Investment needs to achieve SDGs: an overview

Short title: Overview of SDG investment needs

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ABSTRACT

Estimating the investments needed to achieve the Sustainable Development Goals (SDGs) is key to mobilising the financial resources to achieve them. Despite an increasing body of research to estimate the capital and operational costs towards achieving various related SDG targets individually and collectively, an overview of the total estimated investment needs at the global scale has not been conducted since the adoption of SDGs in 2015. This study provides such an overview. We have found estimates of investment needs for seven goals: SDG 2 (zero hunger), SDG 3 (good health and well-being), SDG 4 (quality education), SGD 6 (clean water and sanitation), SDG7 (access to energy), SDG 9 (infrastructure), and SDG 13 (climate action). The reviewed studies vary significantly in terms of applied methodology, the assumed targets that need to be achieved, and presented estimates, but overall they indicate significantly higher investment needs to achieve all covered SDGs than previous estimates suggest. For most SDGs, annual investment needs are in the order of hundreds of billion USD annually, and for SDG6 and SDG13 estimates of a trillion or more are reported.

1 INTRODUCTION

Six years after the United Nations (UN) adopted the 2030 Agenda for Sustainable Development in 2015, progress reports paint a concerning picture. While progress has been made on some Sustainable Development Goals (SDGs), especially on those addressing poverty, hunger, maternal health and access to electricity in parts of the world, none of the 193 signatory countries is on track to meet all of them by 2030 (1). The impacts of the global COVID-19 pandemic pose a further threat to their timely achievement by erasing some of the progress made, resetting policy priorities, and throttling resource availability and allocations (2,3). Although the full impact of the ongoing pandemic on different countries, populations, and sectors is not fully known yet, there is an increasing understanding that renewed efforts will be needed to overcome the setback. The UN's call for a Decade of Action on SDGs recognises the need to accelerate global efforts to reach the promised goals at all scales by renewing focus on prioritising SDGs and securing the resources needed to meet the goals (4).

The SDGs target a wide range of interconnected environmental, economic, and societal outcomes. Achieving these targets requires appropriate interventions at many scales, often requiring considerable investments. Examples include investments to develop, strengthen and maintain electric transmission lines, infrastructure for public and goods transportation, education and skill training centres, healthcare facilities, piped water networks, clean sanitation services, sustainable food systems, enforcement of human rights and legitimate political institutions. Securing and allocating financial resources for such an ambitious set of goals remains one of the major challenges.

Estimating the investment needs is a key first step for facilitating finance. Various researchers and organisations have tried to project the anticipated costs of SDG-linked investments. The SDG Investment Trends Monitor 2019 (5) tracks available data on the major investment flows linked to SDGs globally, monitors trends and projected gaps, and supports policymakers in identifying public and private financing means to bridge the gaps. The World Economic Forum particularly focuses on the role of private finance towards sustainable development (6). Ongoing academic and policy research routinely addresses the means of financing SDG implementation by studying regional or project-specific cases (7,8), evaluating alternate sectoral policy options (9,10), or determining the composition of planned overseas development aid (ODA) (11,12).

Two widely cited studies published on the eve of SDG adoption in 2015 provided an overview of the investment needs to achieve them. The first, a UN Sustainable Development Solutions Network (UNSDSN) study, presented a comprehensive overview of the investment needs focusing on the peer-reviewed literature at the time and pegged the annual investment gap at USD 1.4 trillion (Schmidt-Traub, 2015). The other study, the World Investment Report 2014 (14), estimated the additional investments needed to meet the SDG targets at USD 2.5 trillion annually. No updates have been published since.

However, despite the current dire situation, no new update of required investments has been made. In this context, this study provides an updated overview of published investment estimates in the current literature with the aim to inform support policymakers in identifying investments needed to fulfil the SDGs. The study focuses on SDGs for which attainment is clearly dependent on additional investment (with more quantitative investment data available).

