is needed to understand the share of investments in food security and sustainable agriculture that can be privately financed. Careful analyses will need to distinguish between financing strategies for commercial agriculture, and interventions targeting rural infrastructure as well as smallholder farmers.

4.5. Energy access and low-carbon energy infrastructure

By including a goal on sustainable energy and energy access, the SDGs are filling a major gap in the MDGs, which omitted any references to energy. Investment needs in energy are vast. They include universal access to electricity and modern cooking solutions, increased power generation and transmission for industrial and other needs, and decarbonizing the energy system to keep the increase in global temperatures to less than 2°C above pre-industrial levels. By decarbonizing the energy system, countries will also lower air pollution, a key public health concern across the world. This section reports investment needs estimates for both (i) access to modern energy and (ii) large-scale energy infrastructure and decarbonization, but presents them separately as the two investment categories require different financing instruments and investment strategies. Separating the reporting will also help ensure that the much smaller investment needs in energy access are not overshadowed by investment needs in large-scale infrastructure.

Available needs assessments studies and results

There are several needs assessments for meeting the Sustainable Energy for All (SE4All) targets of ensuring universal access to electricity and to clean cooking facilities, including Bazilian *et al.* (2010), International Energy Agency (IEA 2011), Global Energy Assessment (GEA 2012), Pachauri *et al.* 2013, and Galiana and Sopinka (2015). The latter study is based essentially on Bazilian *et al.* (2010) and does not take into account later estimates. For this reason the focus is on the first four studies (Table 6). Annex 3. Overview of infrastructure needs assessments provides a more detailed overview of needs assessments for the infrastructure sector as a whole.

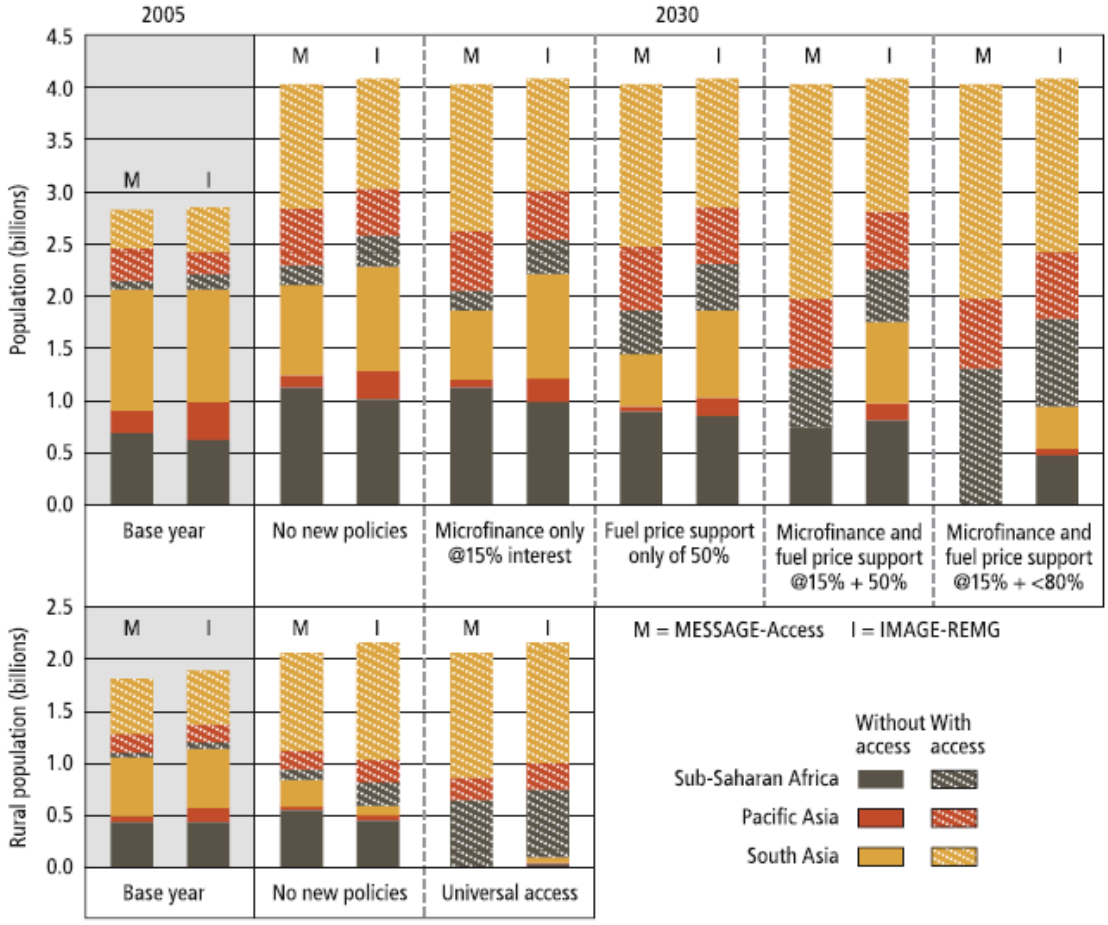
Differences in methodologies and assumptions lead to wide variations in needs assessments for achieving universal access to modern energy and clean cooking fuels. This makes the selection of a single estimate difficult. This paper relies on the results of Pachauri *et al.* (2013), who update GEA (2012) using a similar methodology and, unlike the IEA estimates, take both capital and operating expenditures into account. The latter are particularly important for access to clean cooking fuels since ongoing subsidies of cooking fuels far outweigh the cost of improved stoves. Pachauri *et al.*'s (2013) projected investment needs are driven essentially by microfinance and subsidies for improved cooking fuels (Table 6). The authors conclude that only the higher end of subsidies for cooking fuels is sufficient to achieve the goal of universal access to improved cooking fuels (Figure 1).

Owing to a lack of experience with well-targeted and large-scale microfinance and subsidy schemes for access to improved cooking fuels, these numbers are uncertain and likely subject to a substantial margin of error. However, the projected subsidies for cooking fuels, which include fossil fuels, pale in comparison to the IMF estimates of $333 billion in global direct ("pre-tax") subsidies to fossil fuels in the year 2015 alone (representing some 0.4 percent of global GNI). Post-tax subsidies that include environmental, health, and other externalities are estimated at $5.3 trillion, or 6.5 percent of world GDP in 2015 (Coady *et al.* 2015).

Unlike the IEA figures, GEA (2012) and Pachauri *et al.* (2013) do not cover investment needs for urban electrification, assuming that such investments will be made under a baseline scenario without any additional policy efforts. Moreover, Pachauri *et al.* (2013) assume a lower per capita electricity consumption, which in combination with the exclusive focus on rural electrification explains the lower investment needs for electrification. The IEA is updating its needs assessment; new results are scheduled for publication in late 2015 and may fill some of the gaps identified in this section.

For large-scale infrastructure investment needs, the paper draws on estimates by the World Bank (2013b), which are computed based on projections of electricity consumption needs and an average unit cost per kW of generation capacity. The estimates include investment needs for generation, transmission, and distribution of electricity. However, the underlying assumptions are uniform across countries. The results should therefore be considered preliminary and in need of further refinement.

Figure 1. Impact of policies and price support on access to modern energy services and rural electrification under different policy scenarios



Source: Pachauri *et al.* (2013)

Table 6. Needs assessment studies for energy access and infrastructure

Study	Bazilian *et al.* (2010)	IEA (2011)	GEA (2012)	Pachauri *et al.* (2013)	World Bank 2013b
Coverage and development outcomes	Universal access to modern energy in urban and rural areas; universal access to clean cooking.	Universal access to modern energy in urban and rural areas; universal access to clean cooking.	Universal access to modern energy in rural areas; universal access to clean cooking.	Universal access to modern energy in rural areas; universal access to clean cooking.	Infrastructure needs for power generation, transmission and distribution.
Relationship to SDGs	Addresses SDG7 - universal access to modern energy (electricity and clean cooking fuel) (7.1).	Addresses SDG7 - universal access to modern energy (electricity and clean cooking fuel) (7.1).	Addresses SDG7 - universal access to modern energy (electricity and clean cooking fuel) (7.1).	Addresses SDG7 - universal access to modern energy (electricity and clean cooking fuel) (7.1).	Addresses SDG7 - universal access to modern energy (electricity and clean cooking fuel) (7.1).
Key gaps	Increase in renewable energy; energy efficiency measures; energy R&D.	Increase in renewable energy; energy efficiency measures; energy R&D; operating expenditure for clean cooking fuels.	Increase in renewable energy; energy efficiency measures; energy R&D	Increase in renewable energy; energy efficiency measures; energy R&D; urban electrification.	Operation and maintenance expenditure for infrastructure.
Methodology	**Synthesis of literature review with marginal adjustments.** For electricity: calculations of investment needs are made in a static linear model, based on the full levelized cost of electricity. Three scenarios – "low" (to cover basic needs), "medium" (allowing for basic productive uses), and "high" (equivalent to current average residential use in Latin America) – are considered to account for the uncertainty linked with methodological limitations. For cooking: doubled capex in reviewed literature to account for operational costs. Population growth is not taken into account.	**Partial Equilibrium Modeling.** For electricity: access is defined as minimum consumption level of 250kWh in rural areas and 500kWh in urban areas for the first connection, which is then assumed to rise to the regional average over 5 years (800kWh on average). 100% of urban households and 30% of rural ones are assumed to connect to the extended grid; mini-grids reach 45.5% of rural households, and off-grid solutions reach the remaining 24.5% of rural households. For cooking: access is defined as provision of cleaner, more efficient and sustainable cooking stoves: LPG stoves and advanced biomass cook stoves are assumed to be replaced every 5 years (4 times capital expenditures) and the biogas systems every 20 years (1 time capital expenditure).	**Integrated Assessment Modeling.** For electricity: two models are used, and two demand scenarios are considered (low demand of 65kWh/household/year and high demand of 420kWh/household/ year) in each: (a) IMAGE: Electrification is driven by GDP per capita, rural population density and distance from the electricity network at the grid cell level. Investment needs are estimated for grid extension and power plants. Access is defined as connection to the grid, i.e. once electricity reaches a grid cell all households in it are considered connected. (b) MESSAGE-Access: Electrification is driven by income growth and distribution. Access is defined as minimum consumption level of electricity (65-420kWh/household/year depending on scenario). Off-grid and standalone connection options are not considered in either model. For cooking: MESSAGE-Access is used to model biomass demand and	**Integrated Assessment Modeling.** Two models are used. (a) IMAGE-REMG, and (b) MESSAGE-Access. For electricity: (a) in IMAGE: Electrification is driven by GDP per capita, rural population density and urbanization. Investment needs are estimated for grid extension and power plants. Access is defined as connection to the grid, i.e. once electricity reaches a grid cell, all households in it are considered connected. Demand is assumed to be 420kWH/household/year. (b) In MESSAGE: Electrification is driven by income growth and distribution. Investment needs are estimated for grid extension, operation and maintenance, and power plants. (Off-grid and standalone connection options are not considered in either model). For cooking: (a) in IMAGE, the model uses relative differences in perceived costs (price of energy carrier + cost of conversion technology) to determine household fuel choice	**Unit cost estimates.** Forecast of demand and supply for each component, and multiplied by the unitary cost of each. Per capita electricity consumption is projected based on electricity consumption patterns studied by the US EIA, along with estimated per capita income growth, and the elasticity per capita of electricity consumption to per capita income. The required generation capacity is then estimated (assuming an average plant capacity of 70%), and multiplied by an average investment need of $2,258 per kW in generation capacity. This average investment need comprises electricity generation (60%), distribution (30%), and transmission (10%).

Study	Bazilian *et al.* (2010)	IEA (2011)	GEA (2012)	Pachauri *et al.* (2013)	World Bank 2013b
			consumption estimates - based on bottom-up assessments from national household survey data - and the impact of policy packages on access. LPG is used as a proxy for clean cooking fuels. Multiple financing scenarios with different levels of subsidy and microfinance are modeled.	(coal, traditional biomass, kerosene, LPG, natural gas, secondary heat, or electricity). Investment needs are estimated of fuel price support (subsidy), the costs of new LPG stoves, minus the costs of avoided biomass stoves. (b) In MESSAGE, fuel choices and demand are driven by population and income growth and distribution, fuel prices, implicit discount rates and inconvenience costs. Households choose the least-cost energy-equipment combination to satisfy useful demands for cooking within household budget constraints. Investment needs are estimated as the sum of costs of new stoves and of fuel price support (subsidies). Multiple financing scenarios with different levels of subsidy and microfinance are modeled (Figure 1).	
Incremental vs. Total costs	**Total**	**Incremental** (to the IEA's "new policies scenario," based on existing country commitments regarding energy).	**Incremental** (to a "no new policies" baseline scenario).	**Incremental** (to a "no new policies" baseline scenario).	**Incremental** (to current investment levels).
Expenditure types	**Capex + Opex** (for electricity: capital costs, operation and maintenance (O&M) and fuel costs; for clean cooking: capital costs for cookstoves and fuel costs)	**Capex only** (for electricity: extension of the established grid, mini-grid, and off-grid solutions; for clean cooking: initial capital costs of improved biogas systems (greater share in rural areas), liquefied petroleum gas (LPG) stoves (greater share in urban and peri-urban areas) and advanced biomass cook stoves (greater share in rural areas), plus deposit or connection fees but no subsidies).	**Capex + Opex** (for electricity: grid extension, operation and maintenance (O&M), and investment for additional power plants; for clean cooking: new LPG and improved biomass stoves, fuel subsidies and microfinance).	**Capex + Opex** (for electricity: grid extension, operation and maintenance (O&M), and investment for additional power plants; for clean cooking: new LPG and improved biomass stoves, fuel subsidies and microfinance).	**Capex only**
Consideration of climate change mitigation and adaptation	The "medium" and "high" scenarios are consistent with stringent climate mitigation scenarios such as the IEA's "450 scenario." No additional	Estimates are calculated under the IEA's "450 scenario," which sets out an energy pathway that is consistent with a 50% chance of meeting the	Based on a single scenario that conforms to normative goals for the transition to a sustainable energy system. This includes stabilizing	The study models the impact of access policies on greenhouse gas emissions, finding that achieving universal access to rural electricity	No

Study	Bazilian *et al.* (2010)	IEA (2011)	GEA (2012)	Pachauri *et al.* (2013)	World Bank 2013b
	investments in climate change adaptation are considered.	goal of limiting the increase in average global temperature to 2°C. No additional investments in climate change adaptation are considered.	future global mean temperature at 2°C above 1990 levels by 2030. Within the main scenario, several pathways are considered. Here, the GEA-Mix pathway (intermediate demand - diverse energy mix) is used. No additional investments in climate change adaptation are considered.	will increase emissions by 2% to 4% over the baseline scenario by 2030. Avoided emissions from reduced traditional biomass use may counteract this and lower emissions overall. No additional investments in climate change adaptation are considered.	
Consideration of economy-wide effects	Does not consider the increases in energy demand linked to structural changes in developing economies. The focus on households excludes needs for industrialization and transport.	The IEA's World Energy Model includes economy-wide carbon pricing, and models policies for the rapid removal of fossil fuel subsidies.	Both MESSAGE and IMAGE models consider carbon pricing and subsidies' influence on fuel prices. Evolution of demand for energy goods is modeled endogenously and influenced by household income (incl. distribution in MESSAGE-Access), fuel preferences and electrification.	Both MESSAGE and IMAGE models consider carbon pricing and subsidies' influence on fuel prices. Evolution of demand for energy goods is modeled endogenously and influenced by household income (incl. distribution in MESSAGE-Access), fuel preferences and electrification.	None
Geographical resolution and scope	Reviews literature on costs at **global, regional, national levels**.	**Regional level** (then extrapolated to global level).	**Regional level**: South and Pacific Asia and sub-Saharan Africa modeled (then extrapolated to global level).	**Regional level:** South and Pacific Asia and SSA modeled (then extrapolated to global level).	**Country-level** (LICs, LMICs and UMICs).
Period covered	2010-2030	2010-2030	2010-2030	2010-2030	2012-2030
Relationship to other studies and observations on methodology	The authors present "the total annual cost incurred once all people who do not currently have access to energy are connected. Annual investment needs will be lower in the interim as people gain access."	n/a	Three regions modeled represent 85% of the global population without access to electricity and 70% of those without access to modern fuels or stoves.	Builds on the GEA (2012) methodology – details are available in the supplementary information to the study. Three regions modeled (SSA, South Asia and East Asia, representing 85% of the global population without access to electricity and 70% of those without access to modern fuels or stoves) before extrapolating global figures.	Draws on unit cost estimates derived from an analysis of best practice compiled by Fay and Yepes (2003).
Base year	Unspecified	Unspecified	Unspecified	2005	2010
Annual investment needs in billions $ (start year)	n/a	n/a	n/a	n/a	n/a
Annual investment needs in billions $ (end year)	n/a	n/a	n/a	n/a	$243 (2030)

Study	Bazilian *et al.* (2010)	IEA (2011)	GEA (2012)	Pachauri *et al.* (2013)	World Bank 2013b
Period average in billions $ per year (years)	**$14-136 (2010-2030)** Breakdown: $12-134 for universal access to electricity + $1.4-2.2 for universal access to clean cooking.	**$34 (2010-2030)** Breakdown: $30.5 for universal access to electricity + $3.5 for universal access to clean cooking.	**$36-41 (2010-2030)** Breakdown: $18.4-19 for universal access to electricity + $17-22 for universal access to clean cooking.	**$65-86 (2010-2030)** Breakdown: $12.7-18.2 for universal access to electricity + $52.3-67.8 for universal access to clean cooking.	**$228 (2012-2030)**
Comments on results	The authors conclude that $100 billion per year would be the best approximation of the costs.	n/a	n/a	Higher investment needs for universal access to clean cooking compared to GEA (2012) are primarily due to higher subsidy levels and a refined fuel choice methodology.	n/a
Adjustments made	Results have not been retained for this paper.	Results have not been retained for this paper.	Results have not been retained for this paper.	Rebased to $\$_{2013}$ and scaled down on a per capita basis, yielding $54-71 billion per year (LICs: $19-26, LMICS: $34-45). A 20% mark-up on capital expenditure is included for climate change adaptation (Stern 2007). For mitigation, Pachauri *et al.* (2013) project that meeting the goals outlined in the study do not have significant emissions impact. This results in investment needs of $64-85 billion per year (LICs: $19-26, LMICs: $34-45). This is combined with World Bank (2013b) for a final estimate for energy of **$308-333 billion per year (LICs: $84-93, LMICs: $224-240)**	Operational expenditure is estimated based on assumption that O&M represent 34.6% of total power infrastructure costs (Foster and Briceño-Garmedia 2010, table O.3). Investment needs are then rebased to $\$_{2013}$. To avoid overlaps, the estimated $15-21 billion needed for access to rural electrification estimated by Pachauri et al. (2013) are removed. Estimates are then scaled down to LICs and LMICs on a per capita basis, for a total of $189 billion per year (LICs: $47 billion, LMICs: $142 billion). A 20% mark-up on capex is included for climate change adaptation (Stern 2007), yielding a total of $244-248 billion per year (LICs: $61 - 62, LMICs: $183-186).
Robustness of estimates	Methodology suitable and numbers are robust.	Methodology suitable and numbers are robust.	Methodology suitable and numbers are robust.	Methodology suitable and numbers are robust.	Methodology not suitable for detailed SDG needs assessments and numbers are not robust.

