Technical Appendix to Chapter 3 of ESCAP Survey 2019

Investment needs to achieve the Sustainable Development Goals

Together with better policies, increased investment is required to accelerate progress across the Sustainable Development Goals. For governments to plan, budget and mobilize funds more effectively, they could benefit from a comprehensive assessment of the investment requirements.[1] This technical appendix complements the analysis contained in Chapter 3 of *Economic and Social Survey of Asia and the Pacific 2019*.

[1] According to Schmidt-Traub (2015), there are four principal reasons why robust needs assessments covering public and private flows must be conducted for the SDGs: First, to show how the SDGs can be achieved and to identify gaps in our understanding of implementation strategies or "production functions." Second, to understand opportunities for private financing and policies needed to support private investments in the SDGs. Third, to estimate domestic public financing, residual international co-financing needs, and supportive macroeconomic frameworks. Fourth, to support resource mobilization and provide an accountability framework.

1. Selected literature review

Several previous studies have estimated the investment requirements to achieve international development goals, including the Millennium Development Goals (MDGs) which preceded the Sustainable Development Goals (SDGs). The table below summarizes the main findings and the methodology of selected studies with relatively broad coverage of SDGs.[2] These estimates vary in scope, baselines, targets and other assumptions and are therefore not directly comparable. Nevertheless, they all point to the need for a considerable boost to future investment to promote sustainable development.

Table A.1. Selected literature review on SDG costing

	Sectoral coverage	Main findings	Methodology
Comprehensive SDG coverage, global			
UNCTAD (2014)	10 sectors including power, transport, telecommunications, water and sanitation, food security and agriculture, climate change mitigation, climate change adaptation, biodiversity, health, and education	Globally, total investment of $5-7 trillion is needed per year to implement the Goals, with an annual average investment gap of $2.5 trillion for developing countries over 2016-2030	Aggregation of existing sectoral cost estimates, with few modifications; no geographic breakdown
SDSN (2015)	Similar to UNCTAD (2014) but climate change is mainstreamed into other sectors rather than explicitly costed; additional elements are data for SDGs and humanitarian work; social protection is discussed but not costed	Globally, an annual average investment gap of $1.4 trillion per year, or 11.5 percent of GDP, for low income countries and lower-middle income countries	Aggregation of existing sectoral cost estimates, with few modifications; no geographic breakdown
IMF (2019)	5 sectors including education, health, roads, electricity, water and sanitation; does not cover environmental dimension	Globally, an additional $2.6 trillion for developing countries in 2030 (no annual average reported) – including $2.1 trillion for 73 emerging market economies and $0.5 trillion for 49 low income developing countries	Country-level costing based on a simplified sectoral costing model; applies peer benchmarking based on SDSN's SDG index
Comprehensive SDG coverage, regional			

[2] Goal-specific costing methodologies are discussed under each sector.

ESCAP (2013)	4 sectors including education, health, social protection – consisting of employment guarantee, social pension and disability benefits – and electricity	For 10 Asia-Pacific developing countries, total investment of $500-800 billion is needed per year, with required investment as percentage of GDP rising gradually through 2030; investment needs are relatively low in China and Russia, and high in Bangladesh and Fiji	Country-level costing based on a simplified sectoral costing model; applies global benchmarks or regional good practices
ESCAP (2015)	Based on studies which address education, health, social protection, infrastructure, climate action; but does not provide sectoral breakdown	For Asia-Pacific region, total investment of $2.1-2.5 trillion is needed per year through 2030	Aggregation of existing multi-sector cost estimates – ESCAP (2013), ADB (2009) and others; no geographic breakdown
Sustainable infrastructure, regional and global			
ADB (2017)	4 infrastructure sectors – electricity, transport, ICT and water and sanitation – with climate proofing	For developing Asia, infrastructure investment need of $1.7 trillion per year during 2016-2030; and for a smaller set of countries, an annual investment gap of $460 billion or 2.4 percent of GDP during 2016-2020	Future infrastructure demand projection (based on panel regression) and application of unit costs; mark-ups to account for climate change
ESCAP (2017)	The above 4 infrastructure sectors with climate proofing	Investment need of 10.5 percent of GDP during 2016-2030, compared to current spending of 4.0-7.5 percent, in 26 Asia-Pacific least developed countries, landlocked developing countries, and small island developing States	Similar to ADB (2017); additional element is convergence of capital stock to the regional average, given wide infrastructure deficits in these countries
IEA (2018)	Power sector, plus efficiency gains in transport, building and industry sectors; provides energy scenarios which are consistent with the Paris climate agreement	Globally, total investment of $2.6 trillion is needed per year to meet growing energy demand through 2040; a sustainable development scenario requires 15 percent higher investment, with marked difference in capital allocation	Future energy demand projection (based on model scenarios) and application of unit costs; energy efficiency investment is defined by the additional amount that consumers have to pay
WB (2019)	3 infrastructure sectors – electricity, transport and water and sanitation – plus flood protection and irrigation	Globally, investments of 4.5 percent of GDP will enable developing countries to achieve infrastructure-related SDGs and stay on track on climate goals; provides a cost range of 2-8 percent of GDP depending on the quality and quantity of service targeted and the spending efficiency	Future infrastructure demand projection (based on model scenarios) and application of unit costs; greater attention to operation and maintenance costs

Several quantitative approaches have been used to estimate the required financial cost of MDGs and SDGs. There is no consensus on which methodology works best. Partly, this is because there is a trade-off between the ease and rigor of different models. As expected, the methods that are considered easier to implement (such as intervention-based needs assessments and unit costs) cannot capture some desirable technical aspects of integrated models. In contrast, the methods that can potentially capture spillover effects are relatively difficult to calculate and interpret. Below table highlights some of the pros and cons of different costing approaches used in the literature.

Table A.2. Pros and cons of different costing approaches

Approach	Brief description	Advantage	Disadvantage
Incremental capital-output ratio (ICOR) and other growth models	Estimate the size of fixed investment that is required to achieve a target per capita GDP growth rate, which would in turn reduce poverty to a target level (based on growth-poverty elasticities)	Simple to calculate	- Simply extrapolate the past into the future - Obtaining ICORs is prone to error as it is based on cross-country regressions - Cannot yield investment needs at a disaggregated level
Simple unit cost estimates or input-output elasticities	Growth regressions on infrastructure to project future infrastructure needs, then compare to current infrastructure stock, and apply a unit cost.	- Simple to calculate - Can be applied to a large group of countries	- Simply extrapolate the past into the future - Results are sensitive to unit costs - Cannot take into account synergies, trade-offs and economy-wide effect of SDG investment
Intervention-based needs assessment	Specify interventions (e.g. provision of goods, services or infrastructure) that are required to achieve certain SDGs, then apply relevant unit costs.	- Simple to calculate - Can be highly disaggregated (e.g. rural/urban populations)	- Cannot take into account synergies, trade-offs and economy-wide effect of SDG investment
Computable General Equilibrium	Changes are introduced to CGE model to estimate investment needs for different policy options	- Take into account synergies, trade-offs and economy-wide effect of SDG investment	- Computational complexity - Data requirements

Source: Compiled from Schmidt-Traub (2015).

2. Methodology overview of Survey 2019

ESCAP *Survey 2019*'s SDG costing analysis is a response to the felt **need for a comprehensive and detailed assessment** focusing on Asia and the Pacific. Most existing studies are either partial in their coverage of the Goals or comprehensive but do not provide details or geographical breakdown, and therefore cannot provide concrete guidance for action.

Consistent with the 2030 Agenda for Sustainable Development, *Survey 2019* **adopts a broad definition of investment to include expenditures if they deliver clear social returns**. Thus, compared to previous studies which focus on capital expenditures and physical infrastructure, our investment package includes social protection as well as health and education, **devoting more to people**. Compared to previous studies, we also **devote more to the planet**, by going beyond electricity access to also explicitly cost an ambitious shift from fossil fuels to renewables and enhancements in energy efficiency, as well as interventions on biodiversity and ecosystems.

Compared to previous studies, *Survey 2019* aims to **establish a clear linkage between the Goals/targets, the interventions, the investment needs**, and the financing and policy considerations, so that the analysis does not stop at the "price tag" but serves as a useful tool for countries (Table A.3). In general, we focus on **additional investments needed** to accelerate progress and reach the Goals/targets. In general, we compare total projected needs to estimated current investment to derive the gap.[3]

Compared to some previous studies which use simplified sectoral models or back-of-the-envelope calculations, the *Survey 2019* analysis is based on relatively elaborate **costing models used by UN and other specialized agencies in their respective areas of work** – for instance, the WHO for health, UNESCO for education and the IEA for energy (Table A.4). For some sectors, we adopt existing published estimates for Asia-Pacific developing countries. For others, we make extensions to expand country coverage, introduce high- and low-cost scenarios, and apply country-specific unit costs or mark ups.

In *Survey 2019*, most of the costing models for social and infrastructure investments are based on **specific interventions and unit costs**. For energy and environmental goals, we use **CGE or integrated assessment models** – such as the IEA World Energy Model and the CSIRO Global Trade and Environment Model. As noted in Table A.2, there are pros and cons of such approaches but the latter is able to illustrate co-benefits as well as provide cost estimates. In particular, as decoupling social and economic progress from environmental degradation is a priority for the Asia-Pacific region, our results illustrate that investments to aid a faster transition to more resource efficient systems of consumption and production would over time deliver substantial returns and eventually fully offset the financial cost.

[3] There are two exceptions. First, in some countries, implementing a social protection floor would cost less than their current social protection spending. However, current composition is heavily geared towards pensions for a small group of the population and even other categories, such as child or maternity benefits, do not have a wide coverage. Thus, the cost for establishing a social protection floor is considered as an additional investment. Second, for clean energy, the investment estimates refer to new energy infrastructure needs, i.e. total energy infrastructure needed to meet the future energy demand netting out the existing infrastructure. Thus, the cost is considered as incremental.

Country coverage varies by sector, with education and infrastructure costs provided for nearly or more than 40 Asia-Pacific countries, while agriculture, nutrition and health covering just under 20 countries (Table A.5). Countries with large GDP and/or population such as China, India and Indonesia are covered in all sectors, such as that more than 90 percent of combined GDP and/or population of developing Asia-Pacific region is typically covered.[4] Thus, with some approximation, *Survey 2019* expresses the aggregated investment need in terms of the region's GDP.

For consistency, a common **reference year** (2016 prices) has been adopted and **United Nations projections through 2030** applied for key variables, such as GDP, population and urbanization.

Table A.3. Targets, interventions, financing and policy options

Investment area	Targets	Interventions	Financing options	Other policy considerations
Education	Universal pre-primary to upper-secondary education of quality and equity	Higher enrolment, more and better-paid teachers, support for marginalized students	National budget	Effective teaching methods and school management
	Higher post-secondary education enrolment		National budget and household spending	
Health	Universal health coverage	More doctors and nurses, hospitals and clinics, stronger supply chain and information system, equitable access to health care services	Mix of contributory and non-contributory schemes; sin tax	Population-wide preventive outreach; early screening; interventions in non-health sectors
Social protection	Universal basic income security throughout the life cycle	Child, orphan and maternity benefits, public works, disability and old-age benefits	Mix of contributory and non-contributory schemes	Protection for those in vulnerable employment; social consensus
Energy	Universal access to electricity and significant increase in share of renewables	Power generation and distribution; investment in renewables	National budget; leveraging private investment through PPP, loan guarantees, public equity co-investments; renewable energy	Long-term and clear energy targets and purchasing policies; preferential tax for renewables; fossil fuel subsidy reform
	Universal access to	Purchase of clean		

[4] An exception is for costing of transport, ICT, and water and sanitation infrastructure, where China, Republic of Korea and Singapore was excluded as their estimated current investment levels exceeded the projected total investment need, i.e. a negative investment gap. Given that annual additional investment needed in such infrastructure is $196 billion, out of $1.5 trillion for all SDG sectors, the use of different base does make a major difference in the main result, that the price tag is equivalent to 5 percent of the region's in 2018.

	clean cooking	cooking stoves	auction	
Transport	Equitable access to urban and rural roads and railways	More paved roads and railways	National budget; PPPs; ODA; project funding (e.g. MDBs)	Urban mobility and cross-border transport; transport safety; climate-resilience
ICT	Universal access to fixed and mobile broadband	Increased broadband investment and subscriptions	National budget; PPPs; Universal Access and Services Fund	Regulatory reforms and pricing policy; non-infrastructure measures to close digital divide (e.g. education, business models)
Water and sanitation	Universal coverage of water and sanitation services	Piped and treated household connection to water supply in rural and urban areas; provision of septic tank in rural area, sewerage with treatment in urban area	Taxes and transfers; service provider tariffs; user investment in self-provision; vendor or supplier finance; microfinance, commercial loans, bonds, equity, blended finance	Participation of local governments and women in WASH management; behavioural change to sustain hygienic practice
Climate action	Mitigation	Additional investment to increase the share of renewable energy in total energy mix, and to procure energy efficient equipment in industry, buildings and transport sectors	National budget; carbon pricing, including carbon tax, emission trading schemes; green bond	Clear policy framework and signals; embed climate change risks in financial regulations; regional cooperation
	Adaptation	A mark-up based on investment needs to build climate resilience into infrastructure	National budget, PPPs; ODA; project funding (e.g. MDBs)	
Resources efficiency	Lower material input and consumption per GDP unit	Selected interventions in housing, mobility, food and energy		Shifts in consumption behaviours
Biodiversity and ecosystems	Reducing pressure on biodiversity, safeguarding ecosystems	Various actions envisioned under the Strategic Plan for Biodiversity and forest and oceans agreements	National budget; Global Environment Facility	