2 METHODS

We have reviewed the literature on investment needs in peer-reviewed publications and grey literature. For peer-reviewed literature, an initial search in Scopus was done using predefined search terms. Subsequently, we have checked the references in relevant articles. Finally, we reached out to experts for additional publications. All papers were screened via the selection criteria described below, based on the goal and scope of this study.

We used an adapted version of the set of pre-defined search queries related to each SDG offered as a feature on Scopus (15) (adaptations were made to make the search results more targeted for investment needs towards SDG achievement – refer to keywords in supplementary information). Next, experts were contacted for any known additional literature. Lastly, manual searches were performed for updated publications on the online catalogues of the relevant institutional bodies such as UN affiliates, including those referenced in Schmidt-Traub (2015) and UNCTAD (2014).

Three criteria were defined for selecting the publications relevant for this study:

a. presented estimates pertain to investment needs, incremental to baseline (as opposed to the total investments or financing means);
b. presented investment estimates are explicitly connected with achieving at least one SDG or sub-target;
c. presented investment estimates are either global or for large world regions and therefore relevant for the global scale.

In the analysis, twenty-three sources, additional to those in Schmidt-Traub and the World Investment Report 2014 (hereafter ST15 and WIR14 respectively), are identified from the peer-reviewed and grey literature using this method. The subsequent sections present an overview of the investment needs disaggregated by the SDGs targeted as found in the literature and a description of the methods that were used.

3 RESULTS

3.1 OVERVIEW OF LITERATURE

In total, the 23 identified sources cover investment needs estimates for 7 SDGs. Four of them cover targets related to multiple SDGs, while the rest focus on specific SDGs or SDG-relevant sectors such as healthcare, education, infrastructure, or energy. To analyse and compare the estimates, it is important to consider which SDG target(s) are considered, which costs are estimated, and how. Seven sources present investment needs related to SDG7 (access to energy). Five sources were found for SGD 6 (clean water and sanitation), four each for SDG 13 (climate action), SDG 3 (good health and well-being) and SDG 9 (infrastructure), three for SDG 4 (quality education), and two for SDG 2 (zero hunger) (Table 1).

The methods used in the identified literature, where specified, are presented using the categorisation in ST15 into simple unit cost estimates, intervention-based needs assessments, computational general equilibrium models, incremental capital-output ratio approaches (but no studies were found that applied this method), or Integrated Assessment Models.

Unit cost method estimates are typically based on available investment data for a specific intervention (e.g. the costs of building a school or sanitation facility). It can also be derived from current government spending divided by the actual progress on key indicators. As such, past expenditure is used to estimate the investment needed to meet the targeted indicator level. Unit cost methods are relatively simple estimation tools useful to make first-order estimates. However, there are questions about whether one can scale investment needs under different pathways using this method. Intervention-based needs assessments apply a similar method but account for dynamically evolving capital and operational costs of implementing a specified set of interventions. They benefit from comprehensive coverage of assessed needs with better identification of overlaps and gaps disaggregated by population or region and an assessment of differentiated responses addressing the differentiated capabilities and needs. CGE models represent an economy in equilibrium using stylised production functions for SDG-relevant economic sectors such as healthcare, education, or energy production. Dynamic economy-wide effects of targeted investments, such as through changing prices, can be assessed by varying the input investment levels and combinations in the modelled sectors. Finally, studies based on IAMs can leverage the detailed representation of various relevant but complex environmental, economic and societal systems and provide investment estimates accounting for cross-sectoral effects under different policies and scenarios.

Other methodological details and underlying assumptions are listed in the supplementary information.