Source: Author's analysis, based on Bazilian *et al*. (2010), IEA (2011), GEA (2012), Pachauri *et al*. (2013), World Bank (2013b) and Stern (2007).

Additional investment needs for climate change mitigation and adaptation

We follow the logic of Pachauri *et al.* (2013) and others (e.g. GEA 2012) that investments in providing universal access to electricity and clean cooking fuels should use least-cost technologies even if some – particularly for clean cooking fuels – may include a very modest expansion of the use of fossil fuels to serve the needs of the poor. Pachauri *et al.* (2013) estimate that such a scenario would not lead to any significant increase in greenhouse gas emissions compared with the "no new policies" scenario in spite of the inclusion of some fossil fuel options to close the access gaps. For this reason no incremental investments in climate change mitigation are projected for access to modern energy. Pachauri *et al.* (2013) and other available estimates also do not project any incremental investment needs in providing universal access to electricity and clean cooking fuels to adapt to a changing climate. The reasoning is that climate change does not significantly affect the cost or supply of non-biomass cooking fuels.

The New Climate Economy Commission (NCEC) emphasizes the need for new infrastructure investments to be "climate-smart," estimating that this will require a 5 percent increase in capital expenditure, mainly from additional spending on energy efficiency (buildings, industry transport) and low-carbon technology for power generation. This corresponds to a $\$_{2010}4$ trillion increase in total investment needs over the 2015 – 2030 period from $89 to 93 trillion, or $270 billion per year at the global level. When taking into account operating expenditure, overall investment needs in infrastructure may fall, as an estimated $5 trillion can be saved over the 2015 – 2030 period through reduced fossil fuel consumption (NCEC 2014a, 2014b, Nelson *et al.* 2014). For comparison, the SE4ALL Finance Working Group report estimates that mitigation will require additional investments in renewable energy and energy efficiency of $166 billion and $165 billion per year respectively (SE4ALL 2014).

To estimate investment needs for adaptation this paper uses the Stern (2007) estimate of a 20 percent mark-up on capital investments to make electricity infrastructure climate-resilient, including through higher construction standards and additional back-up systems. It is important to note, however, that the Stern (2007) estimates should be considered tentative and that they are based on climate scenarios in which the 2°C warming target will likely be exceeded. Applying this mark-up to capital expenditures for universal access to electricity yields an incremental investment need of in the range of $\$_{2013}2$ - 3 billion. No such mark-up is applied to operating expenditure, as no evidence was found that these investment needs exhibited substantial variation to climate change.

Synergies with investment needs in other sectors

The positive impacts of clean energy development on outcomes in other sectors have been widely documented (Modi *et al.* 2006). Poor households often spend high proportions of their income on cooking fuels and electricity (e.g. to charge their mobile phones). Having access to affordable fuels frees up income for other basic needs and helps improve food security. Access to modern energy also promotes education, by reducing the pressure on children to participate in the collection of fuel, and allowing them to work after nightfall and in the early morning. Modern energy services also promote

gender equality and health outcomes. The Global Burden of Disease study estimates that between 2.7 and 4.4 million people die from household air pollution from solid fuels globally every year, making it the third leading risk factor for global disease burden (Lim *et al.* 2013). Achieving the goal of universal access to clean cooking fuels would have huge impacts on health outcomes throughout the developing world, particularly in South Asia (Pachauri *et al.* 2013) and among the poorest segments of developing country populations who suffer most from indoor air pollution (Modi *et al.* 2006).

Energy investment needs are affected by investments in other investment areas. As described above, climate change adaptation and mitigation investments can be highly synergistic with energy investments. McCollum *et al.* (2012) further demonstrate the synergies between investments in energy access, air pollution control, and climate change. The authors show that pursuing all three objectives together substantially reduces the investment needs compared with stand-alone approaches. Unfortunately, available evidence is insufficient to adjust energy investment needs to account for synergies that are not related to climate change adaptation or mitigation. This would require integrated assessment modeling across the full spectrum of SDG interventions and should be an important focus for future research.

Adjustments made for this paper

For universal access to modern energy services, results from Pachauri *et al.* (2013) are rebased from $\$_{2005}$ to $\$_{2013}$. For investment needs in large-scale energy infrastructure, estimates from the World Bank (2013) are adjusted to include expenditure for operation and maintenance using data provided by Foster and Briceño-Garmedia (2010, table O.3), who estimate that operational expenditure account for 34.6 percent of total costs in the power sector. Once rebased to $\$_{2013}$, this yields overall estimates of $368 billion. $15 – 21 billion is then subtracted from the overall estimate to avoid double-counting with energy access investments, yielding a final total of $347 – 353 billion globally each year.

In both cases, investment needs are then scaled down to LICs and LMICs on a per capita basis. Each income group's share of the incremental costs is computed based on its percentage share of the combined population of the low- and middle-income countries covered in the study. Table 14 reports incremental investment needs for energy of $257 – 278 billion per year, of which $70 – 77 billion will be needed in LICs and the remaining $187 – 201 billion in LMICs. Adding incremental needs for climate change adaptation and mitigation raises the total to $308 – 333 billion ($84 – 93 billion in LICs and $224 – 240 billion in LMICs).

Opportunities for public and private financing

Historically, private investment in the power sector of developing countries has accounted for some 43 – 47 percent of the total (UNCTAD 2014). The paper applies this to large-scale infrastructure, and further assume that the private sector will cover 90 percent of O&M costs through consumer tariffs. Applying this same share to investment needs for rural electrification suggests that the private sector might

provide some $\$_{2013}$6 – 11 billion in financing for achieving universal access to electricity. Since rural electrification serves relatively poor customers and requires distributed power grids, this private sector share strikes us as the upper limit of what may be feasible over the coming years.

Private financing opportunities for access to clean cooking fuels must be differentiated by financing needs. Improved cookstoves can absorb substantial shares of private investments since many households are able to afford more efficient stoves that reduce daily expenditure on cooking fuels, particularly in urban and peri-urban areas. In rural areas, however, cooking fuels are typically collected and therefore the financial return on improved stoves depends on the opportunity cost of labor. In the absence of better data, the paper projects that up to 85 percent of capital investment needs for cookstoves might be financed by households since improved cookstoves tend to generate a substantial financial return to households, even over a relatively short period of time (Modi *et al.* 2006). This is in line with the upper end of the private investment share in telecommunication in developing countries estimated by UNCTAD (2014). Moreover, it is assumed that up to 80 percent of microfinancing for cookstoves can be privately financed. This estimate is based on a survey of Microfinance Investment Vehicles (MIVs) undertaken by MicroRate (2013). Since publicly financed subsidies represents between 85 and 95 percent of the total investment needs to achieve this goal (Pachauri *et al.* 2013), the potential for private financing is very low, in the range of $\$_{2013}$ 0.5 – 2.7 billion per year.

Robustness of available assessments and avenues for further research

Available estimates for energy investment needs cover a broad range relative to other sectors, particularly health and education. While IEA projects higher incremental investment needs for electrification owing to the inclusion of urban electrification, their estimates for access to clean cooking fuels are an order of magnitude lower than GEA (2012) and Pachauri *et al.* (2013). The reasons for these discrepancies are described in Table 6, but future research should aim to narrow down this uncertainty. In particular, this will require clearer and more widely shared assumptions about energy access levels and infrastructure standards that are deemed adequate. Perhaps the energy sector can learn in this regard from the water and sanitation community, which through the Joint Monitoring Programme (JMP) has established transparent standards for what counts as “improved” and “safe” water supply and sanitation.

The need to improve our understanding of the financing modalities for the different types of energy access infrastructure is closely related. In particular, this will help develop more robust estimates of private sector investment shares that countries might reasonably aim for given their level of development.

Finally, as mentioned above, investment needs in the energy sector intersect closely with investments in climate change, health, environmental management (e.g. by reducing deforestation rates), and other areas. Several studies that estimate synergies exist, but these analyses remain too partial to be applied for broader SDG needs assessments. It would therefore be important to expand integrated assessment models or computable general equilibrium models to incorporate the full spectrum of SDG investments,

including in energy, in order to better understand the quantitative impact of these synergies. Country-level assessments will be particularly important for improving our understanding of these linkages.

4.6. Water and sanitation

The SDGs emphasize the importance of water and sanitation by elevating these priorities to a dedicated goal and adding water quality, water treatment, and water resources management. As in the case with energy, investment needs for ensuring access to safe water and improved sanitation are distinguished from the broader investment needs in water management and sanitation infrastructure. This is motivated by differences in technologies, delivery systems, and financing strategies. Careful attention must be paid to reaching all unserved populations in order to fulfill the SDGs' pledge to leave no one behind.

Available needs assessments studies and results

Hutton (2015) and Hutton (2012) constitute the two most comprehensive assessments of investment needs for access to water supply and access to sanitation. As described in Table 7, these estimates do not include the large investment needs for the maintenance and replacement of large-scale water and sanitation infrastructure in developing countries, for which the analysis draws on estimates by the World Bank (2013b), which covers investments in water supply infrastructure and wastewater treatment. Investment needs for ending open defecation are also not reported in available sector-wide estimates. A forthcoming assessment of investment needs for water and sanitation is currently being undertaken by the United Nations system and will fill these gaps (Hutton, *personal communication*). The subsequent analysis retains Hutton (2015) data with the adjustments described below since it constitutes the most up-to-date estimates. Annex 3. Overview of infrastructure needs assessments provides a more detailed overview of needs assessments for the infrastructure sector as a whole.

Table 7. Needs assessment studies for water and sanitation

Study	Hutton (2012)	Hutton (2015)	World Bank (2013b)
Coverage and development outcomes	Achieving MDG targets and attaining universal access to improved drinking-water sources and sanitation in urban and rural areas.	Achieving universal access to "basic" water supply and to "adequate sanitation," as well as ending open defecation.	Infrastructure investments for potable water supply and wastewater treatment.
Relationship to SDGs	Partly addresses SDG6 targets on achieving universal access to safe water supply (6.1) and adequate sanitation (6.2).	Partly addresses SDG6 targets on achieving universal access to safe water supply (6.1) and adequate sanitation (6.2).	Partly addresses SDG6 targets on achieving universal access to safe water supply (6.1) and adequate sanitation (6.2).
Key gaps	Access to "safe" water supply, wastewater treatment/pollution control; integrated water management; community participation in water management; water-use efficiency measures; capacity-building for water and sanitation programs.	Access to "safe" water supply, wastewater treatment/pollution control; integrated water management; community participation in water management; water-use efficiency measures; capacity-building for water and sanitation programs.	Wider water and sanitation infrastructure, including operation and maintenance expenditure for infrastructure.
Methodology	**Intervention-based needs assessment.** "Quantitative model" used to calculate costs and benefits of investments to achieve universal coverage targets. Unit costs (updated from previous WHO studies) are linked to population and coverage projections. Rural and urban areas considered separately. Lower and upper bounds are placed on investment needs estimates to account for key uncertainties in the analysis: technology choice, technology lifespan, extrapolation between settings, and the potential impacts of climate change. These ranges are expressed as three scenarios ("low" cost, baseline, and "high" cost) varying in terms of water and sanitation technology choices.	**Intervention-based needs assessment.** Estimation model used to calculate the costs and benefits of WASH interventions, using unit costs (sourced from peer-reviewed and grey literature), linked to coverage, health and economic variables. The study uses three scenarios ("low" cost, baseline, and "high" cost) varying in terms of water and sanitation technology choices, to explore uncertainty related to discount rates, the value of prevented deaths and differences between income groups; but not those related to different technology mixes, technology lifetimes, and low vs. high unit cost estimates.	**Unit cost estimates.** Forecast of demand and supply for each component, and multiplied by the unitary cost of each. Data on the percentage of population with access to improved water as of 2008 (sourced from World Development Indicators) are used to project the increase in population, also assuming that full access by households to improved water and sanitation would be reached by 2030. They then multiplied this additional supply by a unitary cost per connected household of $475 for potable water infrastructure and $832 for wastewater treatment.
Incremental vs. Total costs	**Incremental** (to a baseline scenario of no change in coverage).	**Incremental** (to a baseline scenario of no change in coverage).	**Incremental** (to current investment levels).
Expenditure types	**Capex + Opex** (investments in WASH facilities, operation and maintenance).	**Capex + Opex** (investments in facilities, education and behavior change, maintenance and operating materials, plus ongoing educational efforts).	**Capex only**
Consideration of climate change mitigation and adaptation	None	None	None
Consideration of economy-wide effects	None	None	None

Study	Hutton (2012)	Hutton (2015)	World Bank (2013b)
Geographical resolution and scope	**Country level** (136 countries, then aggregated to regional level (9 regions) and global level, weighted by country population size).	**Country level** (140 countries: LICs, LMICs and most UMICs, presented as aggregates by MDG region).	**Country-level** (LICs, LMICs and UMICs).
Period covered	2010-2030	2015-2030	2012-2030
Relationship to other studies and observations on methodology	Population growth beyond 2015; price increases above the rate of inflation; and the investment needs to maintain gains already made into the 2015-2030 period were not taken into account.	Higher needs estimates compared with Hutton (2012) are due to higher service standards and inclusion of upper-middle-income countries, which account for particularly high per capita costs.	Draws on unit cost estimates derived from an analysis of best practice compiled by Fay and Yepes (2003).
Base year	2010	2015	2010
Annual investment needs in billions $ (start year)	n/a	n/a	n/a
Annual investment needs in billions $ (end year)	n/a	n/a	$65 (2030)
Period average in billions $ per year (years)	**$27 (2010-2030)**	**$49 (2015-2030).** Breakdown: $17.5 for universal access to basic water; $31.5 for universal access to adequate sanitation.	**$61 (2012-2030)**
Comments on results	Authors estimated need of $535 over 2010-2015, but extended the investment horizon to 2010-2030 because they did not believe it likely that it could be absorbed over a 5-year period. Capex accounts for the majority of investment needs.	Numbers reported here are non-discounted numbers provided by the author. Estimates for ending open defecation are not reported as these estimates are due to be updated and will change significantly (Hutton, *personal communication*).	n/a
Adjustments made	Results have not been retained for this paper.	Rebased to $\$_{2013}$ and scaled down to LICs and LMICs using data provided by the author (Hutton, *personal communication*), yielding $28 billion per year (LICs: $7, LMICs: $21). For adaptation, a 25% mark-up is applied to capital expenditure (UNFCCC 2007). Incremental costs for mitigation are assumed to be minimal and not taken into account. This results in a total of $34 billion (LICs: $8, LMICs: $25). Combined with residual investment needs from World Bank (2013b), this leaves a total of **$43-46 billion per year (LICs: $11, LMICs: 32-34).**	Operational expenditure is estimated based on assumption that O&M represent 51.6% of total transport infrastructure costs (Foster and Briceño-Garmedia 2010, table O.3). For all countries covered in the study, this yields a total of $50 billion. Once scaled down to LICs and LMICs on a per capita basis to yield $29 billion per year (LICs: $7 billion, LMICs: $22 billion). To avoid overlaps, estimates from Hutton (2015) are subtracted, leaving to an adjusted estimate of $1 billion per year (LICs: $0, LMICs: $1). Adaptation costs are based on World Bank (2010), and scaled down on a per capita basis, yielding incremental investment needs for adaptation of $8-11 billion per year (LICs: $2-3, LMICs: $6-8).
Robustness of estimates	Methodology suitable and numbers are robust.	Methodology suitable and numbers are robust.	Methodology not suitable for detailed SDG needs assessments and numbers are not robust.

Source: Author's analysis, based on Hutton (2012, 2015), World Bank (2010, 2013b) and UNFCCC (2007).

Additional investment needs for climate change mitigation and adaptation

Climate change is projected to have significant impacts on the water cycle, including on water supply and quality, which are key to achieving SDG 6. Moreover, climate change will increase the frequency and severity of extreme weather, which in turn threaten water and sanitation infrastructure, particularly in densely populated urban environments (IPCC 2007, Ward *et al.* 2010). As a result, substantial investments will be required to make water and sanitation infrastructure climate resilient.