Table A.4. Methodology summary by sector

Dimension	Investment area	Goal	What is included in the estimates	Estimate (annual)	Model owner/Reference	Logic of the model	No. of countries covered	Availability of country level estimates
People	Basic human rights	1 NO POVERTY	**Targeted cash transfer** Target 1.1	32 billion	FAO, IFAD and WFP (2015)	A targeted transfer to close the gap between earned incomes and the poverty line. The poverty line is set at $1.25 PPP a day with a buffer of 40 per cent to deal with income shocks.	25	Yes
			Social protection floor Target 1.2 and 1.3	317 billion	Ortiz and others (2017)	A social protection floor to provide: (a) allowances for all children and all orphans; (b) maternity benefits for all women with newborns (4 months); (c) benefits for all persons with severe disabilities; and (d) universal old-age (65+) pensions. The benefit level is set at the national poverty threshold.	24	Yes
		2 ZERO HUNGER	**Nutrition-specific interventions** Target 2.2	3.5 billion	Shekar and others (2017)	unit cost × number of people × incremental coverage assumed Nutrition specific interventions include: (a) reduced stunting in children under 5; (b) reducing anaemia in women; (c) increasing the prevalence of exclusive breastfeeding among infants; (d) mitigating impacts of wasting among young children.	17	Yes
			Agricultural productivity Target 2.3	20.6 billion	FAO, IFAD and WFP (2015)	The additional investment required is the difference between investments required under the zero hunger scenario and the business-as-usual scenario developed by FAO. Possible domains for additional investment in rural areas -- such as in primary agriculture and agroprocessing -- are identified based on Schmidhuber, Bruinsma (2011), which provided long-term projections for the agricultural sector.	16	Only at subregion level (East Asia and South Asia) based on FAO's definition
	Human capacity	3 GOOD HEALTH AND WELL-BEING	**Universal health coverage** Target 3.8	158 billion	Stenberg and others (2017)	Quantities x price The framework scales up investment to strengthen health system to reach universal health coverage (UHC). It assumes that specific SDG 3 targets are an integrated part of the broader attainment of UHC. Scaling up health system involves a progressive expansion of service coverage of 187 essential health interventions delivered through five delivery platforms; health system components (health workforce, infrastructure, supply chain, information system, financing policy & governance); and prevention and management of risk and emergencies. The pace of scale up to identified benchmarks will depend on the level of development of existing health system, resources and current service delivery performance of each country. To model the scale up curves, health interventions and health system components by country, by year, are multiplied by country-specific prices through the OneHealth Tool (OHT), a software application was developed and overseen by the UN Inter Agency Working Group on costing.	19	Costing is done at country level but results are reported only by country group. Pacific is not included.
		4 QUALITY EDUCATION	**Universal access to quality education** Target 4.3 and 4.4	138 billion	UNESCO	unit cost × increased enroled students Enrilment ratio is assumed to reach 100 per cent in 2030 from pre-primary to upper secondary education Unit cost includes (a) teachers' salaries (number of teachers are based on teacher to student ratio), (b) non-salary recurrent expenditures; (c) infrastructure and facilities, etc. Quality of education is reflected by teacher to student ratio, drop-out rate, repetition rate etc.	37	Yes
Prosperity	Transport	11 SUSTAINABLE CITIES AND COMMUNITIES	**Universal access to safe, affordable, accessible and sustainable transport** Target 11.2	126 billion	ESCAP (2017) ADB (2017) Fay (2003)	Unit cost × total demand - current spending Transport includes: (a) paved roads, (b) unpaved roads, (c) railway. Ports and airports are NOT included.	47	Yes
	ICT	9 INDUSTRY, INNOVATION AND INFRASTRUCTURE	**Significantly increase access to information and communications techonology** Target 9.c	56 billion		Unit cost × total demand - current spending Total demand is calculated by estimating the total investment required to provide the ICT infrastructure stock needed to meet future demand based on assumptions of urbanization ratio, economic growth for fixed broadband with additions of access to electricity power and power consumption for mobile broadband, second by estimating maintenance and climate change mitigation costs, and third by estimating the current investment levels to derive the investment gap. Country-level unit costs provided by International Telecommunication Union (ITU). The unit costs cover: (a) unit cost for grounding fixed broadband infrastructure per subscription unit, and (b) unit cost for building up infrastructure for mobile broadband access For fixed broadband, low and high costs are applied. For high cost scenario, the average of the two highest fibre-to-the-home construction costs per subscriber of countries in the region is used.	47	Yes
	Water and sanitation	6 CLEAN WATER AND SANITATION	**Universal access to safe and affordable drinking water and ending open defecation** Target 6.1 and 6.2	14 billion		Unit cost × total demand - current spending High and low cost scenarios are applied. The low-cost scenario refers to the basic level of service where an improved water source is within a 30-minute round trip; the high-cost scenario refers to the "safely managed level" level of service where water and sanitation infrastructure is within the premises.	47	Yes

Dimension	Investment area	Goal	What is included in the estimates	Estimate (annual)	Model owner/Reference	Logic of the model	No. of countries covered	Availability of country level estimates
Planet	Securing humanity's future		**Universal access to affordable, reliable, and modern electricity** Target 7.1	10 billion	International Energy Agency The estimates are based on World Energy Outlook 2018 (IEA, 2018)	Unit costs × new energy infrastructure demand New energy infrastructure demand is based on the projected total energy demand minus existing energy infrastructure. Demand for different type of renewable energies (including solar, wind, hydro, bioenergy and etc) is based on scenarios. The scenario used in the report is IEA's Sustainable Development Scenario, which is in line with the 2 degree target of the Paris Agreement and target 3.9 (reduce the number of deaths due to air pollution).	45	Only available for the major economies (China, India, Japan, Republic of Korea and Russian Federation). The rest are by country groups.
			Significantly increase renewable energy's share in the energy mix Target 7.2	242 billion				
			Universal access to clean cooking solutions Target 7.1	2 billion		Ditto. Different clean cooking solutions include: natural gas, liquefied petroleum gas (LPG), electricity and biogas, or technologies such as improved biomass cookstoves.		
			Double the rate of improvement in energy efficiency Target 7.3	180 billion		The investment is defined by the additional amount that consumers have to pay for higher energy efficiency. It is the amount that is spent to procure equipment that is more efficient than a baseline, including taxes, freight costs and labour costs that are directly related to an installation. Energy efficiency in industry, buildings and transport sectors are included.		
			**Improve climate resilience of infrastructure (climate adaptation)**	182 billion	ADB (2017) World Bank (2016)	This is a mark-up based on the investment needs estimated to meet the infrastructure demand, including: (a) Capital cost: At least 5 per cent of total capital investment is required as cost of protecting infrastructure against changes in rainfall and temperature. 20 per cent for Pacific SIDS. (b) Maintenanace cost:Additional 0.5 percentage points of maintenance cost for new and existing infrastructure is also employed for all countries (c) Replacement cost: An additional 5 per cent replacement cost for Pacific SIDS.	47	Yes
			Transform the energy sector and improve energy effiency to reduce carbon emissions (climate mitigation)	191 billion	International Energy Agency. Estimates are based on World Energy Outlook 2018 (IEA, 2018)	The estimate is the difference between costing for SDG 7 under Sustainable Development Scenairo and a business as usual scenario, i.e. how much extra investment is needed to meet the 2 degree goal.	45	Only available for the major economies (China, India, Japan, Republic of Korea and Russian Federation). The rest are by country groups.
	Sustainable consumption and production		**NOT INCLUDED IN THE FINAL RESULTS**					
	Protection for nature		**Biodiversity and ecosystems, based on the Strategic Plan for Biodiversity 2011-2020 and associated Aichi targets**	156 billion	CBD (2012)	At the global level, additional investment needs for meeting the 20 Aichi targets were estimated, with interventions ranging from those aimed at addressing the drivers of biodiversity loss, such as reducing pollution, to protected areas (terrestrial and amrine) and reducing habitat loss (forests and wetlands). Given the lack of geographical disaggregaton, it is assumed that the Asia-Pacific region accounts for half of the global estimate.	N/A	No
Investment efficiency			**Education, healthcare and infrastructure investment**			Construct an efficiency frontier based on the observed outputs-inputs patterns, then the efficiency is estimated based on countries' distance to the efficiency frontier. The inefficiency is measured as either input inefficiency or output inefficiency.		

Table A.5. Country coverage by sector

	Poverty gap transfers	Social protection floor	Agriculture	Nutrition	Education	Health	Transport	ICT	Water, sanitation & hygiene	Energy	Climate change	Biodiversity	Resource efficiency
East and North East Asia													
China	•	•	•	•	•	•	•	•	•	•	•		•
Democratic People's Republic of Korea	•		•							•			
Hong Kong China	•												
Macao, China													
Mongolia	•	•			•		•	•	•	•	•		
Republic of Korea	•		•				•	•	•	•	•		•
North and Central Asia													
Armenia		•			•		•	•	•	•	•		
Azerbaijan		•			•	•	•	•	•	•	•		
Georgia		•			•		•	•	•	•	•		
Kazakhstan		•			•	•	•	•	•	•	•		
Kyrgyzstan		•			•		•	•	•	•	•		
Russian Federation	•						•	•	•	•	•		•
Tajikistan					•		•	•	•	•	•		
Turkmenistan		•			•		•	•	•	•	•		
Uzbekistan				•	•	•	•	•	•	•	•		
Pacific islands developing economies													
Cook Islands										•			
Fiji					•		•	•	•	•	•		
French Polynesia							•	•	•	•	•		
Kiribati					•		•	•	•	•	•		
Micronesia, Federate States					•		•	•	•		•		
New Caledonia							•	•	•	•	•		
Palau							•	•	•		•		
Papua New Guinea				•	•		•	•	•	•	•		
Samoa					•		•	•	•	•	•		
Solomon Islands					•		•	•	•	•	•		
Tonga					•		•	•	•	•	•		
Tuvalu							•	•	•		•		
Vanuatu					•		•	•	•	•	•		
South and South-West Asia													
Afghanistan	•	•			•	•	•	•	•	•	•		
Bangladesh	•	•	•	•	•	•	•	•	•	•	•		
Bhutan		•			•		•	•	•	•	•		
India	•	•	•	•	•	•	•	•	•	•	•		
Iran (Islamic Republic of)	•				•	•	•	•	•		•		
Maldives					•		•	•	•	•	•		
Nepal	•	•	•	•	•	•	•	•	•	•	•		
Pakistan	•	•	•	•	•	•	•	•	•	•	•		
Sri Lanka	•	•	•	•	•	•	•	•	•	•	•		
Turkey	•	•		•	•	•	•	•	•		•		
South-East Asia													
Brunei Darussalam										•			
Cambodia	•	•	•	•	•	•	•	•	•	•	•		
Indonesia	•	•	•	•	•	•	•	•	•	•	•		•
Lao People's Democratic Republic	•	•	•	•	•		•	•	•	•	•		
Malaysia	•	•	•		•	•	•	•	•	•	•		
Myanmar	•	•	•	•	•	•	•	•	•	•	•		
Philippines	•	•	•	•	•	•	•	•	•	•	•		
Singapore							•	•	•	•	•		
Thailand	•	•	•	•	•	•	•	•	•	•	•		
Timor-Leste				•	•		•	•	•	•	•		
Viet Nam	•	•	•	•	•	•	•	•	•	•	•		
Developed economies in Asia-Pacific													
Australia	•						•	•	•	•	•		•
Japan	•						•	•	•	•	•		•
New Zealand	•						•	•	•	•	•		•
Total countries covered	25	24	16	17	37	19	47	47	47	45	47	0	7

Note: Country coverage for biodiversity is shown as zero because geographic breakdown was not available. For resources efficiency, in addition to these major economies, the costing model covers several country groups.

3. Social protection floor

The annual cost for a given benefit category – such as child or maternity benefits – is generally the product of the estimated beneficiary population and the unit cost of the benefit. The beneficiary population is determined by the eligibility criteria, which is categorical and not determined by a means-test. The unit benefit level is set at the national poverty line, or a percentage of it.

Table A.6. shows country results generated by the ILO Social Protection Calculator and Table A.7. the national poverty lines in relation to the per capita income. One of the main concerns stemming from the costing results is the fact that countries with similar demographic structure and similar level of development show very different costs for the comparable set of benefits. This can be traced back to the use of the national poverty line as the basis for the calculation of the benefit level (Ortiz and others, 2017).

Table A.6: Cost of universal social protection floors (as a percentage of GDP)

Country	Universal child benefits	Universal old-age pension benefits	Universal unemployment benefits	Universal disability benefits	Universal maternity benefits
East and North-East Asia					
China	0.2	0.5	0.1	0.1	0.0
Mongolia	0.3	0.1	0.1	0.1	0.0
South-East Asia					
Cambodia	2.8	1.4	0.8	0.7	0.3
Indonesia	0.7	0.5	0.4	0.2	0.1
Lao PDR	1.8	0.8	1.2	0.4	0.2
Malaysia	2.3	2.2	0.1	0.8	0.2
Philippines	0.7	0.4	0.3	0.2	0.1
Thailand	0.5	1.2	0.1	0.3	0.0
Viet Nam	1.3	1.5	0.3	0.5	0.1
South and South-West Asia					
Afghanistan	7.1	1.6	1.5	1.5	0.7
Bangladesh	3.2	2.2	2.1	0.9	0.3
Bhutan	1.1	0.8	0.1	0.3	0.1
India	0.9	0.7	0.4	0.3	0.1
Nepal	3.0	2.0	1.1	0.8	0.3
Pakistan	1.6	0.8	0.5	0.4	0.2
Sri Lanka	0.6	0.9	0.1	0.2	0.1
Turkey	1.7	2.0	0.1	0.6	0.2
North and Central Asia					
Armenia	1.5	3.6	0.8	0.8	0.2
Azerbaijan	1.3	1.3	0.1	0.5	0.2
Georgia	1.0	3.2	0.5	0.6	0.1
Kazakhstan	0.5	0.5	0.0	0.1	0.1
Kyrgyzstan	3.7	2.0	1.2	0.9	0.4

Source: Calculated using ILO's Social Protection Floors Calculator and ILO's World Social Protection Report 2017-19 latest available year data on public expenditure on social protection

Table A.7: National poverty lines and GDP per capita floors (in LCU)

Country	National poverty line per year (in LCU)	GDP per capita (in LCU)	Ratio
East and North-East Asia			
China	9,984	43,745	0.23
South-East Asia			
Cambodia	1,763,131	5,193,484	0.34
Indonesia	4,276,296	45,728,103	0.09
Lao PDR	2,614,712	13,025,267	0.20
Malaysia	13,606	36,644	0.37
Philippines	10,969	128,890	0.09
Thailand	23,522	217,410	0.11
Viet Nam	9,544,290	44,078,168	0.22
South and South-West Asia			
Afghanistan	23,932	38,034	0.63
Bangladesh	33,230	78,065	0.43
Bhutan	23,458	147,749	0.16
India	18,898	70,729	0.27
Nepal	24,275	68,763	0.35
Pakistan	30,453	167,520	0.18
Sri Lanka	48,403	500,441	0.10
Turkey	6,692	26,684	0.25
North and Central Asia			
Armenia	500,033	1,561,933	0.32
Azerbaijan	1,657	7,320	0.23
Georgia	1,762	8,039	0.22
Kazakhstan	153,128	2,281,037	0.07
Kyrgyzstan	32,256	70,035	0.46

Source: Calculation done by Ortiz et al. (2018) based on UN World Population Prospects, IMF World Economic Outlook, ILO World Social Protection Database, OECD, national sources.
Notes: Note: The national poverty lines in this table refer to absolute poverty lines reflect poverty lines used in official national reports; in local currency units (LCU) per adult, per year, updated to the year 2015, using the respective CPI change. Absolute poverty lines are aimed to all basic needs, meaning they are different (higher) than the food poverty line. Except for China, Japan, India, and Turkey, the national poverty lines refer to relative poverty lines which correspond to 50 per cent of the median equivalent disposable income.