Table 1: Overview of SDG investment needs literature identified in this study

Source	SDG	Expenditures included	Methodology
von Braun et al. (2021)	2.1, 2.2	22 cross-sectoral interventions with the highest direct potential for reduction of hunger and malnutrition prevalence	Unit costs
Debucquet et al. (2020)	2.1, 2.2, 2.4	Targeted public investments in social protection, vocational education, agricultural subsidies and R&D, infrastructure (irrigation, storage, transport, telecommunication), mechanisation of farm operations, and free trade agreements.	Computable General Equilibrium model

Stenberg et al. (2017)	3.1, 3.2, 3.3, 3.4, 3.5, 3.7, 3.8	Costs of scaling up delivery of comprehensive universal healthcare services across ambition levels, population growth and mortality projections	Unit costs
(Stenberg et al. 2019)	3.1, 3.2, 3.3, 3.8	Public health interventions, general inpatient care, and cross-sectoral investments directly impacting SDG 2 targets (e.g. hygiene, sanitation, diagnostic testing capacity, program support costs)	Intervention-based needs assessment
Bertram et al. (2018)	3.4	Preventive regulatory interventions to reduce tobacco and sodium consumption, and targeted pharmaceutical interventions against cardiovascular disease incidence among at-risk individuals	Unit costs
UNESCO (2020a)	4	Investment gap for reaching universal, inclusive, and good quality pre-primary, primary, and secondary education.	Unspecified
UNESCO (2020b)	4	Additional financing needs from COVID-19 impacts on remediation, re-enrolment, second-chance education and infrastructure costs	Unspecified
Hutton & Varughese (2016)	6.1, 6.2, 6.3	Capital investments and operational costs for providing universal access to drinking water, sanitation, safe faecal waste management, and hygiene infrastructure (hand-washing stations with soap). These include community wells, improved latrines, a basin with soap for basic WASH, and piped water and sewerage for safely managed WASH.	Unit costs
OECD (2015)	6.5	Capital and operational costs of maintaining and upgrading water and sanitation infrastructure in OECD cities	Unspecified
Parkinson et al. (2019)	6.1, 6.2, 6.3, 6.6	Capital and operational costs of infrastructure for freshwater withdrawal and distribution, wastewater collection and recycling, desalination	Unit costs
McCollum et al. (2018)	2.1[1], 3.9, 4.1, 6.1, 6.2, 6.3, 6.4, 7.1, 7.2, 7.3, 13.1	Investments to limit air pollution emissions. Aggregated expenditure towards primary/ secondary education. Expenditures related to rapid expansion of piped water access, wastewater treatment in developing economies, infrastructure upgrading in developed ones, and investments in wastewater recycling and desalination infrastructure in general. Subsidies towards clean cookstoves and modern fuels. Transformation of the energy system towards 1.5 °C climate target	Integrated Assessment Model
Strong et al. (2020)	6.1, 6.2, 6.3, 6.4, 6.5, 6.6	Investment needs for WASH, water pollution control, and integrated water resource management implementation	Unit costs
Dagnachew et al. (2017)	7.1	Capital investment in installed capacity, transmission and distribution networks	Integrated Assessment Model
Lucas et al. (2017)	7.1 7.2	Capital investment in installed capacity, transmission and distribution networks	Integrated Assessment Model
Hof et al. (2018)	7.1	Capital costs of stovetops and costs of purchasing associated fuel	Integrated Assessment Model
IEA (2019)	7.1, 7.2	Fossil and renewable energy production, transmission and distribution	Integrated Assessment Model
World Bank Group (2017)	7.1	Unclear	Uspecified
Rozenberg & Fay (2019)	7.1, 9.1, 13.1	Capital and operational investment costs in renewable energy and energy efficiency; grid transmission for universal access	Integrated Assessment Model
Dulac (2013)	9.1	Rail and road infrastructure under low-carbon scenarios	Intervention-based needs assessment
(35)	9.1	Investments in road, rail, ports, airports	Integrated Assessment Model

[1] The estimate for SDG 2 from McCollum et al. (2018) are not included, since it is limited to avoiding any further increase of those at risk of hunger from transformative energy policy, and is derived as a hypothetical ex post compensation rather than a targeted investment.