For adaptation-related investment needs for access to water supply and sanitation the paper uses results reported in Fankhauser and Schmidt-Traub (2011) by applying a 25 percent mark-up on capital expenditure (UNFCCC 2007). This figure is derived from modeling changes in water supply and demand under two different climate change scenarios (IPCC SRES A1B and B1), which both have a significant likelihood of exceeding the internationally agreed target of 2°C warming. On the supply side, measures modeled include the desalinization of sea water, increased water storage capacity in dams and reservoirs, and increased groundwater extraction, all of which will require new infrastructure investments. On the demand side, interventions focus on increased water-use efficiency through water recycling, reductions in demand from irrigation by changing irrigation methods, and increasing reliance on agricultural imports. Investments in flood control and distribution systems were not included in the analysis. Of the $_{2015}$49 billion annual investment needs reported by Hutton (2015), some $30 billion are for capital expenditure (Hutton, *personal communication*), which in turn yields incremental investment needs for climate change adaptation of $10 billion per year across all countries covered in the study.

In addition, annual investment needs for the adaptation of water supply (based on cost estimates for dam construction) and for riverine flood protection are projected by the World Bank (2010) at between $_{2005}$14.4 - 19.7 billion per year. These estimates have been derived from a background paper to the report (Ward *et al.* 2010), which presents higher gross investment needs in the range of $20.2 – 22.8 annually billion over the 2010 – 2050 period. Although the scope of the latter report is global, the authors estimate that 80 to 90 percent of climate-induced investment needs will be incurred by developing countries. As described below, investment needs reported for water and sanitation infrastructure are equivalent to those required for universal access to basic water supply and adequate sanitation (section 4.6). Subtracting the latter from the former leaves a small residual investment need of $_{2015}$2 billion per year for large-scale infrastructure. One must add to this the substantial investment needs for adapting large-scale water and sanitation infrastructure to climate change, so the World Bank (2010) EACC adaptation costs are included in the estimates (Table 14).

The water and sanitation sector contributes only moderately to greenhouse gas emissions – notably through the release of methane from inappropriate wastewater management systems and disposal of excreta. Associated investment needs are difficult to quantify and likely modest relative to mitigation investments in other sectors. For this reason they are not considered further in this paper.

Synergies with investment needs in other sectors

Improved water and sanitation has major impacts on achieving other SDGs, including health and education (UN Water 2008).[14] Yet, fewer SDG investment areas feed into water and sanitation. The most important synergies and trade-offs are linked to the impact of climate change on the water and sanitation sector, as discussed above. Moreover, access to safe drinking water depends in parts on adequate management of the quantity and quality of freshwater resources. The latter in turn are affected by energy infrastructure (which can be a major user of freshwater), infrastructure for wastewater management, pollution control, and effective integrated water resources management. To the best of our knowledge, the impact of such investments on the investment needs in the water and sanitation sector has not been addressed quantitatively and is therefore not considered further in this paper.

Adjustments made for this paper

Results from Hutton (2015) are rebased from $\$_{2015}$ to $\$_{2013}$, and results by the World Bank (2013) from $\$_{2010}$ to $\$_{2013}$. Investment needs are scaled down to LICs and LMICs using data on the share of global costs borne by each country income group, provided by the author (Hutton, *personal communication*).

In order to avoid overlaps, estimates for access to water and sanitation are subtracted from the World Bank (2013b) infrastructure investments. This leaves a small residual investment need of around $\$_{2013}$ billion globally for water and sanitation infrastructure, which is scaled down to LICs and LMICs on a per capita basis. This figure is likely a significant underestimate, given that the World Bank estimates do not include investment needs in large-scale infrastructure for water treatment, distribution, and the handling of wastewater.

With these adjustments incremental investment needs for water and sanitation amount to $29 billion ($7 billion in LICs and $22 billion in LMICs) per year. Table 14 also reports incremental investment needs for climate change adaptation and mitigation of $13 – 16 billion, which raise the total to $43 – 46 billion ($11 billion in LICs and $32 – 34 billion in LMICs)[15] per year.

Opportunities for public and private financing

Household financing for water and sanitation can be an important source of financing and is a critical tool for ensuring effective water use. Tariffs on water can help reduce water wastage and enable efficient water use by avoiding its use for low-value purposes. However, many low-income households may not be able to finance the full connection costs for new water and sanitation infrastructure. For

[14] The impact of water and sanitation investments on these areas will depend to some extent on whether educational and health facilities are specifically targeted for improvement (rather than focusing only on improved facilities in the home), but this is difficult to quantify. Estimates used in this paper (Hutton 2015) cover investment needs for improved facilities in homes only.

[15] Results have been rounded and so do not add up exactly.

example, Greenhill and Ali (2013) suggest that households contribute an average of 44 percent of all financing for water and sanitation.

Current private sector investment in the water and sanitation sector is low. The 2012 Global Analysis and Assessment of Sanitation and Drinking Water (UN 2012) estimates that a mere 7 percent of total spending comes from the private sector, excluding households. The potential for increasing this share appears strong. UNCTAD (2014) estimates that private sector investment in water and sanitation can reach up to 20 percent in developing countries. Using this upper threshold suggests that some $11.6 billion of the $58 billion gap might be financed by the private sector. We propose a range of $6.5 – 11 billion in view of the large investment needs in very poor countries where the private sector will only be able to contribute at the margin. This corresponds to a net leverage ratio of 1:4 – 1:8, which is at the upper end of rates observed in infrastructure services for very poor people (UN 2012).

For large-scale infrastructure, the paper draws on estimates of the private sector share in capital investments reported by UNCTAD (2014). For water and sanitation, private spending stands in the range of 3 to 22 percent of total spending. It is further assumed that the private sector covers 70 percent of O&M expenditure, as consumer tariffs will serve to recoup the vast majority of these costs.

Robustness of available assessments and avenues for further research

Needs assessments for access to water and sanitation have significantly improved in recent years. They demonstrate a reasonably robust production function for the corresponding SDG. However, these assessments do not cover investment needs for water resources management – a priority under the SDGs. Another major knowledge gap concerns effective financing structures that can mobilize greater volumes of private financing. In addition, we need a clearer understanding of how climate change, rising levels of water pollution, and other environmental change will affect investment needs for water supply and sanitation.

4.7. Transport infrastructure

Transport infrastructure, including roads, railways, and ports, is critical for promoting trade and economic growth, as well as facilitating access to services for previously unserved populations. It therefore represents an important investment area for achieving the SDGs.

Available needs assessments studies and results

Table 8 provides an overview of the available needs assessments for infrastructure considered in this paper (World Bank 2013b, UNCTAD 2014), both of which provide estimates for investment needs in transport infrastructure. Annex 3. Overview of infrastructure needs assessments provides a more detailed overview of needs assessments for the infrastructure sector as a whole.

Table 8. Needs assessments studies for transport infrastructure

Study	World Bank (2013b)	UNCTAD (2014)
Coverage and development outcomes	Infrastructure needs in transport (roads).	Infrastructure needs in transport (rail, roads, airports and ports).
Relationship to SDGs	Addresses SDG9 most directly, but will contribute to a wide range of SDGs (including 2, 3, 4, 6, 9, and 13).	Addresses SDG9 most directly, but will contribute to a wide range of SDGs (including 2, 3, 4, 6, 9, and 13).
Key gaps	Operation and maintenance expenditure for infrastructure. Rail, airports and ports.	Operation and maintenance expenditure for infrastructure.
Methodology	**Unit cost estimates**. Forecast of demand and supply for each component, and multiplied by the unitary cost of each. Data on the total road network in each country (in km – sourced from World Development Indicators) are used to project the required increase in paved road length (1.33% in LICs; 2.11% in LMICs), then multiplied by a unit cost of $487,168 per kilometer.	**Literature review**. Analysis of existing estimates for investment needs. See Table 18 for supplementary details. The majority of studies reviewed estimate investments based on projected demand for infrastructure rather than need (Bhattacharya *et al*. 2012; WEF and PwC 2012, drawing on OECD 2006, 2012; Fay *et al*. 2011; Foster and Briceño-Garmedia 2010; Fay and Yepes 2003). Estimates are based on projections of GDP growth (typically 4%, ranging up to 6%) and investment-to-GDP ratios (ranging from 2.7% in Yepes (2009) to 10% in Foster and Briceño-Garmedia 2010). BCG (2013) estimates the financing gap for infrastructure as the difference between supply (based on the historical share of GDP invested in infrastructure) and demand (based on macroeconomic modelling). McKinsey (2013) uses three separate methodologies: (i) a projection of future investments based on historical spending (which corresponds to 3.8% of GDP) and a GDP growth assumption of 3.3% per year, (ii) an analysis of historical infrastructure asset-to-GDP ratios (which they estimate at 70%) in a perpetual inventory model based on 12 countries, and (iii) a review of projections of infrastructure needs from other sources, including the OECD (2006), IEA (2011), and Global Water Intelligence data.
Incremental vs. Total costs	**Incremental** (to current investment levels).	**Incremental** (to current investment levels).
Expenditure types	**Capex only**	**Capex only**

Study	World Bank (2013b)	UNCTAD (2014)
Consideration of climate change mitigation and adaptation	No	No – investment needs for climate change mitigation and adaptation are covered under separate categories.
Consideration of economy-wide effects	None	None
Geographical resolution and scope	**Country-level** (LICs, LMICs and UMICs).	"**Developing countries**" (the underlying studies have varying geographical scopes).
Period covered	2012-2030	2015-2030
Relationship to other studies and observations on methodology	Draws on unit cost estimates derived from an analysis of best practice compiled by Fay and Yepes (2003).	Draws on estimates by McKinsey (2013), Bhattacharya *et al.* in collaboration with G-24 (2012), MDB Committee on Development Effectiveness (2011), Fay *et al.* (2011), OECD (2006, 2012), WEF and PwC (2012).
Base year	2010	Unspecified – varies across underlying studies.
Annual investment needs in billions $ (start year)	n/a	n/a
Annual investment needs in billions $ (end year)	$254 (2030)	n/a
Period average in billions $ per year (years)	**$283 (2012-2030)**	**$50-470 (2015-2030)**
Comments on results	Estimates are systematically underestimated due to data unavailability.	n/a
Adjustments made	Operational expenditure is estimated based on assumption that O&M represent 51.6% of total transport infrastructure costs (Foster and Briceño-Garmedia 2010, table O.3), rebased to $\$_{2013}$, and scaled down to LICs and LMICs on a per capita basis to yield $361 billion per year (LICs: $90 billion, LMICs: $271 billion). A 20% mark-up on capex is included for climate change adaptation (Stern 2007), yielding a total of **$434 billion per year (LICs: $108 billion, LMICs: $326 billion)**.	Results from this study have not been retained for this paper.
Robustness of estimates	Methodology not suitable for detailed SDG needs assessments and numbers are not robust.	Methodology not suitable for detailed SDG needs assessments and numbers are not robust.

Source: Author's analysis, based on World Bank (2013b), UNCTAD (2014), Foster and Briceño-Garmedia (2010) and Stern (2007).

Additional investment needs for climate change mitigation and adaptation

The World Bank (2010) reports overall incremental investment needs for adapting infrastructure to climate change of $\$_{2005}13$ – 27.5 billion per year. Rail and road transport represent 18 and 16 percent of this total or $2.3 - 5 and $2 - 4.4 billion, respectively. However, due to the large uncertainties underlying many infrastructure needs assessments and the differences in assumptions across studies, this paper follows Stern (2007) by applying a 20 percent mark-up to capital investments in order to take the need for climate adaptation into account through higher construction standards and greater provision for wear and tear. The approach taken by Stern (2007) is a tentative one that it is based on climate scenarios in which the 2°C warming target will likely be exceeded. Yet, as described in section 3.1, this approach has the advantage of applying mark-ups for climate change adaptation to the full infrastructure investment needs to achieve the SDGs instead of only baseline infrastructure investments. Since the latter tend to be vastly insufficient, particularly in low- and lower-middle-income countries, any investment needs for climate change adaptation derived from baseline infrastructure investments will significantly underestimate adaptation needs under a scenario where countries achieve the SDGs.

Synergies with investment needs in other sectors

By enabling movement and greater access to previously unconnected areas, investments in transport infrastructure can contribute to economic activity, including greater agricultural productivity (FAO *et al.* 2015), as well as allow easier access to health, education and other services to previously unserved populations. Unfortunately, available needs assessments for infrastructure and cross-sector effects are not robust enough to draw general conclusions about the quantitative impact of such synergies and their implications for investment needs. Based on available studies it does seem unlikely that investment needs in transport infrastructure will change significantly as a result of investments made in other areas.

Adjustments made for this paper

Investment needs are scaled down to LICs and LMICs on a per capita basis. Each income group's share of the incremental costs is computed based on its percentage share of the combined population of the low- and middle-income countries covered in the study.

Operation and maintenance expenditure make up a significant share of infrastructure investments, but they are excluded from the World Bank (2013b) estimates. To include O&M expenditure, the analysis refers to Foster and Briceño-Garmedia (2010, table O.3) who estimate that O&M represent 51.6 percent of total transport infrastructure costs in sub-Saharan Africa. In the absence of global assessments, the paper assume that the same investment share holds for the rest of the developing world. This assumption should be refined in subsequent work. With these adjustments, incremental investment needs for transport infrastructure are $361 billion per year ($90 billion in LICs and $271 billion in LMICs). They rise to $434 billion per year ($108 billion in LICs and $326 billion in LMICs) when incremental investment needs for climate change adaptation are included (Table 14).

Opportunities for public and private financing

UNCTAD (2014) estimates that the private sector covers between 32 and 44 percent of the total capital expenditure for transport infrastructure. We apply this share to capital expenditure, and assume further a 70 percent private sector share for O&M costs, as these can be recouped through gasoline taxes and in some cases toll roads.

Robustness of available assessments and avenues for further research

Compared with other sectors considered in this study, the transport needs assessment is based on simplistic assumptions about uniform unit costs of roads, GDP growth, and the elasticity of transport investments to GDP growth. Results depend entirely on these assumptions, and the underlying methodology does not back-cast from a desired level of per capita transport infrastructure by 2030. This makes it difficult to assess whether the results are consistent with achieving the SDGs. Moreover, the needs assessment does not include operational expenditure or infrastructure for rail and ports, thereby omitting a significant share of the total cost of transport infrastructure. For this reason, the transport needs assessment results should be considered tentative and with a high margin of error.

4.8. Telecommunications infrastructure

Information and communication technologies (ICTs) are disruptive technologies that can accelerate progress towards achieving the SDGs and lower the cost of doing so, notably in health, education, and agriculture, but also in the energy and water sectors by helping to monitor and reduce consumption (Broadband Commission 2014). ICTs can also make production processes more efficient, facilitate the collection and exchange of information, and help create, organize and strengthen communities (Souter *et al*. 2010).

Available needs assessments studies and results

Table 9 summarizes two needs assessments for telecommunication infrastructure identified in this paper (World Bank 2013, UNCTAD 2014). Annex 3. Overview of infrastructure needs assessments provides a more detailed overview of needs assessments for the infrastructure sector as a whole.

Additional investment needs for climate change mitigation and adaptation

Fankhauser and Schmidt-Traub (2011) show that incremental investment needs for climate adaptation and mitigation for telecommunication infrastructure are minimal. They have therefore been excluded from this assessment.

Table 9. Needs assessment studies for telecommunications infrastructure

Study	World Bank (2013b)	UNCTAD (2014)
Coverage and development outcomes	Infrastructure needs in telecommunications (fixed lines and mobile connection).	Infrastructure needs in telecommunications (fixed lines, mobile and internet).
Relationship to SDGs	Addresses SDG9 most directly, but will contribute to a wide range of SDGs (including 2, 3, 4, 6, 9, and 13).	Addresses SDG9 most directly, but will contribute to a wide range of SDGs (including 2, 3, 4, 6, 9, and 13).
Key gaps	Operation and maintenance expenditure for infrastructure.	Operation and maintenance expenditure for infrastructure.
Methodology	**Unit cost estimates.** Forecast of demand and supply for each component, and multiplied by the unitary cost of each. 2009 data on tele-density values (lines per 100 persons – obtained from World Development Indicators) are used to project the increase for fixed lines (8.2% in LICs, 9.1% in LMICs) and mobile lines (decreasing percentage change starting at 17.8% in LICs, 14.9% in LMICs) then multiplied by their associated unitary cost (fixed: $475; mobile: $689).	**Literature review**. Analysis of existing estimates for investment needs. See Table 18 for supplementary details. The majority of studies reviewed estimate investments based on projected demand for infrastructure rather than need (Bhattacharya *et al.* 2012; WEF and PwC 2012, drawing on OECD 2006, 2012; Fay *et al*. 2011; Foster and Briceño-Garmedia 2010; Fay and Yepes 2003). Estimates are based on projections of GDP growth (typically 4%, ranging up to 6%) and investment-to-GDP ratios (ranging from 2.7% in Yepes (2009) to 10% in Foster and Briceño-Garmedia 2010). BCG (2013) estimates the financing gap for infrastructure as the difference between supply (based on the historical share of GDP invested in infrastructure) and demand (based on macroeconomic modeling). McKinsey (2013) uses three separate methodologies: (i) a projection of future investments based on historical spending (which corresponds to 3.8% of GDP) and a GDP growth assumption of 3.3% per year, (ii) an analysis of historical infrastructure asset-to-GDP ratios (which they estimate at 70%) in a perpetual inventory model based on 12 countries, and (iii) a review of projections of infrastructure needs from other sources, including the OECD (2006), IEA (2011), and Global Water Intelligence data.
Incremental vs. Total costs	**Incremental** (to current investment levels).	**Incremental** (to current investment levels).
Expenditure types	**Capex only**	**Capex only**
Consideration of climate change mitigation and adaptation	No	No – investment needs for climate change mitigation and adaptation are covered under separate categories.
Consideration of economy-wide effects	None	None

Study	World Bank (2013b)	UNCTAD (2014)
Geographical resolution and scope	**Country-level** (LICs, LMICs and UMICs).	"**Developing countries**" (the underlying studies have varying geographical scopes).
Period covered	2012-2030	2015-2030
Relationship to other studies and observations on methodology	Draws on unit cost estimates derived from an analysis of best practice compiled by Fay and Yepes (2003).	Draws on estimates by McKinsey (2013), Bhattacharya *et al.* in collaboration with G-24 (2012), MDB Committee on Development Effectiveness (2011), Fay *et al.* (2011), OECD (2006, 2012), WEF and PwC (2012).
Base year	2010	Unspecified – varies across underlying studies.
Annual investment needs in billions $ (start year)	n/a	n/a
Annual investment needs in billions $ (end year)	$302 (2030)	n/a
Period average in billions $ per year (years)	**$238 (2012-2030)**	**$70-240 (2015-2030)**
Comments on results	n/a	n/a
Adjustments made	Operational expenditure is estimated based on assumption that O&M represent 22.2% of total telecommunications infrastructure costs (Foster and Briceño-Garmedia 2010, table O.3), rebased to $\$_{2013}$, and scaled down to LICs and LMICs on a per capita basis to yield **$189 billion per year (LICs: $47 billion, LMICs: $142 billion)**. Incremental costs for climate change adaptation and mitigation are assumed to be minimal and not taken into account.	Results have not been retained for this paper.
Robustness of estimates	Methodology not suitable for detailed SDG needs assessments and numbers are not robust.	Methodology not suitable for detailed SDG needs assessments and numbers are not robust.