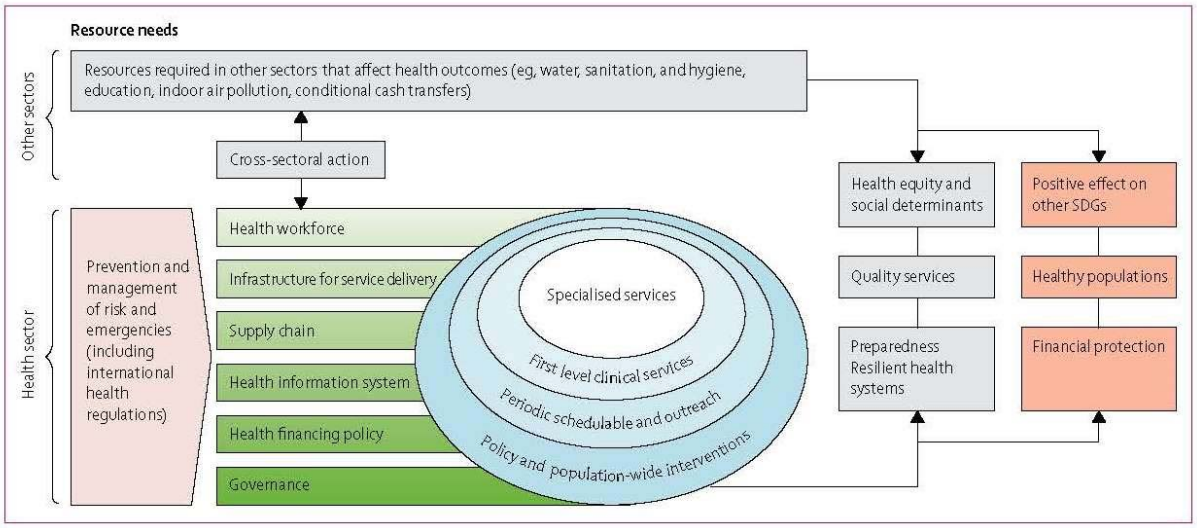
For detailed methodology, please refer to Annex IV in Ortiz and others (2017). Universal social protection floors: costing estimates and affordability in 57 lower income countries. ESS-Working Paper, No. 58. Geneva: International Labour Office. Available at https://www.ilo.org/wcmsp5/groups/public/---ed_protect/---soc_sec/documents/publication/wcms_614407.pdf

4. Health

Survey 2019 health cost estimates are based on the latest WHO study (Stenberg et al, 2017) which estimates additional resources needed to strengthen comprehensive health service delivery towards attaining health goals and achieving universal coverage in 67 LICs and MICs between 2016 and 2030. The framework gradually scales up the health care coverage over time. Under two scenarios the additional spending required per year by 2030 to make progress towards health system targets ranges between $274 to $371 billion, or $41 to $58 per person by the final years of scale-up. Health impact is also modelled for disease specific SDG indicators. Investments to bring countries closer to UHC standards could save up to 97 million lives.

The WHO study estimates are higher than previous estimates due to several reasons. *Firstly*, the study includes more middle-income countries; *secondly*, this study includes new and more ambitious health system benchmarks such as health workforce density. *Third*, the study also includes emergency risk management and NCDs which has broadened the scope of the analysis compared to other studies. *Lastly,* it includes more ambitious targets for specific diseases and higher current baseline health spending.

Figure A.1. Conceptual framework



Source: Stenberg et al. (2017)

The framework to estimate resource needs to attain UHC entails costing the various components that influence health targets (Figure A.1). *Health systems* is a major component required to reach UHC. It consists of health inputs needed for service delivery[5] including infrastructure, health workforce, supply chain, and health

[5] Some examples of health service delivery inputs: infrastructure (health centers, equipment, ambulances); health workforce (health workers, doctors, nurses, training); supply chain (transporting of commodities, medicines, equipment, warehouses, trucks, buffer stocks cold chain); health information system (unified underlying information system including surveillance).

information system; and those related to institutions - health financing policy and governance. [6] Another large component of the framework is the 187 *specific interventions* grouped under four service delivery platforms representing varied modes of service provisions – (1) policy and population wide interventions (deliverable to population *en masse* at low cost such as reduce tobacco use campaign, promotive exercise, mosquito nets); (2) periodic schedulable and outreach services (routine and periodic services such as mass distribution of deworming drugs, iodine supplementation); (3) first level clinical services (services delivered through primary level facilities, more individualized interventions specific to patients' needs such as TB treatment, diabetes); and (4) specialized care (services delivered by highly skilled health personnel on highly individualized manner, relying on sound diagnostic and referral systems such as cancer, infertility, obstructed labour). Other components of the framework include prevention and management of risk and emergencies and cross-sectoral interventions indirectly influencing health outcomes and relate to other SDG targets such as nutrition (SDG 2), WASH (SDG 6), and clean cooking fuels (SDG 7).

To estimate additional resources needed to scale up health systems to UHC, targets are set to reach the 2030 agenda based on global health system benchmarks based on WHO intervention guidelines and recommended practices.[7] For disease-specific interventions, costs are modelled using the OneHealth tool (OHT)[8] that estimates cost assumptions around health workforce inputs, demographic and epidemiological data. Interventions not included in the OHT are supplemented through an excel-based model.

Scaling up is modelled under two scenarios, the *progressive scenario* – where countries' advancement towards UHC is constrained by their health system's assumed absorptive capacity or distress, but progress can still be made[9]; and the *ambitious scenario* – where most countries attain the global targets and the full package of services is expanded towards 95 percent coverage. The general approach is a bottom-up costing, where costs to close the gap between current coverage and reaching set benchmarks are multiplied by country-specific prices from WHO-CHOICE database or other publicly available sources. The distinct levels of ambition among the two scenarios recognizes that not all countries may fully achieve these targets through resource constraints, or limited capacity to absorb new funding and efficiently translate into service delivery.

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[6] Health financing refers to investments in unified and transparent financial management system, procurement, secure and transparent financial flows; governance includes local health governance systems, district health management, community engagement.

[7] Some examples are a ratio of 4.45 health workers per 1,000 population based on the Global Strategy on Human Resources for Health - the model will estimate the costs related to additional health workers needed to be employed; costs related to health centers built per population density; cost of delivering medicines, construction cold-chain required to store vaccines and stocks. Numerous sources were employed for compiling the global benchmarks including but not limited to the Global Health Observatory data, WHO frameworks country review meetings, grant proposals, survey or census results, World Bank's Country Policy and Institutional Assessment (CPIA), humanitarian response plans, other expert opinions.

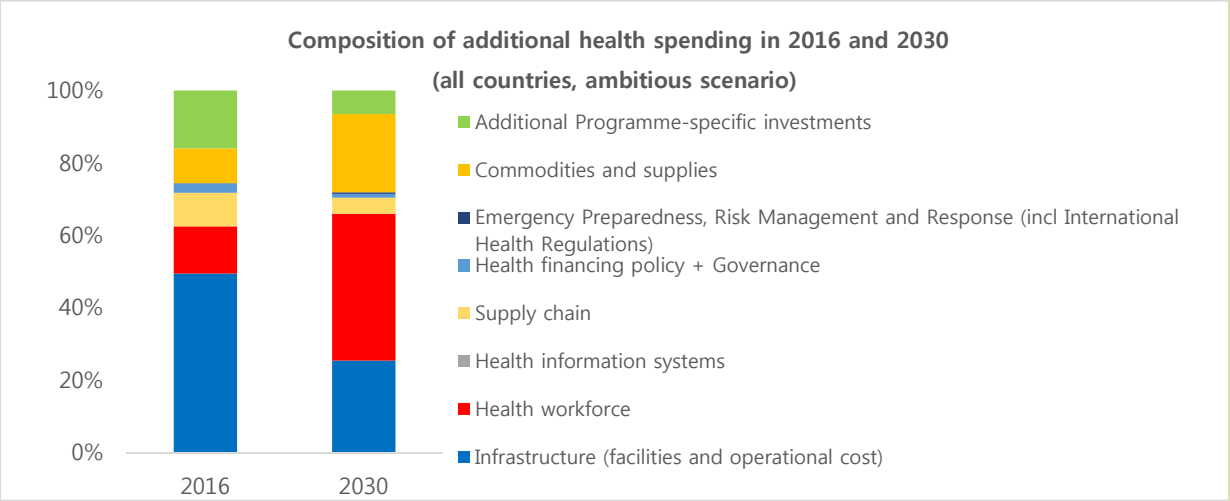
[8] OneHealth Tool, a software application developed and overseen by the UN Inter Agency Working Group on costing and carried out by Avenir Health. OneHealth tool includes pre-populated country profiles including demographic and epidemiological data by country, and also cost assumptions around consumables, health workforce inputs. The OHT incorporates a variety of impact estimation models such as the Lives Saved (LiST) tool, FamPlan model, and many non-communicable diseases models to help project the costs and health impacts of scaling up specific interventions and activities in a country. http://www.who.int/choice/onehealthtool/en/

[9] Under progress scenario, varied targets are assumed across services. For more detail please see technical appendix.

The model considers country-specific demographic and epidemiological context and coverage – including population growth, reduced mortality, reduced incidence or prevalence as coverage increased, projected urbanization, current health system structure and country-specific prices of inputs.

Approximately 70 percent of the additional cost would be spent on health systems under the two scenarios. The main drivers of cost are infrastructure and health workforce (Figure A.2). Substantial investments are needed in infrastructure in the initial years to increase coverage of service delivery to peak in 2029. Health workforce costs are higher in the latter stage of the scale up as coverage increases and health targets are achieved.

Figure A.2. Composition of additional health spending in 2016 and 2030



5. Education

In *Survey 2019*, the UNESCO (2015) costing model is applied and updated to estimate the incremental public investment needs to achieve the following targets: reasonable provision of pre-primary to post-secondary education and promotion of education quality and equity. **The extended education costing model could be downloaded from the *Survey 2019* webpage**, where the user could adjust specific parameters to run different scenarios.

Investment needs to meet the targets are calculated using a projection model incorporating a basic expenditure function and a number of key targets including pupil-teacher ratios, gross enrolment ratios and transition rates, as well as assumptions about GDP growth, population trend, and evolution of teacher salaries (Table A.8). The logic flow is illustrated Table A.3. Then, we use national data to construct estimates of the financing needs and external finance gaps, after factoring in expanded domestic resources for education.

In particular, the basic expenditure function is the sum of two types of expenditures, namely recurrent and infrastructure. For recurrent cost, its main component is teacher salaries, which are the product of the number of teachers and the average teacher salary. On top of salaries, material cost is added as a fraction of salary cost. These recurrent costs, in turn are multiplied by one plus cost for the marginalized pupils. On the other hand, infrastructure cost consists of classroom construction, furnishings, materials, and maintenance. Note that we only apply the basic expenditure function to calculate the budgetary needs for pre-primary to upper secondary education; for post-secondary education, we apply unit cost estimates instead.

The function for the domestic public budget on education is equal to total government revenue raised through taxes, times the proportion of public budget on education, and times the proportion of the education budget for each level of education.

Lastly, the external finance gap is calculated as the difference between the total investment needs and the total domestic resources coming from the public budget and household contributions to education. It shows how much additional funding is needed to achieve a particular trajectory of education growth for all given the assumptions for expansion, costs, and domestic financing. The full results, aggregated by ESCAP sub-region and by income level, are shown in Table A.9. Country-specific results are available from the costing model which is made public.