Fischer-Romito & Guivarch (2019)	9.1	Capital and operational investment costs of meeting global transportation infrastructure requirements	Integrated Assessment Model
Bertram et al. (2021)	13	Investments into non-fossil energy supply technologies to achieve 1.5°C -2°C outcomes	Integrated Assessment Model
Schinko et al. (2020)	13	Global costs of building dikes in adaptation to sea-level rise	Integrated Assessment Model, unit costs

3.2 Overview of investment needs

Figure 1 presents the overview of published estimates in constant 2019 USD. All numbers reported here refer to the investment needs additional to baseline, i.e. incremental needs, except SDG 9 (covering transport and communication infrastructure), for which only total investment needs were found in the literature. We have chosen to still report these results in Fig. 1 given their significance and the lack of viable alternatives. All estimates are disaggregated to specific targets whenever possible. In case such disaggregation is not possible based on the information presented in the sources, the estimates are mapped directly against the associated goal. However, very few studies cover the needs of all targets defined for a goal. Estimates reported as a single value are plotted as dots, while a line plots those reported as ranges. Estimates from the previous ST15 and WIR14 studies (as reported in UNCTAD (2019)) are plotted in grey for comparison.

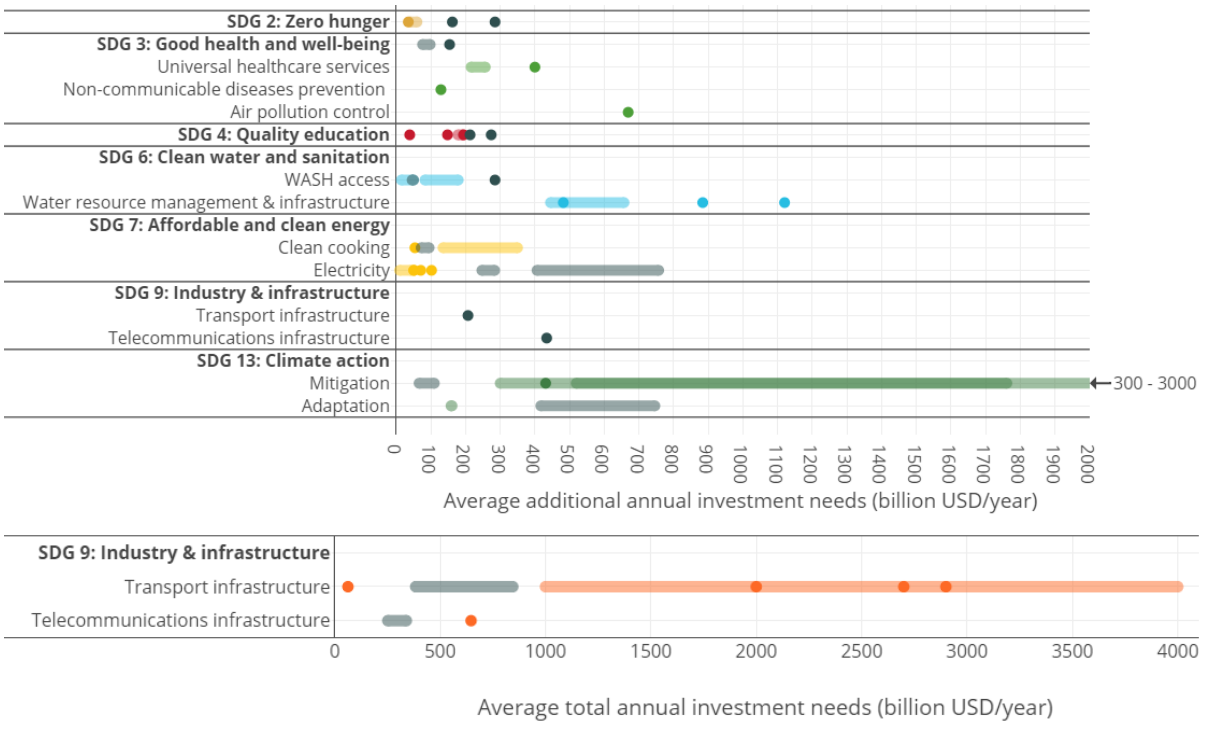

Figure 1: (a) incremental and (b) total investment needs estimates from identified literature

The highest investment gaps are found for SDG 13 (climate action) at up to USD 3 trillion annually, followed by SDG 6 (clean water and sanitation) with estimates up to USD 1.1 trillion annually (Fig. 1 (a)). The ranges are lowest but still substantive for SDG 2 and 4 (up to 300 billion each). A detailed description of results per SDG is provided below.