Source: Author's analysis, based on World Bank (2013b), UNCTAD (2014) and Stern (2007).

Synergies with investment needs in other sectors

Telecommunication infrastructure can profoundly change the "production function" for many SDG,s and lower associated investment needs (Broadband Commission 2014). Each sector assessment must carefully determine opportunities for rapid technological change and how they might affect investment needs. As discussed further in the sector discussion as well as section 5 most SDG needs assessments do not pay adequate attention to the role that ICT and other technological changes might play.

Conversely, it is less clear to what extent changes in other sectors might affect investment needs in telecommunication infrastructure. No assessments could be found that have attempted to identify and quantify these relationships.

Adjustments made for this paper

Investment needs are scaled down to LICs and LMICs on a per capita basis. Each income group's share of the incremental costs is computed based on its percentage share of the combined population of the low- and middle-income countries covered in the study.

Operation and maintenance expenditure make up a significant share of infrastructure investments; yet, the World Bank (2013) estimates only take into account capital expenditure. Foster and Briceño-Garmedia (2010, table O.3) estimate that O&M costs represent 22.2 percent of total telecommunications infrastructure costs in sub-Saharan Africa. In the absence of other estimates, this O&M share is applied to the rest of the developing world. This assumption ought to be refined in subsequent analytical work. This yields incremental investment needs for telecommunications infrastructure of $189 billion per year ($47 billion in LICs and $142 billion in LMICs), as reported in Table 14.

Opportunities for public and private financing

UNCTAD (2014) estimate that the private sector will finance 41 – 44 percent of the capital expenditure for telecommunications infrastructure. It is further assumed that the private sector will finance the entirety of O&M costs as they can be recovered through line rentals and user fees.

Robustness of available assessments and avenues for further research

The SDG needs assessment for telecommunications infrastructure is based on simple assumptions about the nature of fixed-line infrastructure needed in countries. Some of these needs have probably been replaced by mobile phone technology, while the needs assessment does not cover the cost of fiber optic network infrastructure. Since the vast majority of investments in telecommunication are financed by the private sector, these analytical shortcomings have little impact on public investment needs.

4.9. Ecosystem services and biodiversity

The SDGs emphasize the importance of preserving and sustainably managing marine and terrestrial ecosystems, as well as biodiversity (SDGs 14 and 15). Needs assessments therefore need to cover the full spectrum of investments and improved policies for the sustainable management of forests, savannahs, wetlands, coastal zones, oceans, and many other ecosystems. Such assessments are complicated by the facts that the degradation of ecosystems is often caused by a broad range of factors that cannot be addressed through narrowly defined investment programs. This in part explains the preliminary state of needs assessments reviewed in this section.

Available needs assessments studies and results

The two most comprehensive and prominent needs assessments conducted in this area are the High-Level Panel on Global Assessment of Resources for Implementing the Strategic Plan for Biodiversity 2011 – 2020 (CBD 2012a) and the Needs Assessments for the 6th Replenishment of the Global Environment Facility (CBD 2012b). Both assessments, presented in Table 10, were undertaken in parallel, and are therefore complementary. The needs assessments are based on the Aichi Biodiversity Targets, adopted in 2010 by parties to the Convention on Biological Diversity (CBD). These 20 targets, to be achieved by 2020, provide a framework for global action on the preservation, sustainable use and fair and equitable sharing of biodiversity resources.

The GEF Needs Assessment differs from the analysis conducted by the High-Level Panel in several ways, which explains the vastly lower numbers but complicates the comparison of the two sets of results: first, the GEF estimates cover investment needs in the 155 GEF-eligible countries, whereas the High-Level Panel undertook a global assessment that includes all high-income countries. Second, the GEF selected activities of "strategic importance" and did not propose interventions for all Aichi targets. Third, the GEF assessment is limited to the period of 2014 – 2018, not 2013 – 2020 as with the High-Level Panel. Fourth, the GEF took into account the absorptive capacity of recipient nations, which led them to vastly lower projected investment needs compared to the High-Level Panel. This assumption may be justified for the relatively short time span covered by the GEF replenishment round, but it becomes less tenable over a 2030 time horizon that would allow capacity constraints to be addressed. Fifth, the GEF estimates do not include administrative, transaction and opportunity costs of the proposed actions. Sixth and most importantly, the focus of the GEF estimates is on incremental funding needs as opposed to total investment needs to reach the Aichi Goals.

Table 10. Needs assessment studies for ecosystem services and biodiversity

Study	CBD (2012a)	CBD (2012b)
Coverage and development outcomes	Achieving the Aichi Goals and Targets.	Achieving a subset of GEF-eligible activities of "strategic importance" to the Aichi Goals and Targets.
Relationship to SDGs	Aichi targets overlap substantially with SDGs 14 & 15.	Aichi targets overlap substantially with SDGs 14 & 15.
Key gaps	Interventions to tackle desertification.	Analysis focuses only on sub-set of activities of "strategic importance."
Methodology	**Intervention-based needs assessment.** Six-step approach: (1) Review of the Targets and their context, needs and expectations; (2) Analysis of the type and scale of the actions required to meet the Targets; (3) Identification of data on the per unit requirements of relevant actions, through literature review and interviews; (4) Definition of a broad global program of activity consistent with meeting the Targets; (5) Specifying appropriate factors and ratios for up-scaling of investment and ongoing expenditures; and (6) Assessment of the investment and ongoing expenditure required to meet the Targets.	**Intervention-based needs assessment.** Estimated funding needs, target-by-target, for selected activities that need to be publicly funded. Estimates of funding needs for each activity were derived from literature, examples of funding from similar GEF projects, and expert opinion. Incremental reasoning was then applied to establish how much funding would be needed for each activity (percentages ranging between 10 and 100%), from which three co-financing scenarios were derived (based on co-financing ratios of 1:2, 1:4 and 1:6).
Incremental vs. Total costs	**Total**	**Incremental** (to baseline investment needs for actions already undertaken in countries to achieve targets).
Expenditure types	**Capex + Opex** (Expenditure for biodiversity action, administrative and transaction costs, and opportunity costs of inaction for each of the targets).	**Capex + Opex** (GEF-eligible activities to achieve each target considered).
Consideration of climate change mitigation and adaptation	None	None
Consideration of economy-wide effects	None	Takes into account absorptive and delivery capacities.
Geographical resolution and scope	**Global level, including high-income countries.**	**All developing countries** (155 GEF-eligible countries).
Period covered	2013-2020	2014-2018
Relationship to other studies and observations on methodology	Study was undertaken in parallel and complements (CBD 2012b).	Study was undertaken in parallel and complements CBD (2012a).
Base year	2012	2012
Annual investment needs in billions (start year)	n/a	n/a
Annual investment needs in billions (end year)	n/a	n/a
Period average in billions per year (years)	**$153-436 (2013-2020)**	**$18-48 (2014-2018)**
Comments on results	See text.	See text.
Adjustments made	Results have not been retained for this paper.	Rebased to $\$_{2013}$. Investment needs are scaled down to LICs and LMICs on a per capita basis, yielding total investment needs of **$21-28 billion per year ($5-7 billion in LICs, $16-21 billion in LMICs)**. In the absence of data, investment needs for climate change adaptation and mitigation are not taken into account.
Robustness of estimates	Methodology not suitable for detailed SDG needs assessments and numbers are not robust.	Methodology not suitable for detailed SDG needs assessments and numbers are not robust.

Source: Author's analysis, based on CBD (2012a, 2012b).

A particular challenge in extrapolating from these investments is the need to distinguish between one-off investments and recurrent expenditures. For example, many new protected areas require substantial one-off investments when they are first established, but have lower annual operating expenditure. As a result it is difficult to extrapolate the GEF and CBD assessments to the much longer time period for the SDGs.

Moreover, both assessments conduct stand-alone needs assessments for each Aichi Biodiversity Target. This approach aligns investment needs with the targets, but it leads to overlaps across investment areas and fails to account for major synergies across investments in biodiversity. Both teams of authors acknowledge these issues and underscore that coordinated action across all targets could significantly reduce the required investment needs. Since the SDGs pursue a much broader agenda with significant implications for ecosystems and biodiversity it is indeed likely that the benefits of concerted actions are substantial.

There are a few additional observations with regards to the two studies:

- The GEF estimates for Aichi Target 5 are more than an order of magnitude lower than the broader CBD estimates (Table 10). This large difference comes from the fact that CBD (2012a) includes financial incentives to counter illegal logging as well as wetland banking.
- Though the control of pollution (Aichi Target 8) may require substantial investments, CBD (2012a) does not consider any interventions. In contrast, CBD (2012b) considers high investment needs, particularly to control air pollution, clean up debris, extend storm water drainage, and promote biodegradable plastic. The consideration of financing needs for Aichi Target 8 might need to be reviewed in future analyses.
- The GEF assessment of ecosystem services (Aichi Target 14) includes no funding needs for wetland-based ecosystems since these would be covered under the Ramsar Convention (CBD 2012b).
- Similarly, the GEF estimates for ecosystem resilience focus only on forests and coral reefs. Other ecosystem needs might need to be considered in a revised assessment.
- Finally, the exclusive GEF focus on GEF-eligible countries will underestimate investment needs in managing ecosystems that constitute global public goods.

On balance and in the absence of better information, the GEF assessment provides the more conservative and appropriate basis for an SDG needs assessment. Yet, these numbers should be considered as incomplete and preliminary. They are therefore placed in square brackets in the summary Table 14.

Table 11. Preliminary results of the financial needs assessments under the Convention on Biological Diversity

Aichi Goals and Targets	Needs Assessment for the 6th GEF Replenishment (annualized, $ million)	High-Level Panel on Global Assessment of Resources for Implementing the Strategic Plan for Biodiversity 2011 - 2020 (Annual, $ million)
GOAL A: Mainstreaming Biodiversity		
Target 1: Awareness raising	6 - 18	280 - 890
Target 2: Biodiversity values	2 - 9	100 – 160
Target 3: Incentives	25 - 75	170 – 270
Target 4: Sustainable production/consumption	2 - 5	12 – 23
GOAL B: Reduction of Pressure on Biodiversity		
Target 5: Reducing habitat loss (forests and wetlands)	523 - 1,297	39,200 - 52,100
Target 6: Fisheries	2,506 - 7,519	16,900 - 40,000
Target 7: Sustainable agriculture, aquaculture and forestry	2,550 - 7,650	13,200 - 13,600
Target 8: Pollution	n/a	35,400 - 139,200
Target 9: Invasive alien species	13 - 38	23,300 - 52,900
Target 10: Coral reefs	30 - 50	80 - 130
GOAL C: Safeguarding Ecosystems		
Target 11: Protected areas	9,750 - 22,000	9,200 - 85,000
Target 12: Species conservation	25 - 75	3,400 - 4,800
Target 13: Genetic diversity	4 - 11	80 - 190
GOAL D: Enhancing the Benefits to All		
Target 14: Ecosystem services	15 - 45	3,750 - 37,500
Target 15: Ecosystem resilience	3,015 - 9,025	6,400
Target 16: Access and benefit sharing	n/a	7 – 39
GOAL E: Enhancing Implementation		
Target 17: National biodiversity strategies and action plans	6 - 19	50 - 170
Target 18: Traditional knowledge	3 - 9	210 - 340
Target 19: Science base	1 - 2	1,600 - 2,100
Target 20: Resource mobilization	2 - 5	4 – 30
Biosafety	43	n/a
Total	**18,521 - 47,895**	**153,343 - 435,842**

Source: UN Task Team (2013)

Additional investment needs for climate change mitigation and adaptation

Climate change is projected to have a severe impact on the stability of ecosystems and biodiversity. Rising temperatures, greenhouse gas concentrations, and ocean acidification threaten coral reefs, global fisheries, boreal and some tropical forests, semi-arid savannahs, and other ecosystems (IPCC 2014). For this reason, investments in reducing greenhouse gas emissions from energy use and other sectors are vital for achieving SDGs 14 and 15. Many of these investments need to be considered in the other investment areas.

Land-use change, including through unsustainable management of forests, wetlands, mangroves, and other ecosystems, is a major driver of global greenhouse gas emissions (IPCC 2014). Yet, incremental investments in sustainable land management in order to reduce greenhouse gas emissions remain relatively poorly understood and are not quantified. Similarly, achieving SDGs 14 and 15 in the presence of unavoidable climate change will also require increased investments in adaptation (CBD 2012b), but the nature and volume of such investments is also poorly understood and has yet to be quantified (World Bank 2010). For these reasons it is currently impossible to adjust investment needs in biodiversity and ecosystem management to account for the incremental investments required to mitigate and adapt to climate change. This represents a major gap in our understanding of how the SDGs can be achieved in an integrated manner that must be quickly closed.

Synergies with investment needs in other sectors

Investment needs in ecosystems and biodiversity are highly dependent on sound policies and effective investments in other areas. For example, modest investments in upstream watershed management can substantially reduce downstream investments in improved water quality. Similarly, low-cost containment of invasive species can prevent the high cost of managing them once the invasive species have become endemic. Unfortunately, little information is available to quantitatively assess synergies with other investment areas. This represents a major knowledge gap that should be filled through targeted research.

Adjustments made for this paper

Some line items in the Aichi resource estimates of the GEF assessment are covered elsewhere in the SDG agenda. Table 12 makes the following modifications to Table 11 in order to avoid double counting:

1. Remove resource estimates for Goals A and E since these would be covered under overall preparedness for implementing the SDGs.
2. Remove the resource estimates for agriculture, amounting to $200 – 600 million, from Aichi Target 7 since these interventions are covered under the agriculture section.
3. Reduce the upper-end estimate for fisheries by $2.4 billion (covered under agriculture, section 4.3).

These adjustments yield the incremental annual financing needs summarized in Table 12, which were then rebased from $_{2012}$ to $_{2013}$. In the absence of country or regional level data, the investment needs are scaled down to LICs and LMICs on a per capita basis. Each income group's share of the total costs is computed based on its percentage share of the combined population of the low- and middle-income countries covered in the study.

Table 12. Adjusted investment needs for ecosystem services and biodiversity

Aichi Targets	Annual investment needs ($ million)
Target 5: Reducing habitat loss (forests and wetlands)	523 - 1,297
Target 6: Fisheries	2,506 - 7,516
Target 7: Sustainable Agriculture, Aquaculture and Forestry	2,500 - 7,498
Target 9: Invasive Alien Species	13 - 38
Target 10: Coral Reefs	30 - 50
Target 11: Protected Areas	9,750 - 22,000
Target 12: Species conservation	25 - 75
Target 13: Genetic Diversity	4 - 11
Target 14: Ecosystem Services	15 - 45
Target 15: Ecosystem Resilience	3,015 - 9,025
Total	**18,381 - 47,555**

Source: Author's calculations based on CBD (2012b).

Opportunities for public and private financing

Based on discussions in CBD (2012a, Table 5.4), private, for-profit financing for ecosystems and biodiversity will be limited. Some 85 percent of these investment needs will likely require public financing.

Robustness of available assessments and avenues for further research

The needs assessments related to SDGs 14 and 15 should be considered as preliminary placeholders for more detailed analyses. For this reason they are presented in square brackets in tables 14 and 15. In particular the following issues should be addressed in further research:

1. In many instances the justifications for the numbers is limited, and investment needs in Table 10 are based on global averages. More detailed analyses are required to build a clearer understanding of how to structure operational programs that can deliver the headline investment needs – as has happened in health and education over recent years. To mobilize more resources the "production function" for maintaining ecosystem services must be developed more clearly.
2. The estimates are built around the Aichi Goals to align them with the CBD. Yet, this approach is inconsistent with how the underlying investments might be programmed and executed. A more operationally-focused needs assessment is required that organizes interventions and investment needs by areas of activity and implementation, such as forests, oceans and coastal management, watershed management, etc.
3. More work is required to understand incremental investment in biodiversity and ecosystem management in order to mitigate climate change and adapt to rising concentrations of greenhouse gases.
4. The time frame for an SDG needs assessment must be extended through to 2030 – particularly in order to distinguish clearly between one-off and recurrent investments.

5. Finally, our understanding of synergies across investment areas must be improved. This will be greatly facilitated by arranging investments in ecosystems by operational areas of activity (see above) and comparing them to the seven other investment areas outlined in this paper.

4.10. Data for the SDGs

Achieving the SDGs and promoting sustainable development will require significant investments in data and monitoring systems – a genuine "data revolution" is required. Though comparatively small in volume, these investments will be critical for success and should be included in any SDG needs assessment.

Available needs assessments studies and results

A broad coalition of experts on data for development, including the SDSN, World Bank, Open Data Watch, PARIS21, Simon Frazer University, UNICEF and others, has recently published a needs assessment for SDG data (Espey *et al.* 2015). This analysis expands more limited earlier needs assessments for MDG data (World Bank 2004). It focuses only on countries eligible for the International Development Association (IDA), which includes all low-income and some middle-income countries. The results are summarized in Table 13. Another recent report by the African Union Commission (AUC), the African Development Bank Group (AfDB), and the Economic Commission for Africa (ECA) on a Strategy for the Harmonization of Statistics in Africa (AUC, 2015) estimated much higher total needs for 54 African countries to be between $1.7 and $5 billion in 2015.