Figure A.3. Logic flow of education costing

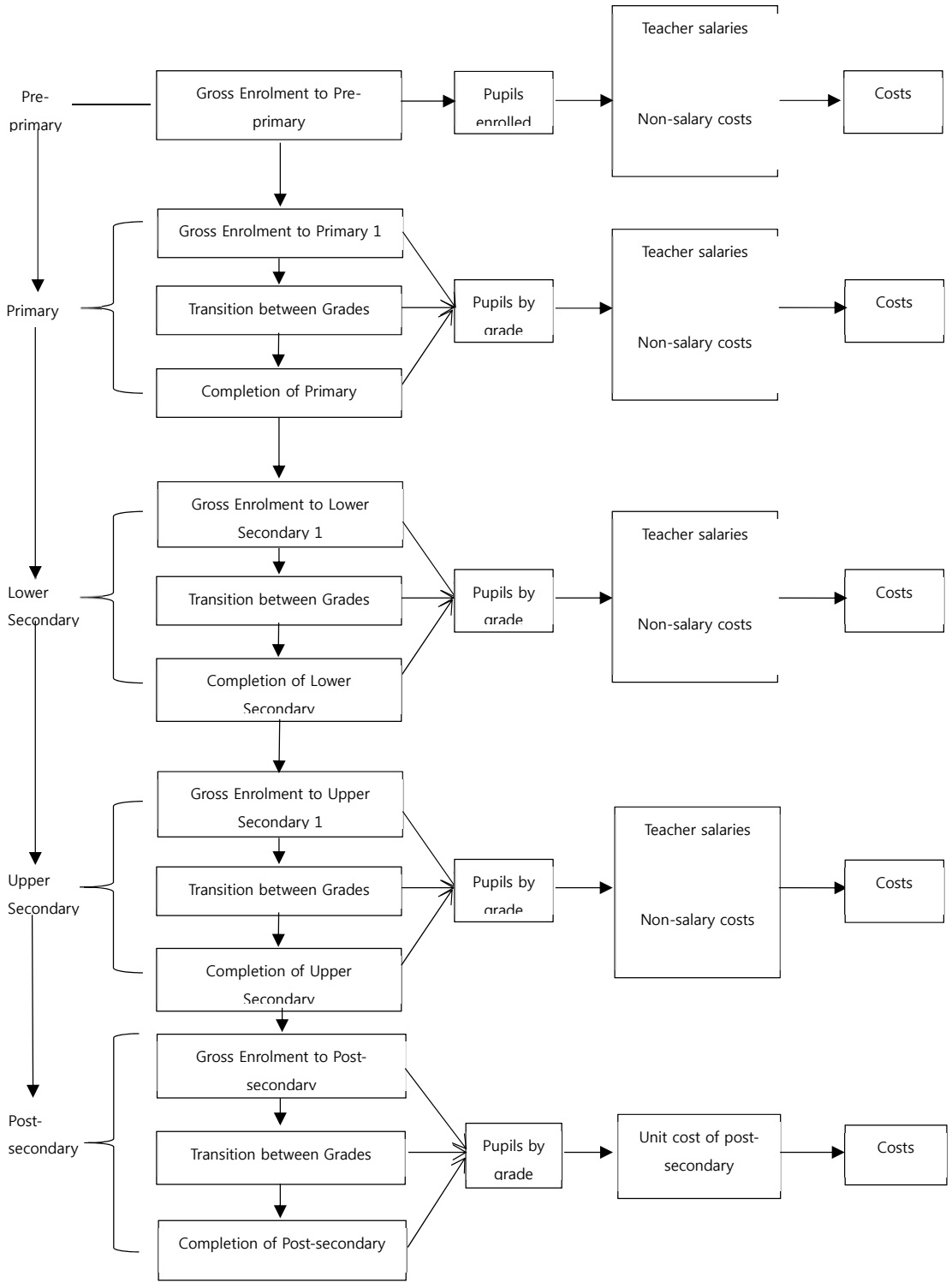


Table A.8. Main assumptions regarding indicators used and corresponding targets

	Measurable targets		Target value
1. Pre-primary education	a. Pre-primary gross enrolment ratio (GER)		100%
2. Primary and secondary education	a. Transition rate to primary		100%
	b. Primary completion rate		100%
	c. Lower secondary completion rate		100%
	d. Upper secondary completion rate		100%
	e. Repetition rate		5%
3. Post-secondary education	a. Post-secondary tertiary GER	LICs	28%[1]
		LMICs	55%[1]
		UMICs	74%[1]
	b. Post-secondary non-tertiary GER	LICs	10%[2]
		LMICs	20%[2]
		UMICs	27%[2]
	c. Post-secondary tertiary completion rate		80%
	d. Post-secondary non-tertiary completion rate		80%
4. Quality of education	a. Percentage of publicly funded pupils	Pre-primary	90%
		Primary	90%
		Lower secondary	90%
		Upper secondary	90%
		Post-secondary	20%
	b. Pupil-teacher ratio (PTR)	Pre-primary	20
		Primary	40
		Lower secondary	35
		Upper secondary	35
	c. Teacher salaries (as multiples of GDP per capita)	Function of income, rising to the top 50% of salaries (relative to income) by 2030	
	d. Share of non-salary recurrent costs		35%
	e. Post-secondary unit cost (as % of GDP per capita)[3]	Post-secondary tertiary	100%
		Post-secondary non-tertiary	100%
5. Equity of education	a. Mark-up of per student costs to attract marginalised children (living on < US$2/day)	Pre-primary/primary	20%
		Lower secondary	30%
		Upper secondary	40%
6. Financing of education	a. Max. household contribution to basic education (pre-primary to upper secondary)	LICs	10%
		LMICs	10%
		UMICs	10%
	b. Max. household contribution to post-secondary education	LICs	25%
		LMICs	50%
		UMICs	50%

[1] The target tertiary GER for each country group is based on the average tertiary GER in the next higher income group of ESCAP countries in 2015. For instance, for LICs, the target tertiary GER is based on the average tertiary GER in lower-middle income ESCAP countries in 2015. For LMICs, the target tertiary GER is based on the average tertiary GER in upper-middle income ESCAP countries in 2015.

[2] The target post-secondary non-tertiary GER is calculated based on the empirical evidence that the proportions of high school graduates enrolled into tertiary and non-tertiary education are 73% and 27% respectively for low and middle income ESCAP countries in 2015.

[3] Given that data are mostly unavailable for post-secondary education (e.g. PTR, teacher salaries, etc), we assume the unit cost for post-secondary education is 100% of GDP per capita by 2030. This approximately reflects the post-secondary unit cost in UMICs and HICs.

Table A.9. Summary of projection results (including post-secondary)

	All		East and North-East Asia		South-East Asia		South and South-West Asia		North and Central Asia		Pacific		Low income		Lower-middle income		Upper-middle income	
Number of pupils (public and private), in millions																		
	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030
Pre-primary	49	63	13	14	9	11	26	36	0.8	1.6	0.2	0.3	1	2	32	43	16	18
Primary	361	348	95	91	67	65	192	183	5.8	6.7	1.6	1.9	11	11	233	225	117	112
Lower secondary	176	206	44	49	32	37	93	110	6.3	8.8	0.4	0.6	4	6	115	136	57	64
Upper secondary	137	228	43	51	17	29	74	143	3.5	4.4	0.1	0.2	2	6	79	155	55	67
Post-secondary	129	237	55	78	19	36	52	117	2.6	5.6	0.3	0.8	2	3	54	136	74	98
Public expenditures per pupil, unweighted average, US$ per year*																		
	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030	2015	2030
Pre-primary	714	1313	1235	2085	634	1308	549	1237	622	1316	972	1163	127	457	509	969	1180	2073
Primary	588	741	1269	1592	607	862	570	639	456	658	553	519	83	208	362	495	1071	1264
Lower secondary	781	871	1474	1544	670	931	767	849	679	820	853	619	96	237	561	688	1295	1320
Upper secondary	894	940	1287	1483	726	1005	1012	948	673	822	1083	783	206	315	583	753	1531	1393
Post-secondary	2379	5889	5530	11879	1437	5882	1318	5826	2034	5590	4321	4405	494	1234	1552	3807	4149	10523
Total public cost, average, annual, in billions, US$																		
	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average
Pre-primary	44.8	69.0	27.1	36.9	7.4	11.3	9.4	19.5	0.7	1.3	0.1	0.0	0.1	0.4	13.6	25.7	31.1	43.0
Primary	289.3	314.1	197.7	205.1	37.1	41.2	51.4	64.5	2.5	3.2	0.7	0.2	0.9	1.3	63.9	82.9	224.6	229.9
Lower secondary	149.5	176.8	94.1	97.4	20.3	25.8	29.3	48.4	5.5	5.1	0.3	0.1	0.4	0.8	36.1	60.3	113.0	115.7
Upper secondary	122.5	176.9	72.2	82.5	14.0	19.1	33.5	72.8	2.6	2.3	0.1	0.1	0.6	1.0	33.0	75.8	88.8	100.0
Second chance youth literacy programs	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1
Post-secondary	675.7	1229.1	588.5	900.3	31.7	106.1	50.0	206.1	4.1	14.5	1.3	2.0	0.8	1.6	45.2	214.1	629.7	1013.4
ALL levels	1281.9	1965.9	979.6	1322.3	110.7	203.5	173.6	411.3	15.5	26.3	2.6	2.4	2.7	5.1	192.1	458.8	1087.1	1501.9
Financing of education, in billions, US$																		
	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average	2015	2015-2030 average
Total public cost	1281.9	1965.9	979.6	1322.3	110.7	203.5	173.6	411.3	15.5	26.3	2.6	2.4	2.7	5.1	192.1	458.8	1087.1	1501.9
Government expenditure	756.7	1421.3	519.0	942.4	83.2	161.5	141.4	297.0	12.0	19.9	1.0	0.5	0.8	2.9	150.7	335.8	605.1	1082.6
Household expenditure	520.4	536.6	460.0	379.9	27.7	42.7	29.2	107.5	3.1	6.1	0.4	0.4	1.0	1.1	38.5	116.5	480.9	419.0
External finance gap	6.2	7.8	0.6	0.1	1.3	0.4	3.6	6.8	0.4	0.3	0.3	0.1	0.9	1.2	4.2	6.2	1.2	0.4

* We use unweighted averages (i.e. averages not weighted by number of pupils in each country) in our exercise to avoid over-representation biases.

In addition to the above base scenario, we estimate three alternatives – within-income-group tertiary GER targeting, online provision of post-secondary education, and alternative PTR targeting – to explore and highlight different avenues and costs for post-secondary education, and different assumptions about class size, two of the main cost drivers of education costing. In each alternative scenario, we apply comparative statics by firstly changing only one factor in the targets of indicators and holding all else unchanged as in the SDG base scenario, and then studying how the variables of interest (e.g. total public cost, external finance gap, etc.) behave accordingly. The descriptions and projection results of each alternative scenario are summarized in Tables A.10 and A.11.

Table A.10. Description of alternative scenarios

Scenario	Description
1. Within-income-group tertiary GER targeting scenario	The targets are the same as those in the SDG base scenario (Table A.8), except for target tertiary GERs. Now we assume that the target tertiary GER for each income group is based on the average tertiary GER in the same income group of ESCAP countries in 2015. Hence the targets for LICs/LMICs/UMICs are 23%/28%/55%.
2. Online provision of post-secondary education scenario	The targets are the same as those in the SDG base scenario (Table A.8), except for the percentage of pupils who receive post-secondary education online. The percentage changes from 0% to 25%.
3. Alternative PTR targeting scenario	The targets are the same as those in the SDG base scenario (Table A.8), except for target PTRs for pre-primary to secondary education. The target PTRs for pre-primary, primary, and secondary education change from 20/40/35 to 25/50/45 for all ESCAP countries in discussion.

When compared to the SDG base scenario, the budgetary needs for 2015-2030 in all three alternative scenarios are reduced, yet through different channels. In the within-income-group tertiary GER targeting scenario, each country only needs to reach the average performance of the income group that it belongs to (no longer the next higher income group as in the SDG base scenario) in terms of tertiary GER. As a result, each country admits fewer post-secondary pupils, and the total public cost is lower by $236 billion on average for 2015-2030. In comparison, the online provision of post-secondary education scenario mostly reflects the innovations in teaching methods we are now undergoing in higher education (think of Coursera, for instance). They are more accessible to pupils, and less costly to set up. The projection results are as expected: the number of pupils taking formal post-secondary education decreases to 168 million in 2030, and the post-secondary unit cost reduces to an annual average of $5846; the total public cost is lower by $207 billion on average for 2015-2030. Lastly, in the alternative PTR targeting scenario, as we allow for higher PTR targets, for given number of pupils, there will be lower demand for teachers, and as a result the expenditure on teachers' salaries will decline. This is shown as lower unit costs for pre-primary to upper secondary education in the last column of Table A.11. Given that the projected number of pupils remains unchanged in 2015-2030, the total budgetary needs for basic education are lower to $676 billion, compared to $737 billion in the SDG base scenario.

The external finance gap exaggerates to more than $20 billion in 2030 if we assume more ambitious post-secondary admission target and stricter standard of learning through lower target pupil-teacher ratios. The projected external finance gaps in all three alternative scenarios average around $5 billion during 2015-2030, while the gap jumps from $6.2 billion to $22.6 billion in the SDG base scenario for 2015-2030. However, one should not be misled by that as the financial needs are much lower in the alternative scenarios, they should be the targets to achieve in 2030. This exercise only serves to identify the two main cost drivers of education costing – post-secondary education admission and basic education PTRs, and to study how each cost driver affects the aggregate outcome.

Table A.11. Projection results of alternative scenarios

		SDG base scenario	Within-income-group tertiary GER targeting	Online provision of PS education	Alternative PTR targeting
Number of pupils (public and private), in millions					
	2015	2030	2030	2030	2030
Pre-primary	49	63	63	63	63
Primary	361	348	348	348	348
Lower secondary	176	206	206	206	206
Upper secondary	137	228	228	228	228
Post-secondary	129	237	**144**	**168**	237
Public expenditures per pupil, unweighted average, US$ p.a.					
	2015	2030	2030	2030	2030
Pre-primary	714	1313	1368	1359	**1126**
Primary	588	741	831	817	**650**
Lower secondary	781	871	994	961	**741**
Upper secondary	894	940	1136	1095	**793**
Post-secondary	2379	5889	5889	**5846**	5889
Total public cost, average, annual, in billions, US$					
	2015	2015-2030 average	2015-2030 average	2015-2030 average	2015-2030 average
Pre-primary	44.8	69.0	70.0	69.5	**63.9**
Primary	289.3	314.1	321.1	318.0	**292.4**
Lower secondary	149.5	176.8	182.5	180.2	**159.4**
Upper secondary	122.5	176.9	182.9	180.4	**159.9**
Second chance youth literacy programs	0.1	0.1	0.1	0.1	0.1
Post-secondary	675.7	1229.1	**973.5**	**1010.3**	1229.1
All levels	1281.9	1965.9	1730.2	1758.5	1904.8
Financing of education, in billions, US$					
	2015	2015-2030 average	2015-2030 average	2015-2030 average	2015-2030 average
Total public cost	1281.9	1965.9	1730.2	1758.5	1904.8
Government expenditure	756.7	1421.3	1419.3	1419.6	1420.7
Household expenditure	520.4	536.6	307.6	334.7	480.8
External finance gap	6.2	7.8	3.6	4.3	3.1

6. Infrastructure

1. Overall methodology

A conventional 'top-down' approach to forecast infrastructure financing needs is used whereby unit capital costs and unit maintenance costs are applied to projected changes of physical infrastructure stock and to existing stock, respectively. It is assumed that the annual financing needs by 2030 are decomposed and expressed as follows:

$$F_{i,t} = \sum_j F_{i,t}^j \text{ and}$$

$$F_{i,t}^j = \max\left(\frac{I_{i,T}^j - I_{i,t}^j}{T-t}, 0\right) \times c_i^j + I_{i,t}^j \times m_i^j$$

where $F_{i,t}$ represents the total annual financing needs for country *i* at time *t*; $F_{i,t}^j$ indicates financing needs for infrastructure type *j*; $I_{i,t}^j$ is the infrastructure stock of type *j* in country *i* at time *t*; c_i^j and m_i^j are the annual unit capital costs and unit maintenance costs of infrastructure of type *j* in country *i*; and *T* is a targeted time period by which universal access should be provided.

The two terms of $F_{i,t}^j$ represent the first two components of annual financing needs, respectively: the first term indicates the costs induced by the construction of infrastructure stock to meet the rising demand driven by demographic evolution, economic growth and urbanization by 2030 and the second term represents the maintenance cost of the existing stock of infrastructure. The third component of annual financing needs, which is associated with additional costs required for climate change mitigation and adaptation, will be factored in into each of the three terms of $F_{i,t}^j$ through the annual unit capital cost c_i^j and unit maintenance cost m_i^j.

For the ICT and water and sanitation sectors, two different unit costs are used for the calculation of the estimates, corresponding to a high and low-cost scenario. For the water and sanitation sector, the two scenarios have been calculated using the unit costs provided for different types of technologies at the country level by Hutton and Varughese (2016). Due to data availability, for the ICT sector, the low and high-cost scenarios have been calculated for the fixed broadband indicator only. For the low-cost scenario, sub-regional averages have been calculated based on the unit costs provided for selected Asia-Pacific economies by ITU (2016). The high-cost scenario has been calculated using the average of the two highest fibre-to-the-home construction cost per subscriber of countries in the Asia-Pacific region provided by ITU (2016).

The indicators range from 1990 to 2017, except for that covering mobile phone and fixed broadband subscriptions which only starts in 2004 and 2000, respectively. Due to limited availability of data, three-year averages have been used instead of yearly data. This transformation also captures the fact that

infrastructure development is a slow process. Linear intra/extrapolations have been performed to fill in the missing values and thus obtained a balanced data panel.

2. Projection of infrastructure indicators by 2030

The methodology first estimates the component of financing needs that corresponds to the growing demand for new infrastructure based on the 'top-down' approach described above. This is done by projecting the demand for infrastructure to 2030 under the assumption that infrastructure services are both demanded as consumption goods by individuals and as inputs into the production process by firms, in accordance with the work of Fay (2000), Fay and Yepes (2003), Bhattacharyay (2012), Ruiz-Nunez and Wei (2015) and ECLAC (2017). Once the new demand is projected to 2030, financing needs can be calculated by applying it to a set of unit cost estimates.