3.2.1 SDG 2

Apart from ending hunger and all forms of malnutrition, SDG 2 aims to achieve broader goals of ensuring food security, agricultural productivity, and just and sustainable agricultural practices.

We have identified two new sources for this goal's investment needs, with estimates ranging from USD 35 billion to USD 127 billion per year incremental to the baseline spending. Both sources are reports from grey literature and vary in their coverage of SDG targets, the methodology employed, and the types of expenditures included.

von Braun et al. (2021) uses a unit costs approach based on marginal abatement costs curves to select among a set of twenty-two interventions. A model is used to find the least-cost pathway to achieve the target by 2030 using the incremental costs of raising people out of poverty. The included interventions span a broad coverage, including measures such as crop protection, soil fertility management, mechanisation of agricultural operations, improved access to transport, communication, and energy infrastructure, as well as social protection, child nutrition, and educational programs. The study estimates an additional investment need of USD 40 to 60 billion annually by this method. The optimisation method is agnostic to the order by which the interventions are implemented and the interventions' effects on other SDGs or other socio-economic goals.

The other study employed a CGE model to simulate targeted investments at various scales of resolution – from the international to the household – and estimated the investment needs to end hunger at an incremental USD 35 billion per year (17). It is based on the premise that improving small-scale producers' productivity and incomes are key to eradicating hunger sustainably. The investment estimate includes interventions across food production, transport, storage, vocational education, and social protection programs to empower the vulnerable and excluded.

Both ST15 and WIR14 reported higher estimates for this goal, at least partly because investments in rural infrastructure needs were included, such as access to basic electrification and transport connectivity, which are covered under the respective SDGs in this study.

3.2.2 SDG 3

Recent strides reflect significant progress towards achieving SDG 3 (good health and well-being) targets overall, particularly towards reduced maternal and neonatal mortalities. Still, less than half of the global population is estimated to have access to essential health services (39). The grim outlook is further exacerbated by the strain on existing healthcare capacity, program disruptions (such as immunisation drives) and resource re-allocation from the ongoing pandemic.

Investment estimates in the healthcare sector follow a unit costs approach that can address regionally relevant needs to bridge the gap to global benchmarks (40). A 2017 WHO study estimates an annual investment gap of USD 400 billion for comprehensive health service delivery in 67 low- and low-to-middle-income countries (18). Its simple, bottom-up unit costs approach covers the costs of scaling up WHO recommended interventions. They primarily address access to universal healthcare services (SDG 3.8) but also contribute to other SDG 3 targets such as maternal mortality (SDG 3.1), neonatal health (SDG 3.2), epidemics and communicable diseases, including AIDS (3.3), access to reproductive healthcare (SDG 3.7).

Stenberg et al. (2019) cover a smaller set of direct SDG 3 targets and report an annual investment gap of USD 257 billion. This estimate includes associated investment needs beyond the health sector. For instance, investments directly related to public health interventions include investments into diagnostic tests, orthopaedic devices, hygiene and sanitation infrastructure. These additional inclusions are associated with its broader focus on primary healthcare contributing to universal health coverage.

Bertram et al. (2018) focus on SDG 3.4 (non-communicable diseases) related interventions, specifically those combating cardiac diseases in the top twenty countries with the highest risk prevalence. At USD 120 billion per year, the study estimates a relatively high investment need for the subset of the targets covered by the previous studies, likely due to higher costs in developed economies where cardiac diseases are more prevalent.

Investments in air pollution control addressing SDG 3.9 are estimated in McCollum et al. (2018) under the global emissions scenarios. For scenarios consistent with the Paris Agreement and SDG 13, they estimate annual investments up to USD 669 billion.