Additional investment needs for climate change mitigation and adaptation

The investment needs for collecting key data relating to climate change mitigation and adaptation have been included in Espey *et al.* (2015). No further adjustments are made since it appears unlikely that climate change will have a significant additional impact on the investment needs for SDG data and monitoring systems.

Synergies with investment needs in other sectors

Investments in data for better monitoring and evaluation will improve the targeting and effectiveness of investments in other investment areas. No significant synergies from other sectors are projected to affect investment volumes in data for the SDGs.

Table 13. Needs assessment studies for SDG data

Study	Espey *et al.* (2015)
Coverage and development outcomes	Production and dissemination of data to monitor progress towards operationalizing and achieving the SDGs.
Relationship to SDGs	Covers data needs for a representative set of likely SDG indicators, covering the 17 SDGs and associated targets.
Key gaps	Data literacy; communication; long-term programs of modernization of data systems.
Methodology	**Intervention-based estimates:** The total operational cost of each statistical production method is estimated using average unit costs and then scaled-up to a global estimate.
Incremental vs. Total costs	**Incremental** (to current investment levels).
Expenditure types	**Capex + Opex** (Core statistical products: household surveys, census, civil registration and vital statistics, administrative data, agricultural surveys, environmental data, geospatial data, labor force surveys, establishment surveys, international monitoring, and international reporting + 14% allowance for human resources and legislative reform).
Consideration of climate change mitigation and adaptation	n/a
Consideration of economy-wide effects	Absorptive capacity considered.
Geographical resolution and scope	**Country level** (77 IDA-eligible countries – investment needs extrapolated from a subset of countries: 30 for the household survey component and 26 for the census component).
Period covered	2016-2030
Relationship to other studies and observations on methodology	n/a
Base year	2010 - 2015 price average, not attempting to control for inflation.
Annual investment needs in billions $ (start year)	n/a
Annual investment needs in billions $ (end year)	n/a
Period average in billions $ per year (years)	**$0.5 (2016-2030)**
Comments on results	Incremental needs correspond to an estimated 50% of total need of $1 billion (2016-2020): $0.86 for core statistical products + $0.14 for human resources and legislative reform.
Adjustments made	Estimates scaled down on a per capita basis to LICs ($0.3 billion) and LMICs ($0.1 billion) for total investment needs of **$0.4 billion per year**.
Robustness of estimates	Methodology and results are suitable, but significant gaps and uncertainties remain.

Source: Author's analysis, based on Espey *et al.* (2015).

Adjustments made for this paper

The investment needs estimated by Espey *et al.* (2015) use the most recent data available, so they are not rebased to $\$_{2013}$. In the absence of country or regional level data, the investment needs are scaled down to LICs and LMICs on a per capita basis. Each income group's share of the total costs is computed based on its percentage share of the combined population of the 77 IDA-eligible countries covered in the study. Incremental investment needs for SDG data reported in the summary Table 14 are therefore $0.4 billion per year, of which $0.3 billion needed in LICs and $0.1 billion in LMICs.

Opportunities for public and private financing

A lot of data is produced and financed privately, but the limited set of investment needs reviewed in Espey *et al.* (2015) constitute public goods that do not generate any revenues. For this reason they are not amenable to significant private co-financing.

Robustness of available assessments and avenues for further research

As underscored by Espey *et al.* (2015) their analysis of investment needs for SDG data remains incomplete. In particular it does not consider the additional investment needs and cost savings resulting from the use of modern technologies.

4.11. Emergency response and humanitarian work

The SDGs' central call to leave no one behind extends also to the victims of war, civil strife, and natural disasters who receive support in the form of humanitarian assistance. According to the OECD DAC (2015) official humanitarian assistance commitments from all donors (including non-DAC donors) have risen sharply, from $\$_{2012}$ 4.6 billion in 2000 to some $15.3 billion in 2013, accounting for 4.8 percent of total ODA in 2000 rising to 8.1 percent in 2013 (OECD 2014b). Most of the increase is explained by the humanitarian consequences of the wars and unrest in the Middle East and Afghanistan, though Africa remains a focus of much humanitarian ODA. Natural disasters make up a relatively small share of humanitarian ODA, but the incidence and economic cost of natural disasters attributable to climate change has risen steadily since the 1990s (CRED 2015).

No forward-looking needs assessment for incremental spending needs for humanitarian work in conflict zones is available or possible through to 2030, since the nature and scale of such events remains unpredictable. Natural disasters are stochastic, and insurance companies forecast them over a relatively short period of time, but their data is not publicly available. Much investment in climate change adaptation is slated to reduce the need for humanitarian responses to climate-related disasters, which further complicates any attempts to forecast investment needs for humanitarian work. So there are substantial investment needs that cannot be forecasted quantitatively. The methods of SDG needs assessments do not apply to this important "line item" for financing the SDGs.

To get a sense of possible incremental funding needs for humanitarian assistance one can consider the scale of unfunded needs today. In 2015 United Nations inter-agency appeals were launched requesting $16.4 billion to assist 57.5 million people in 22 countries. Funding needs in 2014 were slightly higher ($17.9 billion) and 52 percent funded (OCHA 2015). GHA (2015) includes reporting on humanitarian giving outside the UN inter-agency appeals. In 2014 a total of $24.5 billion was given, including $5.8 billion in private giving.

At the very least today's funding gap for humanitarian work corresponds to the unfunded gap in inter-agency appeals. Applying the 2014 funding ratio to published 2015 needs yields a gap of some $8 billion. However, inter-agency humanitarian appeals cover only areas where United Nations organizations can operate effectively and in relative security, so they tend to underestimate total needs significantly. To get a sense of the possible upper-range of humanitarian needs one can multiply the GHA (2015) estimates with the same funding ratio, yielding a potential funding gap of $23 billion.

Incremental funding needs for humanitarian work of $8 – 23 billion do not constitute a needs assessment and should only be an indication of what the needs might be. This estimate does not consider spending needs for peacekeeping, which amounted to some $9.8 billion in 2013 (GHA 2015).

4.12. Aggregating investment needs for low- and lower-middle-income countries

Table 14 consolidates incremental investment needs across the SDG investment areas in low- and lower-middle-income countries. The table also identifies an approximate division between public and private financing sources. As the review of existing needs assessments in section 4 shows, available data does not allow the computation of total investment needs. Major gaps in the eleven investment areas covered in this study are for social protection and incremental investment needs for climate change and adaptation for ecosystems.

Incremental per capita investment needs are presented in 2013 international US dollars in Table 15. With the exception of the health sector, for which Jamison *et al.* (2013) provide per capita estimates, per capita investments are computed by dividing average annual investment needs over the period 2015 – 2030 by total population in 2013 as reported by the World Bank (2015).

Table 14. Incremental annual investment needs by investment area in developing countries (average for 2015 – 2030 in $2013 billion)

Investment area	Countries covered	"Development" investment needs	Incremental climate mitigation and adaptation investment needs	Total investment needs	Private, commercial financing (% of total investment needs)	Private, commercial financing needs	Public financing needs
1. Health	***Total***	**68 - 87**	**1 - 1.4**	**69 - 89**	**0%**	**0**	**69 - 89**
	LICs	25 - 29	0.3 - 0.3	25 - 29	0%	0	25 - 29
	LMICs	43 - 59	0.8 - 1	44 - 60	0%	0	44 - 60
2. Education	***Total***	**194**	**0**	**194**	**0%**	**0**	**194**
	LICs	**37**	**0**	**37**	**0%**	**0**	**37**
	LMICs	**157**	**0**	**157**	**0%**	**0**	**157**
3. Social protection	***Total***	**?**	**?**	**?**	**?**	**?**	**?**
4. Agriculture and food security	***Total***	**[125]**	**[22]**	**[148]**	**[51%]**	**[75]**	**[73]**
	LICs	**[61]**	**[6]**	**[67]**	**[51%]**	**[34]**	**[33]**
	LMICs	**[64]**	**[16]**	**[80]**	**[51%]**	**[41]**	**[40]**
5. Energy	***Total***	**257 - 278**	**51 - 55**	**308 - 333**	**[55 - 59%]**	**169 - 196**	**137 - 138**
	LICs	**70 - 77**	**14 - 15**	**84 - 93**	**[54 - 58%]**	**45 - 54**	**39 - 39**
	LMICs	**187 - 201**	**37 - 40**	**224 - 240**	**[56 - 59%]**	**124 - 143**	**98 - 100**
Access to electricity and clean cooking fuels	*Total*	54 - 71	10 - 14	64 - 85	[40 - 50%]	26 - 42	38 - 42
	LICs	19 - 26	4 - 5	23 - 31	[40 - 50%]	9 - 15	14 - 15
	LMICs	34 - 45	7 - 9	41 - 54	[40 - 50%]	16 - 27	24 - 27
Power infrastructure	*Total*	[203 - 207]	[41 - 41]	[244 - 248]	[59 - 62%]	[144 - 154]	[94 - 100]
	LICs	[51]	[10]	[61 - 62]	[59 - 62%]	[36 - 38]	[23 - 25]
	LMICs	[153 - 155]	[31]	[183 - 186]	[59 - 62%]	[108 - 116]	[71 - 75]
6. Water and sanitation	***Total***	**29**	**13 - 16**	**43 - 46**	**[5 - 26%]**	**2 - 12**	**34 - 40**
	LICs	**7**	**3 - 4**	**11 - 11**	**[5 - 26%]**	**1 - 3**	**8 - 10**
	LMICs	**22**	**10 - 12**	**32 - 34**	**[5 - 26%]**	**2 - 9**	**25 - 30**
Basic water supply and adequate sanitation	*Total*	28	6	34	[0 - 20%]	0 - 7	27 - 34
	LICs	7	1	8	[0 - 20%]	0 - 2	7 - 8
	LMICs	21	4	25	[0 - 20%]	0 - 5	20 - 25
Water and sanitation infrastructure	*Total*	[1]	[8 - 11]	[9 - 12]	[24 - 44%]	[2 - 5]	[7]
	LICs	[0]	[2 - 3]	[2 - 3]	[24 - 44%]	[1]	[2]
	LMICs	[1]	[6 - 8]	[7 - 9]	[24 - 44%]	[2 - 4]	[5]
8. Transport infrastructure	***Total***	**[361]**	**[72]**	**[434]**	**[52 - 68%]**	**[225 - 295]**	**[139 - 208]**
	LICs	**[90]**	**[18]**	**[108]**	**[52 - 68%]**	**[56 - 73]**	**[35 - 52]**
	LMICs	**[271]**	**[54]**	**[326]**	**[52 - 68%]**	**[169 - 221]**	**[104 - 156]**

Investment area	Countries covered	"Development" investment needs	Incremental climate mitigation and adaptation investment needs	Total investment needs	Private, commercial financing (% of total investment needs)	Private, commercial financing needs	Public financing needs
7. Telecommunications infrastructure	***Total***	**[189]**	**[0]**	**[189]**	**[54 - 84%]**	**[102 - 159]**	**[30 - 87]**
	LICs	**[47]**	**[0]**	**[47]**	**[54 - 84%]**	**[25 - 40]**	**[8 - 22]**
	LMICs	**[142]**	**[0]**	**[142]**	**[54 - 84%]**	**[77 - 119]**	**[23 - 65]**
9. Ecosystems, including biodiversity	***Total***	**[21 - 28]**	**?**	**[21 - 28]**	**[15%]**	**[3 - 4]**	**[18 - 24]**
	LICs	**[5 - 7]**	**?**	**[5 - 7]**	**[15%]**	**[1]**	**[4 - 6]**
	LMICs	**[16 - 21]**	**?**	**[16 - 21]**	**[15%]**	**[2 - 3]**	**[13 - 18]**
10. Data for the SDGs	***Total***	**0.4**	**0**	**0.4**	**[0%]**	**0**	**0.4**
	LICs	**0.3**	**0**	**0.3**	**[0%]**	**0**	**0.3**
	LMICs	**0.1**	**0**	**0.1**	**[0%]**	**0**	**0.1**
11. Emergency response and humanitarian work*	***Total***	**8 - 23**	**?**	**[8 - 23]**	**[0%]**	**[0]**	**[8 - 23]**
All SDG investment areas**	***Total***	**1253 - 1316**	**160 - 167**	**1413 - 1483**	**[41 - 50%]**	**577 - 741**	**743 – 836**
	LICs	**342 - 355**	**42 - 44**	**384 - 399**	**[42 - 51%]**	**162 - 205**	**194 – 222**
	LMICs	**903 - 938**	**118 - 123**	**1021 - 1061**	**[41 - 51%]**	**415 - 536**	**525 – 606**

Sources: See text in section 4.

Note: Numbers have been rounded and may not add up exactly. Numbers in square brackets are particularly uncertain or incomplete and subject to refinement.

* Emergency response and humanitarian work will be entirely funded by concessional public international financing and cannot be disaggregated by income group.

** This total excludes several SDG investment needs identified in this paper, including social protection and incremental investment needs for climate change mitigation and adaptation for ecosystems. Total does not equal sum of LICs and LMICs since cost of emergency response and humanitarian work is allocated to total only.

Table 15. Annual per capita incremental investment needs by investment area in developing countries (average for 2015 – 2030 in $\$_{2013}$ billion)

Investment area	Countries covered	"Development" investment needs	Incremental climate mitigation and adaptation investment needs	Total investment needs	Private, commercial financing (% of total investment needs)	Private, commercial financing needs	Public financing needs
1. Health	***Total***	**20 - 26**	**0**	**20 - 26**	**0%**	**0**	**20 - 26**
	LICs	**29 - 34**	**0**	**29 - 34**	**0%**	**0**	**29 - 34**
	LMICs	**17 - 23**	**0**	**17 - 23**	**0%**	**0**	**17 - 23**
2. Education	***Total***	**57**	**0**	**57**	**0%**	**0**	**57**
	LICs	**43**	**0**	**43**	**0%**	**0**	**43**
	LMICs	**61**	**0**	**61**	**0%**	**0**	**61**
3. Social protection	***Total***	**?**	**?**	**?**	**?**	**?**	**?**
4. Agriculture and food security	***Total***	**[37]**	**[7]**	**[43]**	**[51%]**	**[22]**	**[21]**
	LICs	**[72]**	**[7]**	**[79]**	**[51%]**	**[40]**	**[39]**
	LMICs	**[25]**	**[6]**	**[31]**	**[51%]**	**[16]**	**[15]**
5. Energy	***Total***	**75 - 82**	**14**	**89 - 96**	**[55 - 59%]**	**49 - 57**	**39 - 40**
	LICs	**82 - 91**	**16 - 18**	**99 - 109**	**[54 - 58%]**	**53 - 63**	**46**
	LMICs	**73 - 78**	**14 - 16**	**87 - 94**	**[56 - 59%]**	**49 - 56**	**38 - 39**
Access to electricity and clean cooking fuels	*Total*	16 - 21	2	17 - 23	[40 - 50%]	7 - 12	10 - 12
	LICs	23 - 31	4 - 6	27 - 36	[40 - 50%]	11 - 18	16 - 18
	LMICs	13 - 18	3	16 - 21	[40 - 50%]	6 - 11	10 - 11
Power infrastructure	*Total*	[60 - 61]	[12]	[71 - 73]	[59 - 62%]	[42 - 45]	[28 - 29]
	LICs	[60 - 61]	[12]	[71 - 73]	[59 - 62%]	[42 - 45]	[28 - 29]
	LMICs	[60 - 61]	[12]	[71 - 73]	[59 - 62%]	[42 - 45]	[28 - 29]
6. Water and sanitation	***Total***	**9**	**4 - 5**	**12 - 13**	**[5 - 26%]**	**0 - 3**	**11 - 12**
	LICs	**9**	**4 - 5**	**13 - 14**	**[5 - 26%]**	**0 - 3**	**11 - 13**
	LMICs	**9**	**4 - 5**	**12 - 13**	**[5 - 26%]**	**0 - 3**	**11 - 12**
Basic water supply and adequate sanitation	*Total*	8	2	10	[0 - 20%]	0 - 2	8 - 10
	LICs	8	2	10	[0 - 20%]	0 - 2	8 - 10
	LMICs	8	2	10	[0 - 20%]	0 - 2	8 - 10
Water and sanitation infrastructure	*Total*	[0]	[2 - 3]	[3]	[3 - 22%]	[0 - 1]	[3]
	LICs	[0]	[2 - 3]	[3 - 4]	[3 - 22%]	[0 - 1]	[3]
	LMICs	[0]	[2 - 3]	[3]	[3 - 22%]	[0 - 1]	[2 - 3]
7. Transport infrastructure	***Total***	**[106]**	**[21]**	**[127]**	**[52 - 68%]**	**[66 - 86]**	**[41 - 61]**
	LICs	**[106]**	**[21]**	**[127]**	**[52 - 68%]**	**[66 - 86]**	**[41 - 61]**
	LMICs	**[106]**	**[21]**	**[127]**	**[52 - 68%]**	**[66 - 86]**	**[41 - 61]**

Investment area	Countries covered	"Development" investment needs	Incremental climate mitigation and adaptation investment needs	Total investment needs	Private, commercial financing (% of total investment needs)	Private, commercial financing needs	Public financing needs
8. Telecommunications infrastructure	***Total***	**[55]**	**[0]**	**[55]**	**[54 - 84%]**	**[30 - 47]**	**[9 - 26]**
	LICs	**[55]**	**[0]**	**[55]**	**[54 - 84%]**	**[30 - 47]**	**[9 - 26]**
	LMICs	**[55]**	**[0]**	**[55]**	**[54 - 84%]**	**[30 - 47]**	**[9 - 26]**
9. Ecosystems, including biodiversity	***Total***	**6 - 8**	**?**	**6 - 8**	**[15%]**	**[1]**	**[5 - 7]**
	LICs	**6 - 8**	**?**	**6 - 8**	**[15%]**	**[1]**	**[5 - 7]**
	LMICs	**6 - 8**	**?**	**6 - 8**	**[15%]**	**[1]**	**[5 - 7]**
10. Data for the SDGs	***Total***	**0.1**	**0**	**0.1**	**[0%]**	**0**	**0.1**
	LICs	**0.3**	**0**	**0.3**	**[0%]**	**0**	**0.3**
	LMICs	**0.0**	**0**	**0.0**	**[0%]**	**0**	**0.0**
11. Emergency response and humanitarian work*	***Total***	**2 - 7**	**?**	**2 - 7**	**[0%]**	**0**	**[2 - 7]**
All SDG investment areas**	***Total***	**367 - 386**	**45 - 47**	**413 - 433**	**[41 - 50%]**	**168 - 216**	**217 - 245**
	LICs	**403 - 419**	**49 - 51**	**452 - 470**	**[42 - 51%]**	**190 - 241**	**230 - 262**
	LMICs	**353 - 366**	**46 - 48**	**398 - 414**	**[41 - 50%]**	**162 - 209**	**205 - 237**

Sources: See text in section 4.