For each infrastructure sector, Table A.12 shows the indicator used, their definition and data sources. Not that energy was costed separately using the IEA model (see appendix 7), but the basic approach is shown here for comparability with other studies such as ADB (2017).

The projection of each indicator to 2030 is performed using an OLS[10] regression with fixed effects on a sample of 108 economies[11] of which 47 are Asia-Pacific countries. For the transport, energy, and water and sanitation sectors, as well as for the indicator accounting for broadband subscriptions of the ICT sector the future infrastructure demand is described by the following process:

$$I_{i,t}^{j} = \alpha_0^j + \alpha_1^j I_{i,t-1}^{j} + \alpha_2^j y_{i,t} + \alpha_3^j A_{i,t} + \alpha_4^j M_{i,t} + \alpha_5^j U_{i,t} + \alpha_6^j P_{i,t} + \alpha_7^j D_i^j + \alpha_8^j t,$$

where $I_{i,t}^{j}$ is the infrastructure stock of type *j* needed in country *i* at time *t*; $y_{i,t}$, $A_{i,t}$ and $M_{i,t}$ represent, respectively, the GDP per capita and shares of agriculture and manufacture value added in GDP[12]; $U_{i,t}$ and $P_{i,t}$ stand for the urbanization rate and the population density; D_i^j is the country fixed effect; and t a time trend, used to capture time effect. All the variables in the equation are expressed in natural logarithm to linearize the model.

For the "mobile phone subscription per 100 people" indicator, access to electricity for rural and urban

10 In theory, the use of GMM-IV estimator would be more applicable than OLS given the presence of the lagged variable in the model. However, ADB (2017) found that its explanatory power was actually lower than OLS and that the performance in out-of-sample forecasting was uneven and unsatisfactory.

11 For the "Broadband per 100 people" indicator of the ICT sector, developed countries were taken out of the panel data due to inconsistencies found in the projected indicator.

12 Due to the absence of future estimations for GDP composition, the shares of agriculture and manufacture value added in GDP have been projected using basic linear extrapolations.

population as well as power consumption per capita were included in the model as independent variables based on the methodology developed by Ofa (2018). For this indicator the model therefore becomes:

$$I_{i,t}^{j} = \alpha_0^j + \alpha_1^j I_{i,t-1}^{j} + \alpha_2^j y_{i,t} + \alpha_3^j A_{i,t} + \alpha_4^j M_{i,t} + \alpha_5^j U_{i,t} + \alpha_6^j P_{i,t} + \alpha_7^j D_i^j + \alpha_8^j t + \alpha_9^j Er_{i,t}^{j} + \alpha_{10}^j Eu_{i,t}^{j} + \alpha_{11}^j Pc_{i,t}^{j}$$

Where $Er_{i,t}^{j}$ and $Eu_{i,t}^{j}$ represent access to electricity for rural and urban population, respectively, and $Pc_{i,t}^{j}$ accounts for the power consumption per capita.

3. Integration of climate change in the financing needs

The first element of integrating climate change concerns the need to integrate climate resilience into infrastructure. It is assumed that climate proofing will increase capital and maintenance costs of providing infrastructure. Following ADB (2014), this paper assumes that at least 5% of total capital investment is required as the cost of protecting infrastructure against changes in rainfall and temperature. ESCAP estimates that Small Island Developing States and Pacific islands would face higher costs amounting to 20% of total capital investment.

Furthermore, a second element of an additional 0.5 percentage points of maintenance cost for new and existing infrastructure is also imposed for all countries.

Finally, the third element is to incorporate costs of protecting infrastructure in SIDS from increased tropical cyclone wind intensity. Following World Bank (2016), an additional 5% replacement cost is assumed. While sea level rise, coastal erosion, and sea and river flooding induced by climate change do require a huge amount of investment to mitigate losses, the estimation of related costs would be beyond the scope of this study, since the various engineering solutions such as building sea walls and beach nourishment cannot be incorporated into the discussion of four infrastructure sectors. Thus, the actual financing requirements in SIDS concerning climate resilience would be much higher than the estimation provided in this paper.

4. Current investment levels

Table A.13 shows the methodology and data sources used when calculating the investment flows in infrastructure. Due to a lack of reliable estimates of the current levels of public investment in infrastructure in several countries, the group of small island developing States includes only Fiji, Kiribati, Maldives and Solomon Islands. Private investments are composed of the share of PPPs in infrastructure coming from the private sector as well as greenfield FDI. Development assistance are composed of ODA flows for all country groups and includes flows from multilateral development banks for the group of Asia-Pacific developing countries only.

Table A.12. Infrastructure indicators sources and definitions

Type of physical infrastructure	Name of indicator	Definition	Sources
Transport	Paved roads (total route km per 1000 people)	Paved roads are those surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents with concrete or with cobblestones.	World Bank Development Indicators, ADB, CIA Factbook
	Unpaved roads (total route km per 1000 people)	Total road network excluding the paved road network. Total road network includes motorways highways and main or national roads secondary or regional roads and all other roads in a country.	
	Rail lines (total route km per 1 000 000 people)	Rail line is the length of railway route available for train service, irrespective of the number of parallel tracks.	World Bank, Transportation, Water, and Information and Communications Technologies Department, Transport Division.
Energy	Power consumption (kWh per capita)	Electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants.	IEA Statistics, OECD/IEA
	Access to electricity (% of rural population)	Access to electricity is the percentage of rural population with access to electricity.	World Bank, Sustainable Energy for All (SE4ALL) database from World Bank, Global Electrification database.
	Access to electricity (% of urban population)	Access to electricity is the percentage of urban population with access to electricity.	
ICT	Fixed broadband subscriptions per 100 people	Fixed broadband subscriptions refers to fixed subscriptions to high-speed access to the public Internet (a TCP/IP connection), at downstream speeds equal to, or greater than, 256 kbit/s. This includes cable modem, DSL, fiber-to-the-home/building, other fixed (wired)-broadband subscriptions, satellite broadband and terrestrial fixed wireless broadband.	International Telecommunication Union, World Telecommunication/ICT Development Report and database.
	Mobile telephone subscriptions per 100 people	Refers to the subscriptions to a public mobile telephone service and provides access to Public Switched Telephone Network (PSTN) using cellular technology, including number of pre-paid SIM cards active during the past three months. This includes both analogue and digital cellular systems (IMT-2000 (Third Generation, 3G) and 4G subscriptions, but excludes mobile broadband subscriptions via data cards or USB modems. Subscriptions to public mobile data services, private trunked mobile radio, telepoint or radio paging, and telemetry services should also be excluded. This should include all mobile cellular subscriptions that offer voice communications.	
Water supply and sanitation	Access to improved water sources, rural (% of rural population)	The improved drinking water source includes piped water on premises (piped household water connection located inside the user's dwelling, plot or yard), and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection).	World Bank Development Indicators
	Access to improved water sources, urban (% of urban population)		
	Access to improved sanitation facilities, rural (% of rural population)	Improved sanitation facilities are likely to ensure hygienic separation of human excreta from human contact. They include flush/pour flush (to piped sewer system, septic tank, pit latrine), ventilated improved pit (VIP) latrine, pit latrine with slab, and composting toilet.	
	Access to improved sanitation facilities, urban (% of urban population)		

Table A.13. Sources for investment flows in infrastructure

Type of investment	Methodology	Sources
Public investment	Public investments were calculated the following way: (1) Total public investment data at country level were primarily taken from the World Bank (2019) study. When data for a country was missing, the IMF Expenditures by functions of governments database and the ADB (2017) report were used in lieu. However, as outlaid in World Bank (2019) the IMF database captures public investments that might be broader than investments in infrastructure only. To overcome this issue, IMF estimates were adjusted based on the average ratio of World Bank estimates/IMF estimates for countries where both data were available. (2) In a second step, total public investments were broken down by infrastructure sector using the following method: the IMF database was used as the primary source of data for public investments broken down by sectors (ICT, energy and transport). Public investment in WSS data were taken from the GLAAS 2017 report from WHO. As those two sources capture public investments that may go beyond infrastructure only, the share for each sector was calculated and then applied to the World Bank (2019) estimates.	World Bank (2019), IMF (2018), ADB (2017), WHO (2017)
Private investment	Greenfield FDIs from the FDI market website and the private participation in PPPs in infrastructure made available for the World Bank were added to for this component.	FDI Markets (2019), World Bank PPI database (2019)
Development assistance	The QWIDS database of OECD was used to retrieve ODA by sector in the different countries. The following sectors could be differentiated: “energy”, “water and sanitation” and “transport & ICT”. Since the breakdown at the country level wasn’t available for the transport and ICT sector, the average repartition of ODA in these two sub-sectors, available for the total in all developing countries, was used to break down these two sub-sectors at the country level.	OECD (2018)

7. Affordable and clean energy

The *Survey 2019* calculation is based on the World Energy Model (WEM) developed by the International Energy Agency (IEA).

INVESTMENT AREAS:

The estimates are composed of 4 investment areas following the targets of SDG7:

SDG 7.1 Investment to achieve universal access to electricity and clean cooking

Universal access to electricity: The investments in generating assets are a straightforward calculation multiplying the capital cost ($/kW) for each generating technology by the corresponding capacity additions for each modelled region/country, as shown below:

Additional investment needed = incremental capacity needs × unit *capital* cost

The investment costs assumed in the power generation sector are based on a review of the latest country data available and on assumptions of their evolution over the projection period. They represent overnight costs for all technologies.[13] Access to electricity is closely linked with the reliability or quality of energy services. In this policy brief, in line with the IEA's World Energy Model, access to electricity is defined as the average household having access to electricity powering four lightbulbs to operate at five hours per day, one refrigerator, a fan to operate 6 hours per day, a mobile phone charger and a television to operate 4 hours per day, which equates to an annual electricity consumption of 1 250 kWh per household with standard appliances, and 420 kWh with efficient appliances. This is a similar level to Tier 2 access as defined by World Bank's Multi-Tiered Framework (2015).

Investment in clean cooking facilities: Investment in clean cooking facilities follows a similar way to estimate, i.e. multiplying demand for clean cooking facilities by the unit costs of different clean cooking tools. Access to clean cooking refers to the primary reliance on modern fuels and technologies in cooking, including fuels such as natural gas, liquefied petroleum gas (LPG), electricity and biogas, or technologies such as improved biomass cookstoves. The demand for clean cooking facilities is based on the outlook for the number of people relying primarily on the traditional use of biomass, which is projected by an econometric panel model based on a historical time series.

SDG 7.2 Substantailly increase the share of renewable energy in energy mix

Investment in renewable sources and plants fitted with carbon capture utilisation and storage (CCUS) facilities also follow the same methodology. The projected investment costs result from the various levels of deployment in the different scenarios.

[13] "Overnight costs" include all capital costs spent on a power plant when it comes online in a specific year.

SDG 7.3 Investment in energy efficiency for end-users

Investment in energy efficiency is defined as the additional amount that consumers have to pay for higher energy efficiency. It is the amount that is spent to procure equipment that is more efficient than a baseline, including taxes, freight costs and labour costs that are directly related to an installation. Energy efficiency in industry, buildings and transport sectors are included.

SCENARIOS SETTING:

Three scenarios were selected from the WEM Model to estimate the investment needs (Table A.14). In *Survey 2019*, only the estimates under SDS were reported, as it is the only scenario that is consistent with the Goals 7 and 13.

Table A.14. Energy scenarios

Current Policies Scenario (CPS)	New Policies Scenario (NPS)	Sustainable Development Scenario (SDS)
Baseline scenario	**NDC scenario**	**SDG Integrated Scenario**
It only considers the policies and measures that are enacted or adopted by mid-2018.	It incorporates both of the policies and measures that Governments have adopted in 2018 and the policies that have been announced, including countries' Nationally Determined Contributions (NDC) for the Paris Agreement, submitted as of 2018.	It aims to achieve SDG 7, as well as to substaintially reduce air pollution (SDG 3.9) and to take effective action to combat climate change (part of SDG 13), i.e. consistent with Paris Agreement to keep a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels.

8. Climate action

The estimates of investment needs to achieve Sustainable Development Goal 13 are composed of two parts: (1) the additional costs to strengthen climate resilience into infrastructure, including transport, ICT, and water and sanitation; and (2) the additional investment needs to transform the energy sector and improve energy efficiency of end-users in building, industry and transport sectors. In details:

1. Additional costs to strengthen climate resilience into infrastructure

This is a mark-up based on the investment needs estimated to meet the infrastructure demand, as also explained in Appendix 6. The study assumes that climate proofing will increase capital and maintenance costs of providing infrastructure.

- **Capital costs:** Following ADB (2014), this paper assumes that at least 5 per cent of total capital investment is required as cost of protecting infrastructure against changes in rainfall and temperature. ESCAP estimates that Small Island Developing States and Pacific islands would face higher costs climbing up to 20 per cent of total expenditures (see box 3.2 in the *2019 Survey*).

- **Maintenance costs**: Additional 0.5 percentage points of maintenance cost for new and existing infrastructure is also employed for all countries.

- **Replacement costs:** Costs of protecting infrastructure in SIDS from increased tropical cyclone wind intensity is also incorporated. Following the World Bank (2016), an additional 5 per cent replacement cost is assumed. While sea level rise, coastal erosion, sea and river flooding induced by climate change do require huge amount of investment to mitigate losses, the estimation of related costs would be beyond the scope of this study, since the various engineering solutions such as sea walls building and beach nourishment cannot be incorporated into the discussion of four infrastructure sectors. Thus, the actual financing requirements in SIDS concerning climate resilience would be much higher than the estimation provided in this study.

2. Additional investment needs to transform the energy sector and improve energy efficiency of end-users

The additional investment needs to mitigate climate risks to achieve Goal 13 by transforming the energy sector and improving energy efficiency of end-users in building, industry and transport sectors is the difference of investment estimates under Sustainable Development Scenario and a baseline scenario (i.e. Current Policy Scenario) from the IEA WEM.

The estimates are reported in the 2019 Survey (Chapter 3, Section 2.4) but not included in the headline regional annual additional investment needs to achieve the Sustainable Development Goals, in order to avoid double counting.

9. Investment efficiency

Conceptual framework and methodology overview

Efficiency gains in three ways

Efficiency gains are normally classified into two different but not mutually exclusive types. The first is technical efficiency, i.e. doing more for less. It reflects the additional output that could be produced using the same bundle of inputs, or the savings in inputs to produce the same level of output. Examples of achieving technical efficiency gains include targeted incentives to improve staff performance, improved administration to reduce corruption and leakages, or harnessing technology progresses for greater productivity.