All the above estimates are substantially higher than the estimates of around 100 USD annually, as reported by ST15 and WIR14.

3.2.3 SDG 4

SDG 4 deals with inclusive and equitable access to quality education. It includes early childhood care and pre-primary targets to primary and secondary education and tertiary and vocational education for decent employment.

The Global Education Monitoring Report (21) performs a comprehensive costing exercise for the investments needed to meet all SDG 4 targets, including school infrastructure (classrooms, materials, etc.), hiring and training of teachers, development of quality curricula, policy costs such as those for mid-day meals, incentivising enrolment, WASH, promoting inclusivity across gender, disability, ethnicity, and socio-economic status. It calculates the annual investments needed at USD 340 billion for low- and low-to-middle-income countries, leading to a financing gap of USD 39 billion over baseline domestic funding. Another UNESCO report clarifies that updated data and rechecking model assumptions increase the total investments needed to USD 504 billion, and the gap from USD 39 billion to USD 148 billion. It further estimates that the COVID-19 pandemic likely increases this gap by up to USD 45 billion to USD 193 billion (22). The increase is driven by reduced domestic budgets triggered by economic recession and the additional interventions needed to overcome the effects of the global pandemic.

The study by McCollum et al. uses UNESCO's data on average costs per student. It estimates that USD 194 billion per year will be needed to achieve projected primary and secondary education demands, reflecting only infrastructure investments needed.

In comparison, ST15 estimates an additional annual investment need towards education targets at USD 213 billion, while the WIR14 estimates at a comparable USD 274 billion.

3.2.4 SDG 6

Goal 6 of the SDGs aims for equitable access to water and sanitation (WASH), which is acknowledged as a basic human right being a pre-requisite for survival (41). The targets under this goal focus on sustainable management of water resources in addition to the actual provision of drinking water, hygiene and sanitation services. These include ensuring water quality and limiting pollution, transboundary water management, improving water use efficiency and limiting unsustainable withdrawals.

Five additional sources estimating the investment needs for this SDG were found. The estimates vary widely across the studies, from about USD 30 billion to USD 1.1 trillion per year.

Hutton & Varughese (2016) estimate that providing universal access to basic WASH services poses an investment need between USD 15 and 50 billion (mean USD 32 billion) annually additional to

baseline spending, and up to USD 179 billion per year additional to the baseline to reach a higher "safely-managed WASH" ambition level. The estimates are derived using a simple unit costs approach to include community wells and latrines, access to hand-washing stations with soap for basic WASH, and piped water and faecal waste treatment for safely-managed WASH.

The OECD estimates a much higher annual investment need of almost USD 0.9 trillion (of which USD 482 billion within their member states). This estimate includes the investments needed to maintain and upgrade urban water and sanitation infrastructure (24). In addition to providing access to drinking water and sanitation services, much higher investments are needed towards broader water resource management infrastructure to ensure sustainable extraction of this limited resource, meeting projected global and local water demands. It is, however, unclear if the presented estimates total investment needs or additional to a baseline.

The above estimates do not take the impact of climate change into account. The IAM-based studies that have estimated investment needs for SDG 6 take climate change into account, primarily through the projected water demand in alternative climate, energy-use, behavioural and population growth scenarios. Apart from the water withdrawal and distribution infrastructure associated with meeting increased demand, they also account for the consequent infrastructure needs to ensure water supply (e.g., pollution control, wastewater recycling and desalination), to reduce water demand (e.g. towards improving household, agricultural, and industrial water-use efficiency), and for integrated water resource management. Total annual investment needs estimates to meet SDG 6 targets derived by this method range from USD 445 to 885 billion (25,26).

A World Resources Institute (WRI) working paper provides a comprehensive needs estimate for SDG 6 targets. It includes full capital and operational expenditures spanning access to drinking water and sanitation services, agricultural and industrial water pollution control, reducing scarcity, and regulation and integrated water management (27). At 1.12 trillion USD, it is the highest estimated investment gaps to reach SDG 6 and one of the highest for any SDG.