Note: Numbers have been rounded and may not add up exactly. Numbers in square brackets are particularly uncertain or incomplete and subject to refinement.

* Emergency response and humanitarian work will be entirely funded by concessional public international financing and cannot be disaggregated by income group.

** This total excludes several SDG investment needs identified in this paper, including social protection and incremental investment needs for climate change mitigation and adaptation for ecosystems. Total does not equal sum of LICs and LMICs since cost of emergency response and humanitarian work is allocated to total only.

To put these numbers into perspective and to assess the burden they place on national economies as well as the international system, they can be expressed as shares of GDP. As described in Box 2, the appropriate GDP denominator for SDG investment needs in international US dollars lies somewhere between GDP expressed in international dollars and GDP in $ PPP. Using the GDP growth assumptions for the period 2015 – 2030 outlined in Box 2 suggests that low- and lower-middle-income countries will need to increase annual investments in the SDGs by some 4 - 11 percent of GDP (18 – 43 percent in LICs and 3 – 8 percent in LMICs).[16] Incremental investments needs in these countries represent 0.7 – 1.1 percent of annual world GDP over the period.[17]

The indicative and incomplete nature of these estimates must be underscored, and there are a few important caveats. First, some estimates are incomplete and not based on the ambitious SDG agenda. This applies in particular to the infrastructure numbers, which are based on historic demand and may significantly understate investments needed to close major access gaps. It is likely that the investment needs estimates for the promotion of ecosystem services also include substantial gaps, and, as described above, numbers on agriculture and food security do not map out investment needs in nutrition in adequate detail. Other gaps are social protection mechanisms (section 4.3), as well as investment needs to tackle gender and economic inequalities, promote sustainable consumption and production, and improve government functions.

Second, some needs assessment methodologies, such as assessments based on ICOR estimates, are ill-suited to guide public and private investments in the SDGs. In particular, needs assessment results for agriculture and food security should be complemented by studies using interventions-based methodologies. Third, although care has been taken to remove overlaps from the analyses, there may be some double counting when adding up investment needs from different sectors. The issue of synergies and trade-offs across investment needs in different sectors is addressed in the next section.

Fourth, the treatment of incremental investment needs for climate change adaptation and mitigation remains preliminary. These investment needs are included in sector investment needs to avoid an artificial separation of “development” and “climate change” investments (section 3.1). Assumptions, methodologies, and sources for computing incremental investments related to climate change are described throughout this report. Several gaps are highlighted (e.g. for ecosystems). Future research should focus on improving the robustness of needs assessments to account for incremental climate mitigation and adaptation investment needs, filling gaps, and testing adaptation with regards to different reference temperature scenarios.

[16] Note that this paper employs a broad definition of “SDG investments” that includes operating expenditures for social services and infrastructure (Box 1, page 26). So the investment shares of GDP cannot be compared with traditional macroeconomic investment ratios that including only expenditures on fixed capital.

[17] Annual investment needs in the SDGs rise to 6 – 15 percent of projected GDP in low- and lower-middle-income countries (28 – 64 percent in LICs; 4-12 percent in LMICs; 0.9 – 1.3 percent of world GDP) if GDP growth rates are half as high as projected in Box 2. If growth accelerates beyond the projected rates then the investment ratios fall correspondingly.

Box 2: How to express SDG investment needs as a share of GDP

Gross domestic product (GDP) is published in international (market rate) dollars and in purchasing-power-parity (PPP) dollars. The latter tends to be higher in developing countries where price levels are lower than in the United States, which serve as the reference economy. Sectoral needs assessments reported in this paper are expressed in international dollars.

The purpose of expressing investment needs as a share of GDP is to estimate the burden they represent relative to the size of an economy. To adjust for local price levels both the needs assessment and the GDP denominator should be expressed in $ PPP. Detailed input analyses are needed to convert each needs assessment from international dollars to $ PPP, but such analyses are mostly unavailable.

Such input analyses would identify the share of SDGs made in non-tradable goods and services, such as locally-traded building materials or salaries for low-skilled workers, which can then be expressed in $ PPP. Most likely, a much larger share of SDG investments will be made in internationally tradable goods and services, such as many building materials (e.g. cement, steel, and bitumen), machinery, drugs and other health commodities, salaries of professionals (including engineers, doctors, and nurses), and many more.

It appears probable that the share of internationally tradable goods and services in SDG investments exceeds the share of tradables in most countries' GDP. Dividing SDG investment needs expressed in market prices by GDP in international dollars would therefore overestimate the economic burden of achieving the SDGs in the country considered. This is because GDP (with a higher share of non-tradables) will increase further when it is converted into PPP than SDG investments (which have a lower share of non-tradables).

For this reason the appropriate GDP denominator for SDG investments expressed in international prices probably lies somewhere between GDP in $ PPP and GDP in market prices. Future work should decompose SDG investments between tradables and non-tradables to compute investment needs in $ PPP.

In the absence of SDG investments needs expressed in $ PPP this paper reports the share of GDP that must be mobilized for incremental SDG investments as a range. The upper end of this range is obtained by dividing SDG investment needs by GDP in market prices. Dividing the needs by GDP in $ PPP yields the lower end.

SDG investment needs reported in this paper are expressed as incremental annual investments averaged over the 2015 – 2030 period. To ensure comparability, the GDP denominator needs to denote annual GDP averaged over the same period. To project GDP, the paper assumes the following annual economic growth rates (section 6.1):

- Low-income countries: 8 percent
- Lower-middle-income countries: 7 percent
- Upper-middle-income countries: 5 percent
- High-income countries: 2 percent

The shares of GDP that must be devoted to incremental investments for the SDGs are sensitive to assumptions about GDP growth.

Finally, investments in the SDGs will give rise to significant economy-wide effects, such as changes in real wages and relative prices, which are not systematically modeled in sector needs assessments. These issues are considered in the next section.

Overall, available needs assessments in the areas of infrastructure, agriculture and food security, and ecosystem services tend to lack robustness. Some of these assessments are also not systematically based on quantitative objectives that are equivalent in ambition to those contained in the SDGs. For these reasons the corresponding figures are presented in square brackets in tables 14 and 15.

In contrast, financing needs estimates for social services tend to be robust. In particular, the health numbers are based on many years of intensive work. They have also been validated by the experience of major financing mechanisms, such as the Global Fund (2013), Gavi (2014b), or the Global Finance Facility (GFF 2015).

4.13. Global incremental investment needs for the SDGs

Available sectoral needs assessments that are broadly consistent with the SDGs cover mostly low- and lower-middle-income countries only. A number of global estimates – often derived from incremental investments needs in high-income countries – are available to arrive at a tentative approximation of incremental global investment needs to achieve the SDGs by adding them to the investment needs for low- and lower-middle-income countries. Such an extrapolation to global investment needs requires strong assumptions, as described below:

- It is assumed that high-income countries do not need to increase spending on health and education in order to achieve SDGs 3 & 4. Many will have to increase the efficiency and targeting of public and private health and education expenditures, but this will not require additional financial resources. Upper-middle-income countries have by-and-large achieved universal access to primary health care, though the targeting of public expenditure will need to be improved. They do, however, face significant investment shortfalls for non-communicable diseases, which are estimated at $7 billion per year (WHO 2011). In education, UMICs will need to increase lower- and upper-secondary school completion rates from 2015 levels of 86 and 50 percent respectively. Achieving universal lower-secondary completion rates and upper-secondary completion rates comparable to those of EU countries (80 percent in 2014) might require some $62 billion per year if average costs per student derived from UNESCO (2015c) remain constant.

- Global investments in agriculture are taken from FAO *et al.* (2015), excluding investment needs for social protection to avoid double-counting.

- Infrastructure investment needs in power, water and sanitation, telecommunications, and transport are drawn from the studies summarized in the Green Growth Alliance Report (2013), which are OECD (2006), covering all four sectors, OECD (2012), providing an update for transport, and IEA (2012) for energy infrastructure. Total global investment needs for

infrastructure are estimated at some $3.5 trillion per year including investment needs for climate change mitigation and adaptation. To obtain incremental investment needs, estimated current spending of $2 trillion per year, as reported by McKinsey (2013), is subtracted. It is assumed that total infrastructure investment needs cover the investment needs to ensure universal access to modern energy, water supply, and sanitation.

- Investment needs for ecosystems and biodiversity are drawn from CBD (2012a). Given the relatively low investments in ecosystem services and biodiversity reported in the study, the mid-point of the range of investment needs is used.

- Investment needs for humanitarian work are unchanged from section 4.11.

Combining these estimates yields incremental SDG investment needs of some $2.3 trillion per year. This corresponds to 1.3 percent of average world GDP over the 2015 – 2030 period expressed in purchasing power parity (PPP) dollars or 2.0 percent of projected average world GDP in market rates (see Box 2 on page 97).[18] As explained in Box 2, the effective burden on national economies probably lies towards the lower end of 1.3 – 2.0 percent of GDP range. A second reason for considering the lower end of this range is that significant efficiency gains can be expected from the simultaneous expansion of investments across such a broad range of areas and the mobilization of modern technologies for the SDGs (section 5).

Overall, such an increase in global investment is well within reach, particularly if one considers the tremendous benefits that a shift towards a sustainable development pathway would entail. Moreover, a substantial share of these investments can be financed by the private sector. As a general rule, wealthier countries can mobilize a higher share of the necessary financing through the private sector (UNCTAD 2014), so it is likely that at least 50 percent – the upper limit of private investments in low- and lower-middle-income countries – and likely a greater share of incremental global investments in the SDGs can be financed through the private sector.

[18] If GDP growth reaches only half the projected rates (Box 2) then the same level of SDG investments will account for 1.6 – 2.4 percent of world GDP.

5. Synergies and economy-wide effects across SDG investment areas

The previous section briefly reviewed positive and negative synergies on SDG investments in each major investment area. It found that investment needs for education and health systems (with the notable exception of non-communicable diseases) are relatively invariant to investments in other areas. Meanwhile, investments in infrastructure, agriculture, climate change mitigation and adaptation, and other areas exhibit substantial synergies (e.g. McCollum *et al.* 2014). Available studies and data are insufficient to quantify such relationships in global sector needs assessments. Future work should focus on integrated country-level modeling to quantify positive and negative synergies across SDG investments (e.g. by expanding the MAMS tool) as well as global and regional modeling of integrated long-term pathways for achieving the SDGs (see footnote 8 on page 33).

This section discusses the economy-wide effects of SDG investments. Some of the most important effects include supply-side effects on economic growth, impact of foreign currency inflows (Dutch disease), changes in the labor market, and the economic impact of domestic government resource mobilization (Bourguignon *et al.* 2008, Lofgren *et al*. 2013, Kharas *et al.* 2014). This section will briefly review each effect and discuss the state of knowledge on how to quantify its impact.

Changes in the labor market

The scaling-up of government services (e.g. health and education) will exert upward pressure on wages of nurses, doctors, teachers, and other government employees. At the same time it will encourage greater supply of such professionals. The analysis of economy-wide wage effects is complicated by the fact that wages of government employees are often not directly tied to their productivity and depend significantly on broader economic conditions, including the evolution of remuneration in the private sector. The latter depends in turn on a broad range of factors, which make it hard to predict the direction of change on public sector wage bills.

In one of the first applications of MAMS, Bourguignon *et al.* (2008) report for Ethiopia that a 10-year MDG investment program will increase the compound annual growth in nominal wages by up to 1 to 5 percent per year, depending on the level of education. These nominal wage increases can be moderated by adjusting the MDG investment programs (Table 3.6). The authors underscore the complexity of projecting mid-term wage developments since they depend on what happens on both the demand side (government programs and evolution of the private sector) and the supply side (i.e. the educational system). Recent applications of MAMS to Tanzania (Levin 2015a), Bangladesh (Levin 2015b), and the Philippines (Briones 2014) do not include a detailed treatment of the labor market.

On balance, it seems clear that the massive scaling up of public and private investments needed to achieve the SDGs in low-income countries will likely have a substantial impact on the country's labor market, which in turn will have implications on household spending patterns and economic growth. Yet available evidence is not robust enough to assess a likely range for such a wage effect.

Effects on economic growth and trade-offs in sector spending and financing

All MAMS applications focus on the net impact of spending allocations and financing strategies on economic growth. Bourguignon *et al.* (2008) conclude that in the case of Ethiopia, co-financing of MDG investments through increased domestic taxes generates a trade-off between investing in infrastructure and education. According to the specifications of the model, the former has a greater and more immediate impact on economic growth than the latter, so in the presence of scarce public resources (domestic and international), growth will be maximized by underspending on education relative to the MDG objectives. However, this picture becomes more complicated when considering a longer-term perspective since the economic returns to education can be substantial, but they lag relative to returns from infrastructure investments.

Scenarios developed under MAMS help identify possible trade-offs between tax-financed investments, the intertemporal effects of debt financing, and economic growth. By comparing different scenarios, policymakers can gain a better understanding of such trade-offs. However, the quantitative effects depend on the specifications of the models (notably the extent to which supply-side effects through better health, education, and infrastructure are included) and country circumstances (notably the structure of its economy). For this reason it is once more impossible to draw general conclusions from the impact of increased SDG investments on economic growth.

One particularly interesting set of questions concerns the micro-macro linkages between spending effects. For example, Matovu *et al.* (2011) conclude for the case of Uganda that household income growth and resulting increases in household spending were a better driver of improved outcomes in education and health than was public social service delivery. This finding stands in contrast to strong empirical microeconomic evidence from public health that health and education systems relying on household expenditure are unable to meet ambitious health outcomes (section 4.1, Moreno-Serra and Smith 2012, Savedoff 2012, Yates 2009, Jamison *et al.* 2013, Agyepong *et al.* 2014). This example suggests that such macro-micro linkages require careful analysis involving sector experts before definitive conclusions can be drawn.

Impact of foreign currency inflows (Dutch disease)

Inflows of foreign currency (e.g. in the form of aid) may lead to a real exchange rate appreciation and thereby shift domestic investments away from export sectors towards domestic consumption. This in turn may depress economic growth – a phenomenon sometimes referred to as “Dutch disease.” The effects of increased inflows of foreign currency on the exchange rate and the structure of an economy form a central focus of MAMS and its applications (Lofgren and Osorio-Rodarte 2015, Bourguignon *et al.* 2008, Levin 2015a and 2015b). The models conclude that increases in foreign grants will lead to a significant appreciation of the real exchange rate, leading to Dutch disease-type phenomena and a substantial weakening of countries’ export sectors.

However, IMF analyses of this question conclude that under prudential macroeconomic management, the positive effects of substantial increases in ODA flows will outweigh adverse consequences (Prati *et al*. 2003). IMF country case studies in Benin, Niger, and Togo suggest that the macroeconomics of substantial increases in aid to these countries are manageable if central banks and governments pursue sound strategies and if aid inflows are predictable (Christensen 2008, and in particular Mongardini and Samake 2009). This view was echoed by the heads of the major multilateral development institutions (MDG Africa Steering Group 2008), who called for the development of macroeconomic "Gleneagles scenarios" that map out how ODA can increase to $\$_{2007}105$ per capita, which corresponded roughly to a tripling of ODA volumes to the poorest countries.[19]

The differences in conclusions between MAMS and the IMF country case studies stems largely from how each study considers the supply-side effects of increased ODA flows and the granularity with which macroeconomic policies are modeled. Compared with MAMS the IMF work considers a broader spectrum of supply-side benefits of increased public investments, including a more explicit decomposition of aid-financed investments in tradables, such as equipment and international medicines, as well as non-tradables.

On balance, there does not appear to be a clear-cut case why aid-financed increases in domestic investments in sustainable development might be incompatible with the objectives of robust economic growth and macroeconomic stability. These important issues questions of implementation will need to be modeled around specific SDG investment programs in order to offer stronger conclusions.

Efficiency in government expenditure

As mentioned in section 3, available SDG needs assessments tend to focus on incremental expenditures, which are estimated using best practices in the sector and tend to assume efficient government spending. However, baseline government spending is often subject to substantial inefficiencies, including poor targeting, poor operational practice, the use of "ghost workers," and poor M&E. Addressing such inefficiencies as part of a scaling-up of government spending for the SDGs may free up substantial resources and can have significant implications for other parts of the economy.

Available information does not make it possible to estimate inefficiencies in current government outlays or to quantify the impact that more effective use of resources might have on the economy. Such assessments of government spending efficiency should be undertaken through country benchmarking and possibly with the help of computable general equilibrium models or integrated assessment tools. They must also be considered as part of a more comprehensive financing strategy, as outlined further in section 6.

[19] Christensen (2008) and Mongardini and Samake (2009) project increases in ODA to $85 per capita.