The second type is allocative efficiency, i.e. doing the right thing at the right place with the right combinations of inputs. Allocative efficiency gains can be achieved through both better allocation of resources at the input end or through appropriate prioritization at the output end. For example, the 2030 Agenda itself puts a significant emphasis on "leaving no one behind", which requires the reallocation of resources to prioritize the essential services and support for the more vulnerable and disadvantaged groups thus in turn maximize the overall development benefits.

A third channel for efficiency gains, which is closely related to allocative efficiency, is to prioritize sustainable results in the long run over short term improvements in SDG indicators. For example, poverty reduction could be achieved in two different ways: to increase cash transfers to the poor to immediately lift them above poverty lines; or to enable the poor to become productive workers or entrepreneurs through targeted education, training, technology support or financial credit programs and lift themselves out of poverty. The first approach could be more effective and less costly in the short run and could be necessary to address emergency cases and prevent further deterioration in the livelihood of the poor. However, the second approach should be a primary focus for spending, which would generate enormous long-term gains and significantly decrease the overall costs of achieving the poverty reduction objective and sustaining the progresses made.

Much of this would boil down to enhancing overall economic productivity. ESCAP Economic and Social Survey 2016 puts an emphasis on kicking start the virtuous circle between the SDGs and productivity. Indeed, producing more with less resource intensity and less damage to the environment would be the only feasible way to secure prosperity without sacrificing the development opportunities for later generations. And for SDG financing in the long run, this is also the only way to make the daunting cost numbers look small.

Measuring efficiency of SDG related spending

Quantitatively measuring the efficiency in major SDG spending areas, in particular education, health and infrastructure, could provide useful insights on the potential cost savings from efficiency gains. However, despite the seemingly straightforward definition of efficiency as achieving greater desirable results for less inputs, there are multiple challenges to this task.

A first challenge is the lack of theoretical frameworks that explain interactions between the outputs and inputs in these spending areas. As a result, researchers often have to infer a productions function

or statistical relations between the two based on observed input-output patterns, or simply treat the relation between the two as a black box and employ non-parametric methods, most commonly Data Envelopment Analysis (DEA), without assuming any functions or correlations.

A second the challenge is with the definition of outputs and inputs. Different from a factory with clearly defined inputs and outputs and a market-based price structure to reveal the relative importance or value of individual outputs and inputs, SDG spending on education, health and infrastructure often serve multiple functions or objectives and can have complex and intertwined inputs that are difficult to identify, isolate and measure.

In most cases, quantitative indicators measuring "outputs" should also be considered together with qualitative indicators measuring "outcomes" to fully capture how efficiently and effectively the spending has contributed to sustainable development achievements. However, it is important to ensure that the quality indicators are driven by or closely related to the input factors. Education expenditures, for example, may only be able to explain 10 per cent of academic results.[14] Thus including indicators on academic results in the analysis could actually reduce rather than improve the overall estimation accuracy on efficiency.

A third and probably the greatest challenge is the control of condition or exogenous factors that are not analyzed as inputs but have substantial influence on outputs and outcomes. Reducing tobacco and alcohol consumption, for instance, is often not a direct objective or component of health spending in developing countries, but has undeniable effect on health indicators. Parent education is another example, where factors unaccounted for by normal spending figures may lead to substantial differences in results achieved. Such "noises" of condition or exogenous factors that are not fully accounted for could lead to biases in cross country analysis on efficiency.

Of course, it could be argued that exogenous factors like tobacco consumption and parent education could still be influenced by non-spending policies or policies outside the specific sector being analyzed. Thus, they could still be considered as efficiency multipliers, only that the efficiency scores would need to be interpreted beyond the narrow scope of how efficiently the money was spent in the specific sector but in a broader concept of how complementary policies on different aspects could work together for greater achievements with the given inputs.

An exception, however, is with transport infrastructure efficiency, where important factors like geographic remoteness or difficult terrain may have huge implications on transport efficiency and quality but completely beyond the influence of policies.

Data envelopment analysis (DEA) on efficiency: what it does and does not tell

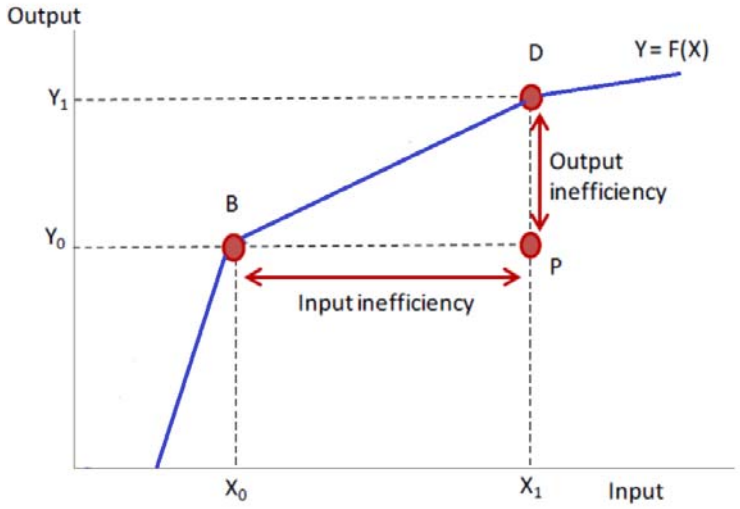
Data envelopment analysis (DEA) is a broadly used approach to evaluate system wide efficiency in major public spending areas such as education and healthcare. Since it is a non-parametric method, it has the advantage of requiring little discretional assumption on the production function or statistical relations between outputs (and/or outcomes) and inputs. It is also able to analyze multiple outputs and inputs at the same time.

[14] Coleman, J.S. (1966). Equality of educational opportunity. Washington, DC: US GPO.

The main task of DEA is to construct an efficiency frontier based on the observed outputs-inputs patterns of the decision making units (DMU) being analyze. In our analysis the DMUs are countries. The only underlying assumptions are that: a. linear convex combinations[15] of any two observed output-input combinations could be feasibly achieved; and b. free disposal is possible[16]. The efficiency frontier thus comprises all feasible input-output combinations if no other feasible combination delivers better results with the same inputs or delivers the same results with less inputs.

After the efficiency frontier is constructed, the efficiency scores of the decision making units, i.e. countries, can be estimated based on their distance to the efficiency frontier. The inefficiency[17] can be measured as either ***input inefficiency***, which measures how much could be saved in inputs to achieve the same results, or as ***output inefficiency***, which measures how much improvement in results could be achieved with the same inputs. Figure A.4 illustrates the efficiency frontier as well as the input and output inefficiencies in a one output one input case.

Figure A.4. Efficiency frontier and efficiency estimation in data envelopment analysis (DEA)



Despite the popularity of the DEA method, it also has a number of important constraints. First, the DEA method estimates efficiency based on what has been achieved rather than what could be achieved. For example, the country with the least input level, say per capita health spending, by default achieves 100 per cent efficiency in DEA, since there is no other country achieving better results with less inputs. Even though this country could be highly primitive in delivering health services. There is some good logic behind this approach, since efficiency is not equivalent to how advanced a country is in the respective spending area. However, it could still significantly overestimate the efficiency of the

[15] A convex combination of X and Y is defined as $\alpha X+(1-\alpha)Y$ when α is between 0 and 1.

[16] Meaning if country A achieves a certain level of output/outcome with a specific bundle of inputs, another country B with more inputs would also be able to achieve the same results if it is as efficient as A. In other words, it is possible for country B to dispose some of its surplus inputs for free, and use exactly the same bundle of inputs to replicate country A's results when B is at least as efficient as A.

[17] Which is 1 minus efficiency.

poorest performing countries only due to a lack of comparator countries when the more efficient countries all have much higher input levels.[18]

A second constraint is that output efficiency scores are often systematically higher than input efficiency scores. This is because output/outcome indicators are often upper bounded. For example, net school enrollment cannot exceed 100 per cent by definition and life expectancy cannot be extended infinitely no matter how good health services are. As a result, the marginal improvements in these indicators driven by extra spending could diminish quickly to almost zero. Moreover, there is often also a lower bound in outcome indicators. For example, even with zero spending on health, maternal mortality rate and life expectancy would still not drop to zero. For these two reasons, output efficiency estimated based on DEA would be systematically skewed towards 100 per cent and higher than input efficiency. A side effect here is that developed countries could be disadvantaged in the efficiency analysis, since the marginal return (as measured by output/outcome indicators) to their higher level of input naturally decreases.

In addition to the above, DEA also has several common disadvantages with any system wide efficiency analysis, such as difficulty in controlling condition or exogenous factors and inability to pinpoint exact drivers behind the inefficiency detected. The choice of output/outcome indicators also poses challenge when developing and developed countries are considered together, since some major spending items and policy objectives of developed countries, such as postgraduate education or medical innovation, may not be policy priorities of developing countries. Thus, in an efficiency estimation focusing on developing countries, these objectives and spending items could be left outside the analysis creating a bias against developed countries. Developed countries also have a disadvantage in efficiency estimations when they prioritize better outcomes over value for money, for instance by having smaller classes or higher quality standards in infrastructure construction.

Despite these constraints, efficiency analysis based on DEA method would still provide useful insights on the output-input profiles in a specific spending area in different countries and on how a country compares to its peers in delivering the desired results using limited resources. However, one should interpret its estimations with great caution, and always keep in mind the limitations of this approach and any other approach for sector-wide efficiency estimations.

[18] One potential way to solve this problem is to assume constant return to scale, i.e. if a country spends X to achieve Y, it would then be able to spend half of X to achieve half of Y or a tenth of X to achieve a tenth of Y etc. However, this assumption is a very strong assumption and can result in equally significant or even much greater biases.

What does the data envelopment analysis on efficiency tell and does not tell

It does tell:

- The relatively efficiency of a country in delivering desirable results in a spending area compared to its peers

It does not tell:

- How advanced a country is in the respective spending areas
- How efficient a country is compared to countries that are much more developed or much less developed than itself
- Ranking of countries in spending efficiency

Limitations of the methodology:

- The influence of conditional or exogenous factors may not be fully controlled
- Efficiency scores of developed countries could be underestimated in a DEA analysis focusing on developing countries
- The efficiency scores of countries with least spending could be overestimated

Estimating spending efficiency in Asia and the Pacific

The estimation follows the Data envelopment analysis (DEA) methodology proposed in Debreu (1951) and Farrell (1957), and further developed by Charnes, Cooper, and Rhodes (1978), Seiford and Thrall (1990) and Färe et al. (1994).

A five-year average over 2013-2017 was used for output indicators to smooth out short-term shocks and increase the sample size. These output indicators were then normalized to 0-1, and a composite output indicator was constructed for the estimation by taking unweighted average of all the normalized output indicators. The normalization method is summarized by the following formula, with *S* representing the normalized indicator while *X* representing the original indicator.

$$S = \frac{\mathrm{X} - \mathrm{Min}}{\mathrm{Max} - \mathrm{Min}}$$

On the input side, a ten-year average over 2008-2017 was used to better reflect the sustained level of spending or investment in the respective sector and eliminate the biases caused by spending fluctuations across years. The input indicator was normalized to population by considering the per capita level of spending/investment. This is to eliminate the estimation biases caused by country size. The level of spending/investment is also measured in purchasing power parity (PPP) terms to partly offset estimation biases caused by different factor prices levels in different countries.

Efficiency estimation for education

Five output indicators from the Global Competitiveness Index database are used for the estimation: primary education enrollment (net), secondary education enrollment (gross), quality of primary education, quality of math and science education, and quality of the education system.

Input is measured as average per capita public spending on education in purchasing power parity (PPP) terms between 2008-2017.

Tables A.15 and A.16 provide a summary of the estimated DEA efficiency scores of public spending on education in Asia-Pacific countries and the indicators used for the analysis.

Table A.15. Efficiency of public spending on education

	Developing Asia-Pacific region	World
Number of observations	31	131
Input efficiency		
average	68%	53%
median	67%	46%
Output efficiency		
average	95%	92%
median	97%	96%

Table A.16. Country level efficiency scores on public spending for education

Subregion	Economy	Input efficiency	output efficiency	Primary education enrollment, net %	Secondary education enrollment, gross %	Quality of the education system, 1-7 (best)	Quality of primary education, 1-7 (best)	Quality of math and science education, 1-7 (best)	Public education spending per capita in PPP (constant international USD)
South-East Asia	Cambodia	100%	100%	96.9	44.9	3.4	3.0	3.2	47.0
	Malaysia	100%	100%	96.2	72.7	5.2	5.1	5.2	1181.5
	Philippines	100%	100%	91.7	86.2	4.4	4.0	4.0	141.6
	Singapore	100%	100%	100.0	107.6	5.8	6.1	6.4	2165.0
	Vietnam	100%	100%	98.3	82.5	3.5	3.5	3.9	233.0
	Lao PDR	58%	97%	95.7	52.4	3.9	3.6	3.7	102.3
	Indonesia	53%	95%	91.9	82.8	4.4	4.3	4.5	292.2
	Myanmar	38%	89%	90.8	51.6	2.6	2.3	2.7	75.9
	Brunei Darussalam	29%	95%	97.2	102.3	4.4	5.1	4.7	2497.0
	Thailand	26%	91%	92.8	93.5	3.6	3.5	3.9	553.7
South and South-West Asia	Iran, Islamic Rep.	100%	100%	99.3	87.2	3.2	4.1	4.6	579.9
	Sri Lanka	100%	100%	95.4	100.1	4.4	4.7	4.7	205.5
	Nepal	99%	100%	97.1	62.8	3.6	3.6	3.8	80.0
	India	81%	98%	92.9	68.6	4.4	4.1	4.5	168.9
	Bangladesh	56%	92%	91.6	56.2	3.4	3.0	3.3	57.4
	Bhutan	39%	87%	87.8	79.1	4.2	4.5	4.1	359.5
	Pakistan	21%	67%	72.7	39.2	3.6	3.0	3.5	112.4
	Turkey	14%	93%	95.0	91.4	3.3	3.3	3.4	940.1
The Pacific	Australia	100%	100%	97.1	135.5	5.0	5.3	4.8	2154.2
	New Zealand	94%	99%	98.6	118.5	5.3	5.8	5.3	2172.1
North and Central Asia	Georgia	100%	100%	98.2	95.3	3.2	3.4	3.4	218.7
	Tajikistan	100%	100%	97.3	87.4	4.0	4.0	3.9	92.5
	Armenia	74%	92%	87.1	93.9	3.6	3.9	4.4	219.6
	Azerbaijan	60%	95%	90.8	101.1	3.5	3.4	3.6	417.6
	Kyrgyz Republic	59%	91%	91.5	89.5	3.0	3.1	3.0	187.0
	Kazakhstan	59%	93%	88.8	103.7	3.6	4.0	4.1	608.7
	Russian Federation	18%	94%	95.5	96.8	3.6	4.3	4.4	969.0
East and North-East Asia	Japan	100%	100%	99.9	101.9	4.4	5.5	5.1	1308.9
	Mongolia	46%	98%	96.4	94.0	2.9	4.0	4.5	473.1
	Korea, Rep.	45%	97%	98.0	97.6	3.7	4.7	4.8	1517.9
	Hong Kong SAR, China	40%	90%	93.8	93.9	4.8	5.0	5.5	1791.3

Efficiency estimation for healthcare

Three output indicators from the World Development Indicators database are used for the estimation: maternal survival rate,[19] infant survival rate,[20] and life expectancy at birth.