ST15 focuses only on basic WASH access targets in SDG 6, and its estimated investment gap of USD 46-50 billion is comparable to the recent estimates that looked at similar targets. The UNCTAD estimate of USD 285 billion in WIR14 still focuses mainly on WASH targets but accounts for more ambitious levels of WASH and pollution control infrastructure.

3.2.5 SDG 7

SDG 7 aims to achieve universal, reliable, and affordable access to modern energy services. As of 2018, 789 million people worldwide still lacked access to electricity, and 2.8 billion – one-third of the planet's population – to clean cooking stoves and fuels. Increasing the share of renewables remains a challenge both in existing and planned energy infrastructure deployment. The greatest deficit is seen in Sub-Saharan Africa (SSA), with about 548 million people, or over half the total population in the region still lacking access to electricity.

Investment needs estimates to bridge these enormous gaps are consequently predominantly focused on the SSA region. Interventions in electricity access are modelled by increasing tiers of the services provided by degrees of access ranging from enough electricity to light a few light bulbs and a cellphone to full 24x7 access to grid electricity. Investment estimates further differ from each other by the ambition levels and technological choices, and energy sources considered in each tier.

In the State of Electricity Access Report 2017, the World Bank estimates an annual investment need of USD 50 billion for full 24x7 grid electricity access globally (32). The IEA estimates an annual investment need of USD 102 billion for the SSA region with a mix of full-grid, mini-grid, and stand-

alone transmission systems (31). While the methods and data sources used in each of the above studies are not made explicit, the IEA estimate is similar to the IAM based approach used by Dagnachew et al. (2017), and Lucas et al. (2020), who use the IMAGE model to assess that additional capital investment of about USD 40 billion to USD 51 billion over a USD 57 billion baseline will be needed to achieve universal access to electricity in SSA by 2030. These recent estimates are notably lower than those estimated by ST15 and WIR14, since the transformational action needed in the energy supply systems are now largely accounted for under SDG 13 (climate action).

Hof et al. (2018) use the same IAM framework to estimate that USD 54 billion would be needed per year towards modern stovetops and associated fuels in the same SSA region in the same period to reach universal access to clean cooking solutions. However, the multi-IAM approach in McCollum et al. (2018) calculates an estimated USD 135 billion to USD 350 billion in capital and fuel costs to achieve universal access to clean cooking globally.

For comparison, ST15 estimates an additional investment of USD 72 billion to USD 95 billion globally to achieve this target, attributable largely to the little progress made over the last two decades outpaced by high population growth in the vulnerable regions (39).

3.2.6 SDG 9

SDG 9 has three objectives: building resilient infrastructure, developing sustainable industrialisation, and fostering innovation. Investment needs estimates in the reviewed literature related to this goal are invariably associated with infrastructure needs alone since infrastructure development is well suited for measurable goal-based modelling of interventions and typically involve enormous investments. Moreover, infrastructure is recognised to influence multiple targets spanning across all 17 SDGs directly or indirectly (43).

All investment needs we found in the literature refer to total needs instead of additional to baseline. Since they also vary in geographic coverage, costing methodology, and assumptions, it is impossible to apply a common baseline exogenously here.

Investment needs assessments in this sector are available for four categories: transport infrastructure, telecommunication infrastructure, energy infrastructure, and infrastructure related to providing basic services such as healthcare, water, food, or education. To avoid double-counting, we present the findings of the first two categories of transport and telecommunication infrastructure under SDG 9. The estimates related to the other categories are accounted for in the respective SDGs associated with those sectors.

A recent assessment is made by Fischer-Romito & Guivarch (2019), which use the Imaclim-R IAM to estimate global transportation infrastructure investment needs in low and high carbon scenarios at USD 1 – 4 trillion per year. The study also presents additional sources in literature for comparison. Annual investment needs estimates by Dulac (2013) at USD 2 trillion, and from the Energy technology Perspective, 2016 (35) are pegged at USD 2.7 trillion. An OECD study updates the latter estimate by IEA to include investments into airports and ports, bringing the total estimate to USD 2.9 trillion annually (44).