Role of technology

Modern technologies in areas such as information and communication, energy, genomics, nanotechnology, transport, and materials science can make profound contributions to our ability to achieve the SDGs and change their production function. Schmidt-Traub and Sachs (2015) provide some illustrative examples. However, it is extremely difficult to predict the future evolution of technologies, so economy-wide models and sector needs assessments do not tend to do so with any rigor. This gap might be filled – at least partially – through systematic consideration of technology roadmaps and consultations with leading technologists in research, government, and business.

Conclusions

Available country studies show that investments in the SDGs generate important economy-wide effects that need to be taken into consideration. The scale and sometimes even the direction (sign) of these effects depend on the country context and the specifications of the models, which forcibly provide only a reduced rendition of the dynamic effects of SDG investments. At this stage this paper can only point to the potential importance of economy-wide effects without making quantitative adjustments to the synthesis of SDG investments needs (section 4.12).

This review of available studies points to three important lines of future inquiry. Available country-level macroeconomic modeling tools, such as MAMS, need to be broadened to include a fuller set of SDG investments. The World Bank has recently begun this work (Gable *et al.* 2015). Findings from such country-level modeling need to be reviewed with sector experts in public health, education, infrastructure, environmental management, etc. to ensure that conclusions from CGE modeling are consistent with the "production functions" for achieving sector outcomes. Such modeling should also address how the efficiency of public and private spending on the SDGs can be increased.

A second line of inquiry needs to focus on integrated modeling of sector interactions and economy-wide effects at the global and regional level, particularly to understand the implications of planetary boundaries (Steffen *et al.* 2015) on sustainable development. As described in footnote 8 on page 33, the Sustainable Development Solutions Network (SDSN) and several partner institutions have recently announced *The World in 2050*, a major new research initiative to investigate these questions.

A third and related research priority needs to focus on improving our understanding of how the transformational role of modern technologies can be harnessed to accelerate progress towards the SDGs, reduce associated investment needs, and improve the integration of available strategies.

6. Financing the SDG investment needs

This section provides a preliminary and illustrative assessment of how the SDG investment needs identified in section 4 can be financed. A more sophisticated assessment of an SDG financing strategy will be developed in a forthcoming paper.

6.1. Methodology

The individual steps of the financing analysis are summarized in Table 16. The analysis starts with current levels of domestic resource mobilization. According to the latest available IMF data for 2012 reported in World Bank (2015), low-income countries generate 13.4 percent of GDP in central government revenue, excluding grants. For lower-middle-income countries this figure is 15.4 percent of GDP. Ideally, one should consider general government revenue, which includes revenues generated by local and other sub-national governments, but data for developing countries is too incomplete to construct regional aggregates. The vast majority of resource mobilization in low- and lower-middle-income countries occurs at the level of central governments (IMF 2012), so this approximation should not skew the results in a major way.

In the absence of more recent data it is assumed that the 2012 GDP share of central government revenues remains unchanged through to 2014. Using World Bank deflators and GDP data, central government revenues are then estimated for 2014 yielding $\$_{2013}52$ billion in low-income countries and $\$_{2013}877$ billion in lower-middle-income countries.

Next, the share of government expenditure devoted to the SDGs is estimated. IMF Government Statistics report government outlays by the following functions: general public services; defense; public order and safety; economic affairs; environmental protection; housing and community amenities; health; recreation, culture and religion; education; and social protection. The following outlay categories are outside the scope of the SDG investments considered in this paper: general public services; defense; public order and safety; and recreation, culture and religion. Our analysis therefore focuses on the remaining categories.

Once again, IMF data (IMF 2012) is too patchy to construct reliable aggregates for the share of SDG expenditure for low-income and lower-middle-income countries. Based on the extremely limited data available it seems reasonable to assume that low-income countries devote no more than 50 percent of their central government spending to SDG-related investments. This share rises as incomes increase, so this preliminary financing analysis assumes 55 percent for lower-middle-income countries. This corresponds to $26 and $482 billion in low-income and lower-middle-income countries respectively. Clearly, these figures must be considered illustrative, and are in need of refinement. Promising data for a large number of low-income and lower-middle-income countries is available through Government Spending Watch (GSW 2015).

For this illustrative long-term analysis it is further assumed that long-term revenues equal long-term expenditure. A more sophisticated analysis will need to incorporate budget deficits and debt levels, including a debt sustainability analysis. Such an analysis would also need to project debt repayment needs, as these might crowd out investments in the SDGs.

SDSN (2015) proposes the following benchmarks for government revenues as a share of GDP to be achieved by 2020: Least-developed Countries (LDCs): 17 percent; other LICs: 20 percent; LMICs: 22 percent; UMICs and HICs: at least 24 percent. The analysis does not yet permit a distinction between LDCs and other low-income countries, so it is assumed that all LICs reach 19 percent of GDP by 2020. If one assumes further that under an SDG scenario, developing countries increase the share of spending devoted to the SDGs by perhaps 20 percent, one obtains target revenue shares of 60 percent of central government revenue in LICs (equal to 11 percent of GDP) and 66 percent in LMICs (equal to 15 percent of GDP).

In a next step, one needs to project average economic growth rates through to 2030. Since economic growth rates are affected by the level of composition of public and private expenditure on the SDGs, a dynamic long-term growth model is needed that incorporates these elements. To our knowledge such a model does not exist. The OECD periodically publishes long-term growth scenarios for OECD and some non-OECD countries, but these forecasts do not include low-income and lower-middle-income countries. Johansson *et al*. (2013) project that growth in OECD countries might average between 2.2 – 2.8 percent through to 2030. For the non-OECD countries considered in the study (Argentina, Brazil, China, India, Indonesia, Russia, Saudi Arabia, and South Africa), growth is projected to reach 7.6 percent at the beginning of the period before falling to 4.3 percent towards the end.

Increased investments in the SDGs should accelerate the process of convergence in GDP per capita, as poorer countries catch up with richer ones, as called for by SDG 10. For this SDG financing analysis it is therefore assumed that low-income and lower-middle-income countries will average 8 and 7 percent in annual GDP growth, respectively. With this assumption a time-path of domestic public resources available for SDG investments can be constructed.

6.2. Results

Under the scenario described above, total central government revenues dedicated to the SDGs each year are estimated to reach $\$_{2013}$153 billion in low-income countries and $2,442 billion in lower-middle-income countries by 2030, equal to an incremental effort over 2014 central government SDG expenditures of $127 billion in LICs and $1,959 billion in LMICs. This corresponds to average incremental central government revenues dedicated to the SDGs for each year from 2015 to 2030 of $61 in LICs and $984 billion in LMICs. To express this in yet another way: the scale-up requires a compound annual growth rate (CAGR) in investments of 12.5 percent in LICs and 11.4 percent in LMICs.

Subtracting the annual public financing needs identified in Table 14 ($194 – 222 billion in LICs, and $525 – 606 billion in LMICs) from average incremental central government revenues dedicated to SDGs each year ($61 billion in LICs and $984 billion in LMICs), yields a financing gap of $133-161 billion per year on average from 2015 to 2030 in LICs, while LMICs are predicted to cover investment needs with $378-459 billion to spare each year. This illustrative analysis suggests that lower-middle-income countries will be able to auto-finance public investments in the SDGs over the full period using the assumptions laid out in this paper. However, these countries may require international co-financing at the beginning of the SDG period, when investments are likely to rise faster than countries' ability to mobilize private and domestic public resources. In contrast, low-income countries will require significant international public finance over the entire period if they are to make the investments required to achieve the SDGs.

Table 16. Schematic financing analysis for SDG investments

Variable	Year	LICs	LMICs
Central government revenue, excluding grants (% of GDP)	2012	13.4%	15.4%
Central government revenue, excluding grants ($_{2013}$ billion)	2014	52	877
Share of central government revenue, excluding grants, devoted to SDGs	2014	50%	55%
Current central government SDG expenditure ($_{2013}$ billion)	2014	26	482
Target central government revenues (% GDP)	2020	19%	22%
Target share of central government revenue, excluding grants, devoted to SDGs	2020	60.0%	66.0%
Target central government revenues devoted to the SDGs (% GDP)	2020	11%	15%
Projected economic growth per year	2014-2030	8%	7%
Total central government revenues dedicated to SDGs ($_{2013}$ billion)	2030	153	2 442
Incremental central government revenues dedicated to SDGs ($_{2013}$ billion)	2014-2030	127	1 959
CAGR central government revenues dedicated to SDGs	2013-2030	12.5%	11.4%
Average incremental central government revenues dedicated to SDGs per year ($_{2013}$ billion)	2015-2030	61	984
Min average public SDG financing gap ($_{2013}$ billion)	2015-2030	-133	459
Max average public SDG financing gap ($_{2013}$ billion)	2015-2030	-161	378

Source: Author's calculations. See text for data sources.

The public SDG financing gap of $_{2013}$133 – 161 billion corresponds to some 0.15 – 0.19 percent of 2013 world GDP or 0.28 percent of high-income countries' GDP. Yet, this preliminary analysis does not distinguish between concessional and non-concessional public international financing. The latter can make a significant contribution towards the financing of infrastructure investments in low-income and lower-middle-income countries. However, many infrastructure needs in low-income countries are inherently unbankable (Bhattacharya *et al*. 2015) and are therefore not amenable to project finance. The large scale of incremental SDG investment needs will make it difficult for low-income country governments to take on additional debt. For this reason ODA will need to play an important role in closing the public financing deficit.

To get a sense of the feasibility of the public international financing, one needs to project ODA volumes through to 2030. As argued in Schmidt-Traub and Sachs (2015) and SDSN (2015), three sources of international public financing can be considered:

1. **ODA from member countries of the OECD DAC:** ODA volumes can be projected using OECD (2014b), the lower-bound (i.e. more conservative) growth estimate prepared by Johansson *et al*. (2013), and the assumption that OECD DAC member countries increase their ODA to 0.7 percent of GNI by 2030, as called for in the Addis Ababa Action Agenda (UN 2015). Note that this latter assumption is substantially less ambitious than previous commitments to increase ODA made, for example, by the G8 at the Gleneagles Summit (G8 2005) and the European Union (Council of the EU 2005).

2. **Concessional public finance from non-DAC high-income countries:** High-income countries that are not members of the DAC currently provide approximately 0.23 percent of their GNI in ODA, with Saudi Arabia and the UAE accounting for the lion share of concessional public financing (OECD 2014a). The SDG financing analysis projects that their ODA increases linearly to 0.7 percent by 2030 using the same growth assumptions as for the OECD DAC member countries.

3. **Concessional public finance from upper-middle-income countries:** Finally upper-middle-income countries, such as Brazil and China, also have significant capacity to provide concessional international public financing (sometimes referred to as South-South Cooperation). As proposed by Schmidt-Traub and Sachs (2015) they could reasonably provide 0.1 percent of GNI in concessional public finance by 2020. This might gradually increase to 0.3 percent of GNI by 2030 – particularly since several will be high-income countries by then. To stay on the conservative side, the analysis uses the lower-end growth scenario ("baseline projections") published by Johansson *et al*. (2013).

Table 17 summarizes how public concessional finance might increase based on the assumptions made above. To these public financing sources one would need to add private philanthropy, which can make a substantial contribution (Schmidt-Traub and Sachs 2015).

Table 17. Plausible increases in public concessional finance through to 2030

Countries		2013	2020	2025	2030	Average (2015-2030)
OECD DAC	ODA (% of GNI)	0.30%	0.46%	0.58%	0.70%	0.52%
	ODA ($2013 billion)	135	245	342	459	299
	Incremental ODA ($2013 billion)		110	207	324	164
Non-DAC HICs	Concessional finance (% of GNI)	0.23%	0.43%	0.56%	0.70%	0.49%
	Concessional finance ($2013 billion)	12	25	37	51	32
	Incremental concessional finance ($2013 billion)		13	25	39	20
UMICs	Concessional finance (% of GNI)	0.02%	0.10%	0.20%	0.30%	0.16%
	Concessional finance ($2013 billion)	3	27	66	123	53
	Incremental concessional finance ($2013 billion)		23	63	119	49
Total	**Concessional finance (% of GNI)**	**0.22%**	**0.35%**	**0.45%**	**0.56%**	**0.40%**
	Concessional finance ($2013 billion)	**150**	**297**	**445**	**632**	**383**
	Incremental concessional finance ($2013 billion)		**147**	**295**	**483**	**233**

Source: Author's calculations. See text for data sources.

Overall, this illustrative analysis suggests that the international public financing gap for the SDGs of $2013133 – 161 billion per year averaged over the period 2015 – 2030 is significantly smaller than the resource envelope that would become available if high-income countries reached the international commitment to provide 0.7 percent of GNI in ODA. If one deducts non-concessional public financing (OOF) then incremental ODA needs may fall substantially below $133-161 billion per year.

6.3. Limitations and outlook for future research

This illustrative financing analysis attempts to provide an initial answer to whether SDG financing needs in low- and lower-middle-income countries can be met through plausibly available private, domestic public, and international public resources. We underscore the preliminary and illustrative nature of this financing analysis and plan to issue a more extensive analysis of the financing strategy for the SDGs. Perhaps most importantly, the results are highly sensitive to projections of GDP, which may be considered optimistic in today's economic climate. Lower GDP growth rates would reduce domestic resource mobilization and thereby increase the external financing gap.

A more sophisticated financing analysis ought to consider more robust domestic resource mobilization estimates for the SDGs. For example, analyses should include government expenditure beyond central government ("general government expenditure") and develop more detailed assessments of the share of public expenditure dedicated to the SDGs. Government Spending Watch (GSW 2015) offers promising data to refine this analysis, even if the scope of the database does not cover all low- and lower-middle-income countries.

Additionally, future analyses should include debt financing to maximize opportunities for domestic resource mobilization. A country should only receive international concessional public finance if it cannot mobilize sufficient and financially sustainable debt financing in addition to private and domestic public resources. Of course, the country also needs to demonstrate effective use of international resources.

There are several reasons why opportunities for mobilizing domestic resources will also require a more granular analysis. First, countries' ability to mobilize domestic resources depends not only on per capita incomes, but also on the structure of the economy. For example, low-income countries that are rich in natural resources can more easily generate domestic public revenues than non-resource-rich countries at a similar level of per capita incomes. Minimum standards for domestic resource mobilization provide very useful benchmarks, but they must not be seen as a straightjacket that applies equally to every country.

Second, countries' growth rates depend in parts on the nature and volume of investments in various capital categories, such as human capital (health and education), infrastructure or business capital. Country-level macroeconomic modeling – perhaps using expanded versions of the World Bank's MAMS – can help us better understand future opportunities for mobilizing domestic resources and their impact on economic growth, including possibly adverse effects of changes in real exchange rate (including the Dutch disease phenomenon).

Third, we need to better understand the microeconomic implications of increases in domestic resource mobilization. In particular low-income countries mobilize resources through tariffs and consumption-based expenditure, which may be regressive. Poorly planned and excessive increases in taxation may undermine the very SDG objectives that countries need to achieve (Higgins and Lustig 2015).

On the international side, future analyses ought to pay greater attention to distinguishing between concessional and non-concessional international public finance. The latter can play a significant role in financing infrastructure and related investments, and it can be mobilized at a more modest cost (see for example, Bhattacharya *et al*. (2015) and Gutman *et al*. (2015).

7. Policy implications and areas for future research

The SDGs represent the most ambitious set of development objectives the world has ever agreed to. They describe an integrated universal agenda covering economic development, social inclusion, and environmental sustainability – all underpinned by sound governance. On current trends the world will miss the goals by a wide margin unless policies are improved, international cooperation is enhanced, and more public and private resources are brought to bear on financing the investments needed to achieve the SDGs (SDSN 2013).

Sound SDG sector needs assessments play an important role in operationalizing and achieving the SDGs. They (i) show how the SDGs can be achieved and help identify gaps in our understanding of implementation strategies or "production functions" for the goals; (ii) identify opportunities for private financing and policies needed to support private investments in the SDGs; (iii) estimate domestic public financing and residual international co-financing needs; and (iv) support resource mobilization and provide an accountability framework, as illustrated by the health sector (Global Fund 2013, Gavi 2014a, GFF 2015). As a result, sector needs assessments are now widely used and available.

Drawing on the experience of MDG sector needs assessments and their effectiveness, this paper proposes standards and an analytical framework for assessing the quality and robustness of SDG needs assessment. This framework is applied to available SDG needs assessments and shows that their quality varies considerably across the investment areas considered in this paper. Needs assessments in the social sectors – particularly health, but also education – tend to be strongest, while needs assessments for the environment, infrastructure, agriculture and food security are weakest. Investment needs for social protection remain to be estimated. Since estimates of financing needs for infrastructure account for the vast majority of total investment needs, the lack of robustness is particularly problematic. The framework also underscores that many SDG needs assessments do not systematically integrate climate change adaptation and mitigation.

For each SDG investment, the paper reports the best available estimates. Where necessary, these are adjusted to ensure consistency. When in doubt it reports the lower financing needs estimates. Therefore the results likely underestimates investment needs, particularly for infrastructure, agriculture and food security, health (non-communicable diseases), social protection, and possibly ecosystems.

The paper aggregates available needs assessments for low-income and lower-middle-income countries. Positive and negative synergies across SDG investment areas are important, but only some have significant implications on overall investment needs. This paper concludes that achieving the SDGs will require incremental annual investments of $342 – 355 billion in low-income countries and $903 – 938 billion in lower-middle-income countries. These investment needs total $1.3 trillion, accounting for 2 to 3 percent of world GDP, of which more than half can be financed privately.

A preliminary financing analysis suggests that investment needs in low-income countries cannot be met through domestic resources and private financing alone. Achieving the SDGs in these countries will therefore require not only significant increases in domestic resource mobilization and private investments, but also expanded international concessional and non-concessional public finance.