Input is measured as average per capita health spending in purchasing power parity (PPP) terms between 2008-2017.

Tables A.17 and A.18 provide a summary of the estimated DEA efficiency scores of health spending, including both public and private health spending, in Asia-Pacific countries and the indicators used for the analysis.

Table A.17. Efficiency of total health spending

	Developing Asia-Pacific	world
Number of observations	28	126
Input efficiency		
average	68%	57%
median	62%	51%
Output efficiency		
average	93%	88%
median	98%	96%

[19] Calculated as 1 minus maternal mortality rate.

[20] Calculated as 1 minus infant mortality rate.

Table A.18. Country level efficiency scores on total health spending

Subregion	Economy	Input efficiency	Output efficiency	Maternal survival rate	Infant survival rate	Life expectancy at birth, total (years)	Total health expenditure per capita, PPP (constant international USD)
South-East Asia	Cambodia	43%	83%	99.7%	96.7%	67.4	190
	Indonesia	43%	82%	99.7%	97.5%	68.5	295
	Lao PDR	47%	75%	99.6%	94.4%	65.1	131
	Malaysia	77%	99%	100.0%	99.3%	74.6	800
	Philippines	54%	86%	99.8%	97.6%	68.6	256
	Timor-Leste	44%	80%	99.4%	95.2%	67.8	139
	Vietnam	100%	100%	99.9%	98.2%	75.5	274
South and South-West Asia	Afghanistan	29%	54%	99.2%	94.0%	62.0	154
	Bangladesh	100%	100%	99.7%	96.6%	71.0	71
	Bhutan	59%	92%	99.9%	96.9%	68.6	219
	India	56%	86%	99.8%	96.0%	67.3	167
	Sri Lanka	100%	100%	100.0%	99.1%	74.7	283
The Pacific	Fiji	79%	99%	100.0%	97.9%	69.6	271
	Kiribati	100%	100%	100.0%	95.3%	65.7	183
	Micronesia, Fed. Sts.	33%	92%	99.9%	97.0%	68.8	406
	Solomon Islands	100%	100%	99.9%	98.0%	69.3	161
	Tonga	97%	100%	100.0%	98.5%	72.5	258
North and Central Asia	Armenia	98%	100%	100.0%	98.6%	73.8	474
	Azerbaijan	37%	98%	100.0%	97.2%	71.3	838
	Georgia	46%	98%	100.0%	98.7%	72.8	654
	Kazakhstan	43%	98%	100.0%	98.5%	69.9	829
	Kyrgyz Republic	85%	98%	99.9%	97.7%	69.9	227
	Russian Federation	39%	99%	100.0%	99.2%	69.9	1323
	Tajikistan	100%	100%	100.0%	96.6%	70.1	142
	Turkmenistan	65%	100%	100.0%	95.3%	67.1	626
	Uzbekistan	100%	100%	100.0%	97.3%	70.5	266
East and North-East Asia	China	75%	99%	100.0%	98.9%	75.6	514
	Mongolia	58%	97%	99.9%	98.1%	68.1	371

Efficiency estimation for infrastructure

Thirteen output indicators from UNdata, the World Development Indicators database, the Global Competitiveness Index database, and the CIA World Factbook database are used for the estimation. These comprise both quantitative and qualitative indicators on the four main areas of infrastructure investment, namely transport, ICT, energy as well as water and sanitation. A detailed list of the indicators used is provided below.

Transport: mileage of roadways per 1 million people, mileage of railways per 1 million people, number of airports per 1 million people[21,22]

Quality of roads, Quality of railroad infrastructure, Quality of air transport infrastructure, Quality of port infrastructure

ICT: Fixed broadband subscriptions (per 100 people), Mobile cellular subscriptions (per 100 people), Secure Internet servers (per 1 million people)

Energy: Energy use (kg of oil equivalent per capita), Perception on electricity supply

Water & sanitation: Per cent of population having access to defecation facilities[23]

Ideally, input should be measured by the per capita level of total infrastructure investment stock over the years. Due to data availability constraints, the per capita national fixed capital formation in purchasing power parity (PPP) terms between 2008-2017 is used as the proxy.

Tables A.19 and A.20 provide a summary of the estimated DEA efficiency scores of infrastructure investment.

Table A.19. Efficiency of infrastructure investment

	Developing Asia-Pacific	world
Number of observations	15	63
Input efficiency		
average	41%	59%
median	46%	56%
Output efficiency		
average	84%	89%
median	80%	85%

[21] The indicators are calculated by ESCAP from the original indicators on roadways mileage, railways mileage and number of airports in each country.

[22] The road and rail mileages and the airport count are normalized to population as the input indicator is also normalized to population (since the per capita level of investment is used).

[23] Defined as '1 - % of population practicing open defecation'.

Table A.20. Country level efficiency scores on infrastructure investment

Subregion	Economy	Input efficiency	Output efficiency
South-East Asia	Indonesia	22%	70%
	Philippines	39%	78%
	Cambodia	48%	67%
	Vietnam	53%	83%
	Malaysia	62%	88%
South and South-West Asia	India	23%	62%
	Turkey	26%	72%
	Sri Lanka	46%	85%
	Bangladesh	47%	76%
	Pakistan	57%	79%
The Pacific	New Zealand	72%	92%
North and Central Asia	Kazakhstan	43%	80%
	Kyrgyz Republic	49%	83%
	Russian Federation	50%	82%
East and North-East Asia	Mongolia	17%	65%
	China	40%	79%
	Korea, Rep.	49%	83%
	Japan	64%	89%

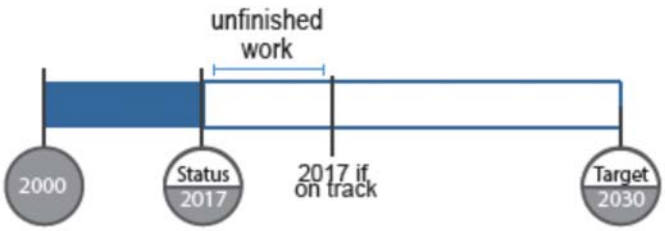
10. SDG progress

Survey 2019 provides a comparison of the SDG progress gap with the SDG investment gap. Below is a summary of the methodology for SDG progress gap. For more details, please refer to ESCAP, *Asia and the Pacific SDG Progress Report*, available at https://www.unescap.org/publications/asia-and-pacific-sdg-progress-report-2017

Measures for tracking progress

Two principal measures to assess regional and sub-regional progress towards the SDG are used: current status index and anticipated progress. The current status index combines information from all the indicators under each goal and provides one index for overall progress towards achi eving specific targets. The anticipated progress tracks progress towards each dimension of the goal, as represented by the targets and their associated indicators, by comparing predicted (anticipated) progress with a specified target value.

Current status index: Given a specified target value for each indicator, the indicator values for 2017 and 2000 can be used to construct a metric that measures the progress made since 2000, in relation to the progress needed to achieve the targets by 2030. The distance between the indicator value for 2017 and the expected value at 2017 (assuming a uniform progress between 2000 and 2030) also shows the "unfinished work" from the Millennium Development Goals (MDGs).



The current status index is constructed in two steps:

Step 1 - A metric is developed for each indicator to measure the progress made (blue bar in the figure above) which can be compared with the entire progress needed from 2000 to 2030.

Step 2 - To see how much progress has been made – and still needs to be made – to achieve the goal, the metrics computed in step 1 are combined into one index that indicates the "average progress made" and the "average progress required" on a fixed scale.

Step 2a - Denoting indicator values for 2000 and the current year by I_0 and I_{cr}, and the target value for 2030 by TV, and setting the normalized values of the indicator at 2000 and 2030 at 0 and 10 respectively, the normalized value for the indicator at the current year on the scale of 0 to 10 can be calculated as:

$$I_{cr}^{N} = \frac{I_{cr} - I_0}{|TV - I_0|} \times D \quad in\ which\ \ D = \begin{cases} 10 & increasing\ is\ desirable \\ -10 & decreasing\ is\ desirable \end{cases}$$

When desirable direction is clear, and for parity indicators as:

$$I_{cr}^{N} = \begin{cases} 10 - \dfrac{|TV - I_{cr}|}{|TV - I_0|} \times 10 & if\ \ |TV - I_{cr}| \leq\ |TV - I_0| \\ \dfrac{|I_{cr} - I_0|}{|TV - I_0|} \times (-10) & Otherwise \end{cases}$$

Step 2b - If the region has progressed since the starting point, the average over all normalized values under each goal ($\overline{I_{cr}^{N}}$) should provide an index that is between 0 and 10. But if the region has regressed the value will be negative.

Indicators for which the current value has already reached or exceeded the target value current status index does not need to be calculated and automatically is set to 10.

Anticipated progress: The second measure compares the predicted (anticipated) progress with the targeted progress. By predicting the indicator value for the target year and benchmarking the predicted value against the target value, we can identify how close we can get to the target by the end of the target year assuming the same pace of progress as previously. Denoting the predicted value of indicator I for the target year by I_t, and value in the base year by I_b, one can approximate the progress gap by P when no regression has occurred, and by $100 - P$ when indicator value has regressed since the base year. Value of P is defined as:

$$P = \frac{TV - I_t}{|TV - I_b|} \times D \ \ in\ which\ D = \begin{cases} 100 & increasing\ is\ desirable \\ -100 & decreasing\ is\ desirable \end{cases}$$

If desirable direction is clear from the target, and

$$P = \frac{|TV - I_t|}{|TV - I_b|} \times 100$$

For parity indicators. We consider no regression if $|TV - I_t| \leq |TV - I_b|$.

Anticipated progress index only needs to be calculated for indicators for which the predicted value has not reached the target value (not expected to achieve the target). Indicators for which the predicted value has already reached, expected to reach the target by 2030, or exceeded the target value are automatically classified as “will be achieved” and Anticipated progress index is 0. For the remaining indicators, P may be interpreted as the extra effort or acceleration needed to meet the target. If progress or no change is expected, the value of P ranges from 0 to 100; if there is a predicted regression from the current level *P* will be negative. For communications purposes, indicators are also classified into three predefined achievement levels:

$$\begin{cases} 0 \le P \le 10 & (Will\ meet\ the\ target\ with\ current\ rate\ or\ minor\ extra\ effort) \\ 10 < P < 100 & (Need\ to\ enhance\ the\ current\ rate\ of\ progress\ to\ achieve\ the\ target) \\ P \le 0 & (Regression\ or\ no\ progress\ expected) \end{cases}$$

More detailed discussions are provided in two working papers: *Tracking progress towards the SDGs: measuring the otherwise ambiguous progress*[24] and *A weighted extrapolation method for measuring SDG progress.*[25]

Setting regional target values

Target values used for assessing the regional progress are set by applying "champion area" approach. This is based on what has been feasible in the past and optimizes the use of available data. The idea is to identify the region's outstanding countries (top performers) and set their average rate of change as the region's target rate. If we imagine all the top performers as belonging to one hypothetical area, this can be labelled as the region's champion area whose rate of change equals the average for the top performers. This can then be considered the target rate for the region. In other words, if the region as a whole can perform as well as its champion area over the 15 years (SDGs era), we should expect to achieve the target value. Subsequently, the universal target value for the region can be derived by applying the rate of change in the champion area to the regional value in the base year.

[24] http://www.unescap.org/sites/default/files/SD_Working_Paper_5_May2017_Tracking_progress_towards_the_SDGs_3.pdf

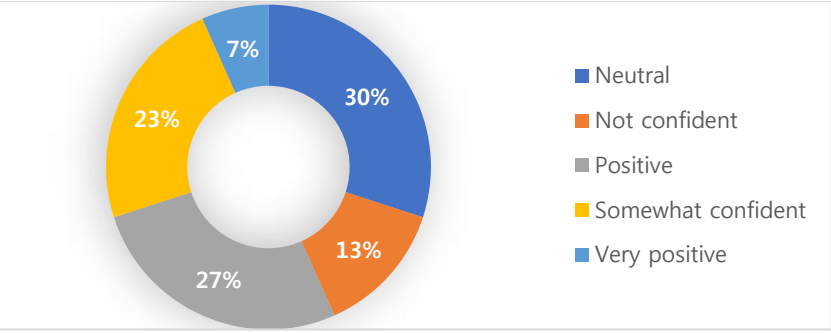
[25] http://www.unescap.org/sites/default/files/SD_Working_Paper_no4_Mar2017_Method_for_measuring_the_SDGs_progress_0.pdf

11. Stakeholder survey

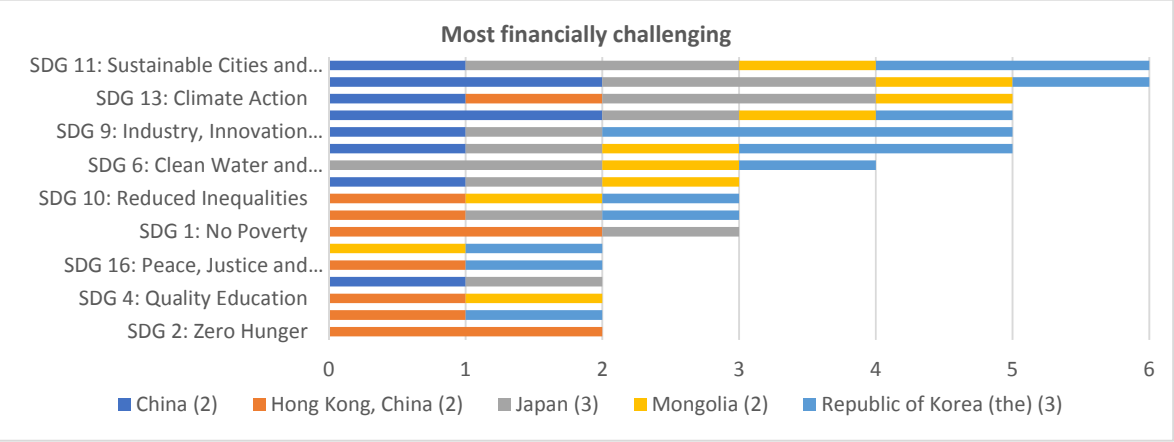
To complement the technical analysis, a questionnaire was sent to policymakers and other stakeholders in the region; almost 300 responses from 44 countries were received. Figure 3.3 in *Survey 2019* summarizes the responses at the regional level; below are the sub-regional breakdowns.