The situation is different in lower-middle-income countries that – as a group and averaged over the entire period – will likely be able to self-finance the vast majority of SDG investments through private and domestic public resources. Though not covered in detail in this paper, upper-middle-income and high-income countries will not require outside public financing to meet the investment needs. This neither means that such countries should not receive international transfers, which have in the past proven effective in helping address complex challenges, nor that they shouldn't be of an international political agreement to address climate change or other global priorities. Rather, the preliminary financing analysis presented in this paper suggests that upper-middle and high-income countries should be macroeconomically able to self-finance the needed investments if sound policies are put in place.

Whereas overall financing needs for the MDGs were in the order of billions, the SDGs will require a few trillion dollars in incremental financing. However, these headline figures hide many different types of financing flows. Only infrastructure financing needs are in the trillions of US dollars per year, and they can and should mobilize a substantial share of private investment. Incremental investment needs for health, education, food security, and other areas are in the order of tens of billions, but they overwhelmingly require concessional public financing. For each SDG investment area this paper identifies likely shares of private financing, which account for 41 – 50% percent of total incremental financing needs in both low-income and lower-middle-income countries.

In summary, this financing analysis suggests that financing needs for the SDGs are manageable given the extent of available global savings. Substantial increases in domestic resource mobilization will be required to ensure adequate resources. Private financing will account for a substantial share of SDG investments. Similarly, concessional international public finance, such as ODA, will also need to rise significantly as compared to the current levels, but the financing needs are well within the existing commitment of 0.7 percent of GNI.[20]

Four priorities for future research emerge from the analysis presented in this paper:

1. **Strengthen and update sector needs assessments** particularly for agriculture and food security, infrastructure, ecosystem services, and social protection. Methodologies should be reviewed to ensure that the results can effectively help guide national and global discussions on how the SDGs can be achieved and financed. Using the analytical framework developed in this paper, sectoral assessments can remove overlaps, fill gaps, and consider how synergies and trade-offs may be addressed. A particular priority needs to be placed on integrating climate change

[20] Today only five countries have met the 0.7 percent commitment: Denmark, Luxemburg, Norway, Sweden, and the United Kingdom. ODA from the Netherlands has recently slipped below 0.7 percent. Average ODA from members of the OECD DAC stands at 0.39 percent of GNI (OECD 2015).

adaptation and mitigation into the sector assessments using assumptions that are consistent across sectors. Needs assessments also must disaggregate between investments in tradables and non-tradables so that they can be expressed in $ PPP. They must also pay greater attention to understanding how quickly private and public investments can be scaled up to achieve the SDGs by 2030. Periodically updated sector needs assessments should be consolidated to guide global policy discussions on financing the SDGs.

2. **Develop country needs assessments and integrated, dynamic modeling for the SDGs.** The sector needs assessments can inform more detailed needs assessments at the country level that should take into account synergies across SDG investment areas and economy-wide effects. Integrated assessment tools and expanded computable-general equilibrium models (such as the World Bank's MAMS), that span the full range of SDG investments are needed to support country-level assessments of investment needs.

3. **Develop a robust financing strategy.** The indicative SDG financing framework identified in this paper needs to be improved by (i) assessing total (as opposed to incremental) investment needs for the SDGs; (ii) developing a framework for domestic resource mobilization, including through government bonds, and an associated debt sustainability analysis; and (iii) determining the potential for non-concessional international public finance and the role of the multi-lateral development banks. A forthcoming SDSN working paper will propose such a detailed financing strategy.

4. **Track financing flows against SDG needs assessments.** The international community, perhaps through UN organizations, should systematically track public and private investments in the SDGs and compare these flows against projected investments needs from SDG needs assessments. This will help refine our understanding of how the SDGs can be achieved, whether the world is on track towards achieving the Goals, and what changes might be needed in implementing the global partnership for the SDGs.

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Annex 1. Sustainable Development Goals

Goal 1	End poverty in all its forms everywhere
Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3	Ensure healthy lives and promote well-being for all at all ages
Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5	Achieve gender equality and empower all women and girls
Goal 6	Ensure availability and sustainable management of water and sanitation for all
Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10	Reduce inequality within and among countries
Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12	Ensure sustainable consumption and production patterns
Goal 13	Take urgent action to combat climate change and its impacts[21]
Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

For the full list of targets proposed by the Open Working Group for the SDGs, refer to OWG (2014).

[21] Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

Annex 2. Country Categories

High income		Upper-middle income		Lower-middle income		Low income	
				Non-IDA eligible	IDA eligible		Non-IDA eligible
Andorra	Kuwait	Angola°	Paraguay	Armenia	Bangladesh°	Afghanistan°	Korea, Dem. Rep.
Antigua and Barbuda	Latvia	Albania	Peru	Egypt, Arab Rep.	Bhutan°	Benin°	
Argentina	Liechtenstein	Algeria	Romania	El Salvador	Bolivia	Burkina Faso°	
Aruba	Lithuania	American Samoa	Serbia	Georgia	Cabo Verde	Burundi°	
Australia*	Luxembourg**	Azerbaijan	South Africa	Guatemala	Cameroon	Cambodia°	
Austria*	Macao SAR, China	Belarus	St. Lucia[i]	India	Congo, Rep.	Central African Republic°	
Bahamas, The	Malta	Belize	St. Vincent and the Grenadines[i]	Indonesia	Côte d'Ivoire	Chad°	
Bahrain	Monaco	Bosnia and Herzegovina	Suriname	Morocco	Djibouti°	Comoros°	
Barbados	Netherlands*	Botswana	Thailand	Philippines	Ghana	Congo, Dem. Rep°	
Belgium*	New Caledonia	Brazil	Tonga[i]	Swaziland	Guyana	Eritrea°	
Bermuda	New Zealand*	Bulgaria	Tunisia	Syrian Arab Republic	Honduras	Ethiopia°	
Brunei Darussalam	Northern Mariana Islands	China	Turkey	Ukraine	Kenya	Gambia, The°	
Canada*	Norway**	Colombia	Turkmenistan	West Bank and Gaza	Kiribati°	Guinea°	
Cayman Islands	Oman	Costa Rica	Tuvalu[i°]		Kosovo	Guinea-Bisau°	
Channel Islands	Poland*	Cuba			Kyrgyz Republic	Haiti°	
Chile	Portugal*	Dominica[i]			Lao PDR°	Liberia°	
Croatia	Puerto Rico	Dominican Republic			Lesotho°	Madagascar°	
Curaçao	Qatar	Ecuador			Mauritania°	Malawi°	
Cyprus	Russian Federation	Fiji			Micronesia, Fed. Sts.	Mali°	
Czech Republic*	San Marino	Gabon			Moldova	Mozambique°	
Denmark**	Saudi Arabia	Grenada[i]			Myanmar°	Nepal°	
Estonia	Seychelles	Iran, Islamic Rep.			Nicaragua	Niger°	
Equatorial Guinea	Singapore	Iraq			Nigeria	Rwanda°	
Faeroe Islands	Sint Maarten	Jamaica			Pakistan	Sierra Leone°	
Finland*	Slovak Republic*	Jordan			Papua New Guinea	Somalia °	
France*	Slovenia*	Kazakhstan			Samoa	South Sudan°	
French Polynesia	Spain*	Lebanon			São Tomé and Principe°	Tanzania°	
Germany*	St. Kitts and Nevis	Libya			Senegal°	Togo°	
Greece*	St. Martin	Macedonia, FYR			Solomon Islands°	Uganda°	
Greenland	Sweden**	Malaysia			Sri Lanka	Zimbabwe	
Guam	Switzerland*	Maldives[i]			Sudan°		
Hong Kong SAR, China	Trinidad and Tobago	Marshall Islands[i]			Tajikistan		
Hungary	Turks and Caicos Islands	Mauritius			Timor-Leste°		
Iceland*	United Arab Emirates	Mexico			Uzbekistan		
Ireland*	United Kingdom**	Mongolia			Vanuatu		
Isle of Man	United States*	Montenegro			Vietnam		
Israel	Uruguay	Namibia			Yemen, Rep.°		
Italy*	Virgin Islands (U.S.)	Palau			Zambia°		
Japan*	Venezuela, RB	Panama					
Korea, Rep.*							

Note: This table presents the 2015 classification. The historical evolution of country-income categories and country classifications is available at: http://go.worldbank.org/U9BK7IA1J0.

* Denotes OECD DAC member, ** Denotes OECD DAC member providing at least 0.7 percent of GNI in ODA, ° denotes Least Developed Country, [i] Denotes country benefiting from the small island economy exception: small islands (with less than 1.5 million people, significant vulnerability due to size and geography, and very limited credit-worthiness and financing options) have been granted exceptions in maintaining their IDA eligibility, [ii] Mongolia graduated to upper-middle-income status but is still eligible for IBRD "blend" lending. Sources: OECD, World Bank, United Nations.

Annex 3. Overview of infrastructure needs assessments

Several infrastructure needs assessments combine different types of infrastructure, which are separated in this paper: energy (section 4.5), water supply and sanitation (4.6), transport (4.7), and telecommunications (4.8). This annex reviews common findings from a broad range of reviewed infrastructure needs assessments (Table 18) and provides additional details on the two principal sources identified in the paper (World Bank 2013, UNCTAD 2014).

Table 18. Summary of selected infrastructure investment need studies

Study	Fay *et al.* (2011)	Bhattacharya *et al.* (2012)	Yepes (2008)	McKinsey (2013)	BCG (2013)	WEF and PWC (2012)	Green Growth Alliance (2013)
Infrastructure investment needs ($ billion)	175 – 700	1000 - 1400	1114	3200 – 3700	1000 – 1500	1000	3500
Power	-	45-60%	388	-	-	-	619
Telecommunications	-	10-15%	107	-	n/a	-	600
Transport	-	15-25%	509	-	-	-	805
Water and Sanitation	-	15-30%	110	-	-	-	1320
Accounting for climate adaptation and mitigation investment needs	No	200-300 (included in total needs)	No	No	No	No	An additional 139 billion is included for greening energy investments
Geographic coverage	Developing countries	Developing countries	Developing Countries	Global	Global	Global	Global
Capex/Opex	Capex only	Capex only	Capex & Opex	Capex only	Capex only	Capex & Opex	Capex only
Total/Incremental	Incremental	Incremental	Unspecified	Total	Incremental	Incremental	Total
Notes	-	-	-	-	Includes social infrastructure	-	Full estimate covers other areas including vehicles, forestry, buildings and industry, and agriculture.

Source: Author's analysis

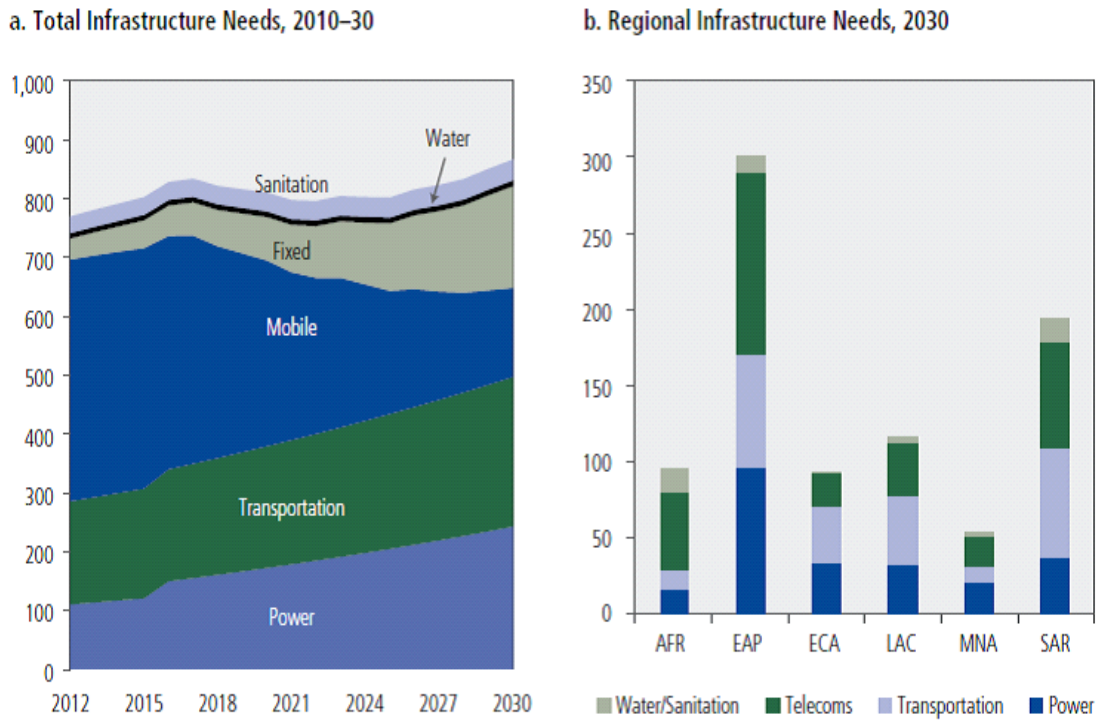
Many methodologies for infrastructure needs assessments remain incomplete and are subject to axiomatic assumptions that to a large extent determine results. Many reports estimate infrastructure investment needs as a function of projected GDP growth and country-level elasticities of infrastructure spending to growth. While this approach may be well-suited to high-income economies that have relatively well developed stocks of infrastructure, this approach does not meet the needs of low- and lower-middle-income countries. As a result, most infrastructure needs assessments are not "goal-based"

and do not project investment needs to close specific access gaps or to achieve minimum coverage standards. In fact many infrastructure needs assessments assume a faster growth of per capita infrastructure stock in richer countries and a divergence with low-income countries. Achieving the SDGs would require, however, that the per capita infrastructure stock in low- and lower-middle-income countries catches up with upper-middle-income and high-income countries.

On balance infrastructure needs assessment therefore underestimate investment needs in low- and lower-middle-income countries. However, McKinsey analysis (Palter and Pohl 2013) suggests that up to 40 percent of infrastructure investments can be saved annually through optimizing project identification and selection, streamlining project delivery, and getting more out of existing infrastructure. Contrary to this finding, Flyvbjerg (2009) shows that most infrastructure projects tend to come in over-time and over-budget. These competing drivers of change must be analyzed carefully to arrive at more robust infrastructure needs assessments.

This paper generally retains the World Bank (2013) estimates (Figure 2), because they have been developed with a common methodology and are more conservative than UNCTAD (2014).

Figure 2. Annual incremental infrastructure investment needs in developing countries in $ billion



Source: World Bank 2013

Infrastructure needs assessments and the policy discussions all too often ignore the need for making infrastructure investments sustainable. For example, 2014's G20 meeting in Brisbane, Australia, focused on infrastructure but was conspicuously silent on the need to ensure that such infrastructure be resilient to climate change and be consistent with limiting the increase in global greenhouse gas emissions to no more than 2°C (G20 2014).

Infrastructure investment needs are highly sensitive to assumptions about climate change adaptation and mitigation needs, so efforts to account for these investment needs in the infrastructure sector show large variations. Bhattacharya *et al.* (2012) report investment needs of $100 to $200 billion annually by 2020 for climate mitigation alone, adding another $70 to $100 billion for adaptation investment needs under a 450ppm scenario. The overall range of $200 to $300 billion represents a 12.5 – 15 percent increase in infrastructure investment needs by 2020 ($1.6 to $2 trillion).

For mitigation, the Green Growth Alliance (2013) estimates global incremental net investments, in power generation, transport vehicles, energy efficiency in buildings and industry and forestry, of $700 billion per year to 2030 to achieve climate stabilization at 2°C. This aggregate figure includes the repurposing of $146 billion of investments in energy under the business-as-usual scenario that are redirected towards low-carbon power production and energy efficiency measures. Indeed, this transition to a low-carbon energy system is a defining challenge for the power sector, and will require large-scale investments.

The most comprehensive assessment of incremental infrastructure investment needs for climate change mitigation and adaptation is the World Bank Economics of Adaptation to Climate Change (EACC) Report (World Bank 2010). UNFCCC (2007) and Stern (2007) estimate mark-ups for climate change adaptation.

Most infrastructure needs assessments do not include maintenance and operating costs, which can add up to 4 percent of GDP (Yepes 2008). The exclusion of maintenance and operating costs for infrastructure is problematic since it complicates the comparison of low-carbon and "traditional" infrastructure. For example, low-carbon power generation tends to have higher upfront investment costs, but in turn it has substantially lower operating costs. Only by comparing the full operating and capital cost of different technologies can one get a true sense of their relative financial performance. Table 19 shows how O&M investment needs can be accounted for using data from Foster and Briceño-Garmedia (2010, table O.3) and World Bank (2013).

Table 19. Scale-up of infrastructure investment needs to include operational expenditure.

	Incremental investment needs in Capex as reported by World Bank (2013) (Constant 2010$)	Opex as % of infrastructure spending, based on estimates by Foster and Briceño-Garmedia (2010)	Incremental investment needs (Constant 2010$)	Incremental investment needs (Constant 2013$)	Incremental investment needs adjusted for overlaps (Constant 2013$)	
					Low	High
Power	228	34.6%	349	368	346	353
Transport	283	51.6%	585	617	617	617
Telecommunications	238	22.2%	306	323	323	323
Water & Sanitation	32	32.0%	47	50	2	2
Overall	**781**	**39.4%**	**1286**	**1356**	**1288**	**1294**

Sources: Author's calculations, based on World Bank (2013) and Foster and Briceño-Garmedia (2010). Adjustments for overlaps based on estimates by Hutton (2015) for water and sanitation, and Pachauri *et al*. (2013) for power.
Note: These numbers do not include incremental investment needs for climate mitigation and adaptation and have not been scaled down to cover only LICs and LMICs. Numbers have been rounded and may not add up exactly.

Since infrastructure investments account for a very large share of overall investment needs in the SDGs, a top priority over coming years should be getting more clarity on infrastructure investment needs. Given the difficulty of making bottom-up projections for infrastructure investment needs at global or even regional levels, analysts should consider detailed country studies that compare infrastructure spending needs based on GDP growth projections with a bottom-up assessment of the infrastructure stock needed by 2030 to deliver the SDGs.