1. East and North-East Asia

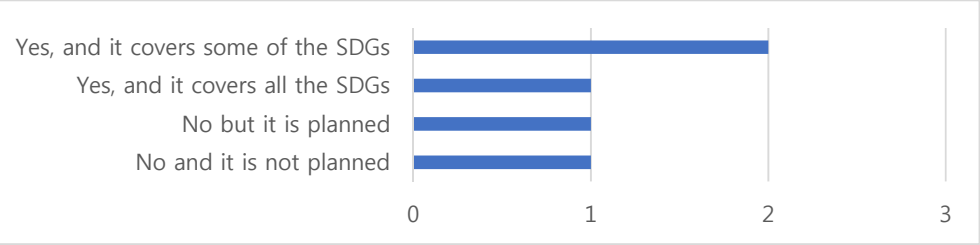
Level of optimism on whether adequate financing is in place to ensure effective implementation of the 2030 Agenda



What do you view as the most financially challenging SDG?

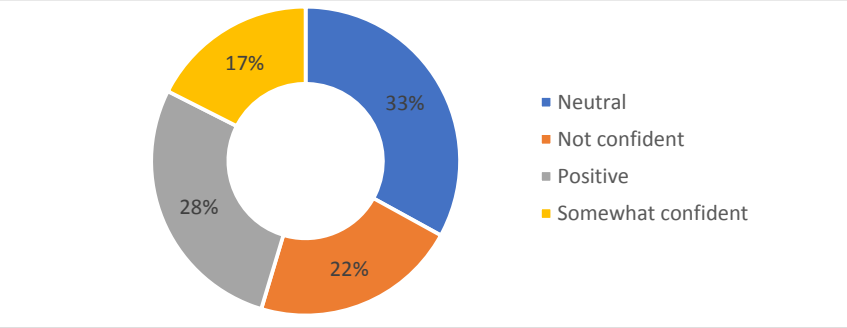


Has your country conducted a quantitative assessment of financing needs for SDGs?



2. South-East Asia

Level of optimism on whether adequate financing is in place to ensure effective implementation of the 2030 Agenda



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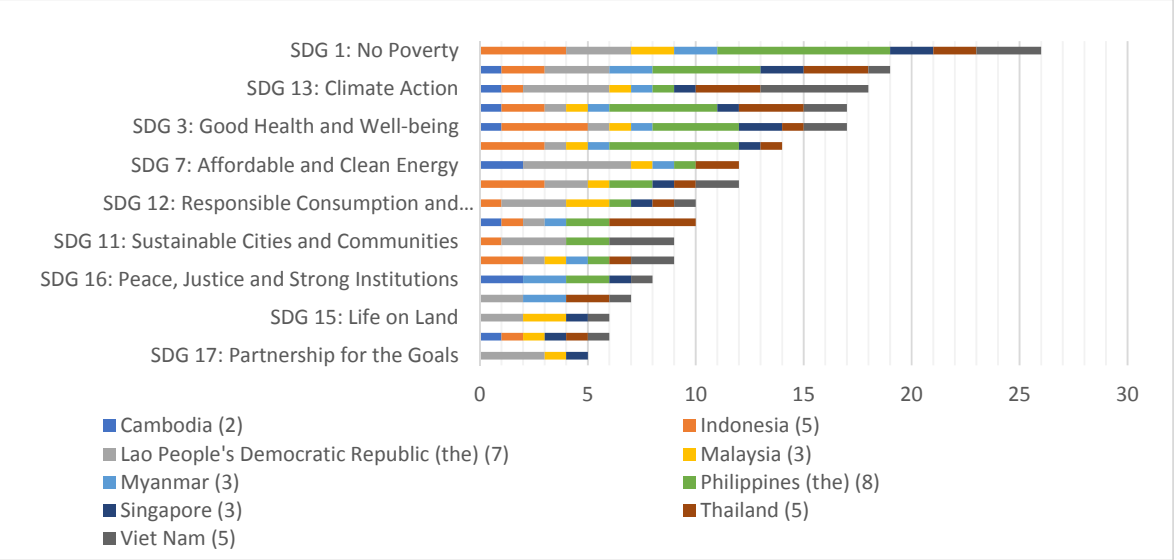
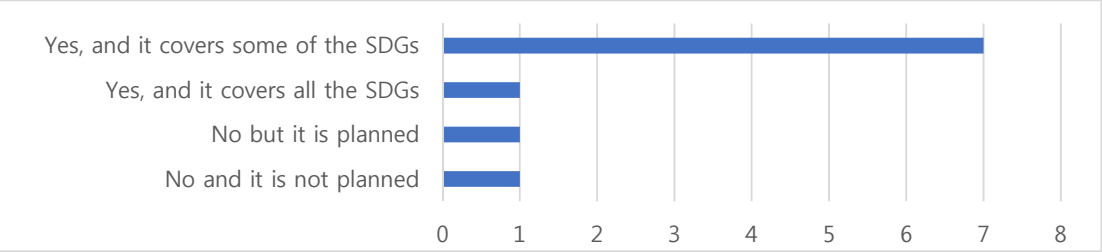
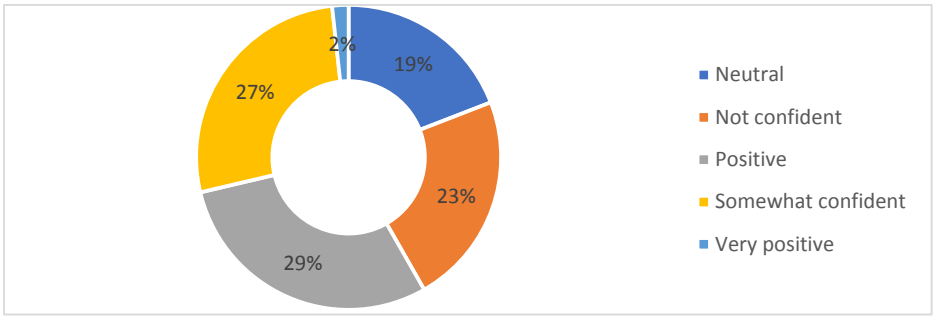


Has your country conducted a quantitative assessment of financing needs for SDGs?

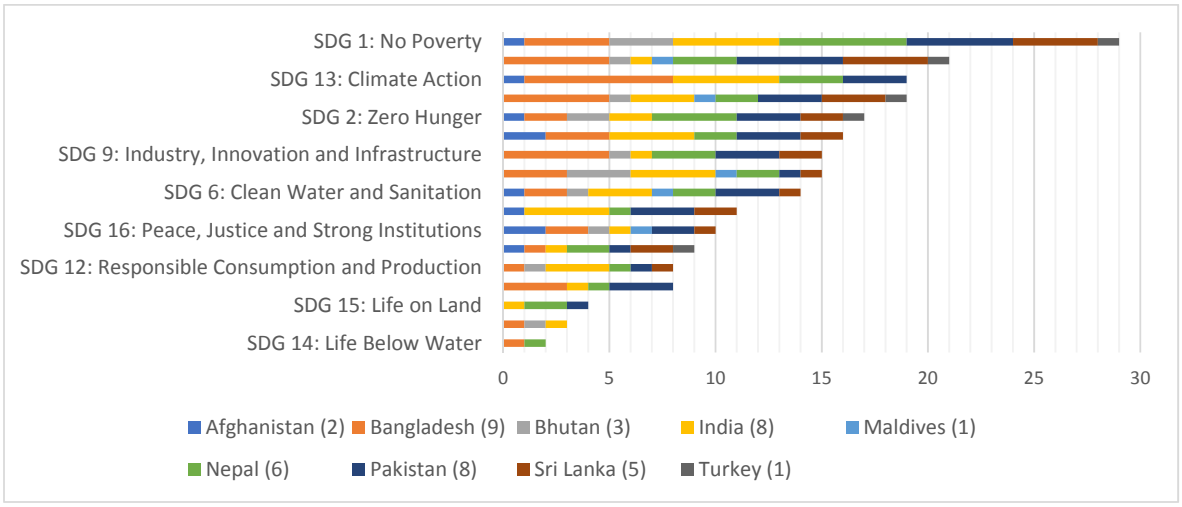


3. South and South-West Asia

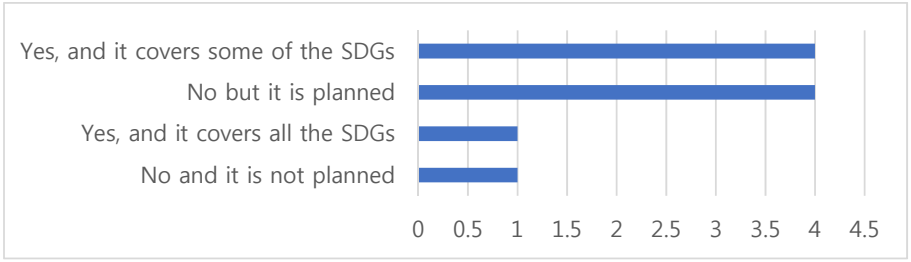
Level of optimism on whether adequate financing is in place to ensure effective implementation of the 2030 Agenda



What do you view as the most financially challenging SDG?

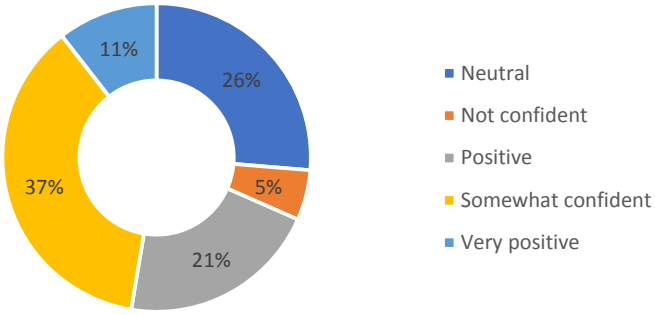


Has your country conducted a quantitative assessment of financing needs for SDGs?



4. North and Central Asia

Level of optimism on whether adequate financing is in place to ensure effective implementation of the 2030 Agenda



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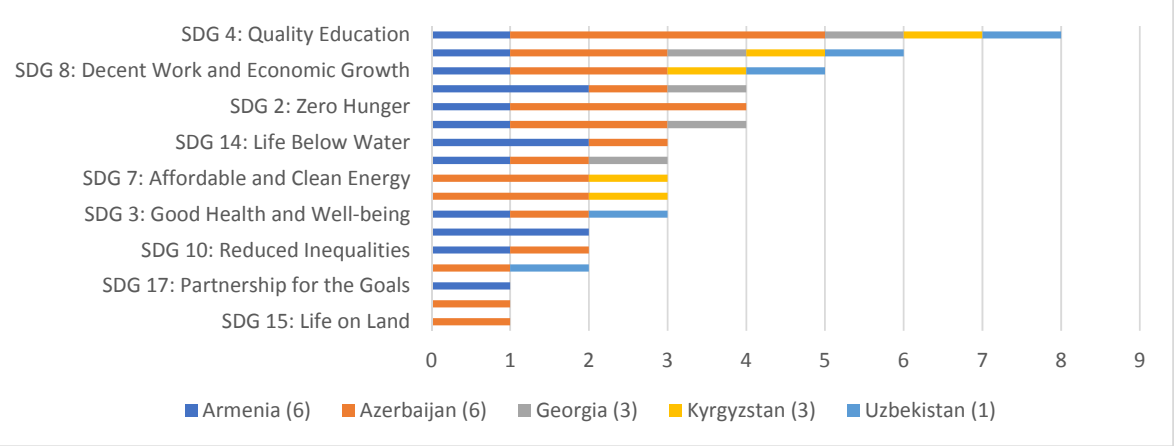
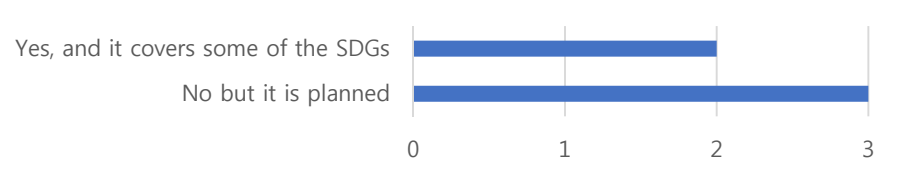
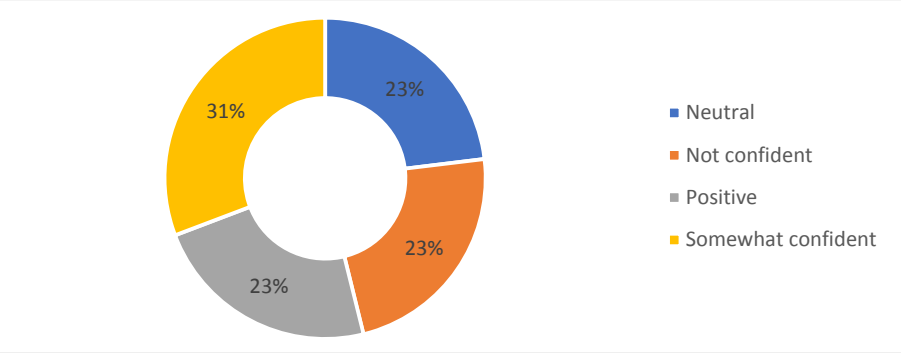


Has your country conducted a quantitative assessment of financing needs for SDGs?

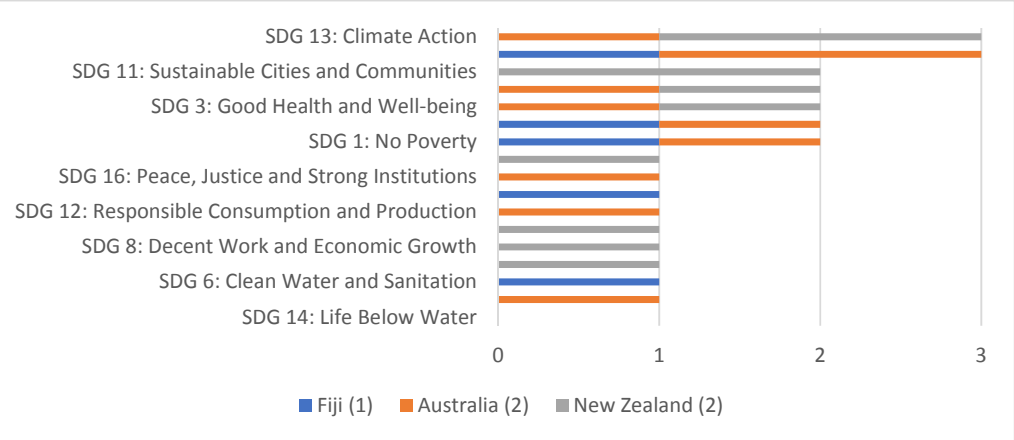


5. Pacific

Level of optimism on whether adequate financing is in place to ensure effective implementation of the 2030 Agenda



What do you view as the most financially challenging SDG?



Has your country conducted a quantitative assessment of financing needs for SDGs?