Rozenberg & Fay (2019) focus on low- and low-to-middle-income countries and use an IAM based method to estimate an annual investment need of USD 63 billion in a socio-economic scenario marked by increasing urban density, high utilisation rates of public transport, and efficient returns to investments.

Total investment needs as reported by WIR14 amounted to USD 350 to 770 billion, of which USD 300 billion as baseline investment and USD 50 billion to USD 470 billion as additional need. The recent studies, therefore, seem to report much higher numbers than WIR14.

3.2.7 SDG 13

McCollum et al. (2018) and Bertram et al. (2021) offer the most comprehensive overview so far of the investments in the energy systems required to mitigate climate change to 1.5°C (SDG 13).

The McCollum et al. study contrasts the Paris-consistent 1.5°C scenario with reference scenarios representing continuation of current policies, and trends defined by the nationally determined contributions (NDCs) to climate mitigation efforts. The resulting annual investment gap between the 1.5°C and current policy scenarios is estimated at USD 900 billion, ranging from USD 481 billion to USD 1.6 trillion, and covering expenditures towards increasing the share of renewables substantially and doubling the energy efficiency improvement rate. The study uses a multi-model comparison from six IAMs that model the global energy/economy system using diverse sectoral coverage and methodologies. This breadth allows calculating how such an energy system transformation by 2030 would affect the investment needs of other SDG targets from air pollution, clean cooking fuels, water and sanitation, food security, and education. These investment needs are presented alongside other estimates for the respective SDGs.

Bertram et al. (2021) also use a similar multi-model approach using IAMs, but feature a substantially lower global emission budget and higher targeted annual reductions compared to the previous study. The approach highlights the critical early- to mid-term emission reductions, mainly through investments in improving energy efficiency in highly energy intense industries and decarbonizing energy sources, necessary to exceed peak 1.5°C warming. Capital heavy energy transition investments are thus front-loaded in the near term compared to approaches which rely on late term atmospheric carbon dioxide removal to meet end of century warming targets. The study consequently pegs the estimated annualinvestment gap at USD 300 billion – USD 3 trillion.

Very little information can be found on the investment needs towards climate adaptation at the global scale. One study, however, addresses a known form of adaptation to one of the better understood global climate change impacts – sea-level rise. It estimates the annual investments needed to build dykes to prevent coastal flooding globally in response to the projected sea-level rise at about USD 160 billion (38).

4 DISCUSSION

Estimates from the reviewed literature suggest that significantly greater investments will be needed overall to achieve them than estimated by ST15 or WIR14, although individual estimates vary considerably. These higher estimates correlate with an increasing body of knowledge of the evolving interpretation of target metrics, availability of more and better data, improved assessment methods used to incorporate increasing levels of complexity, an expanding set of possible and feasible interventions to address the challenges, and use of more sophisticated costing methods. Higher estimates are also seen in studies that include more detailed climate change scenarios, higher ambition levels, and, more recently, impacts of the COVID-19 pandemic. The variation among estimates was also to be expected. Table 1 showed us that these developments are reflected by the variation among the studies in the targets aimed to be met (also within SDGs), the interventions and types of associated expenditure included (what to cost), and costing methods used (how to cost).

While the various approaches try to derive a single number, investment needs estimates are driven by national ambition levels, development strategies, implementation policy choices, and investment efficiency (36,44). Estimates also hinge on other exogenously assumed key socio-economic factors such as population and GDP growth rates, technology diffusion and adoption, and urbanisation trends which the SDG interventions directly aim to influence.

Despite much new research since the ST15 and WIR14, explicit coverage of investment needs at a global scale is still only available for a subset of SDGs. One explanation could be the difficulty in quantifying progress for some SDGs and targets, and further, in attributing or correlating them with investments. Even so, UNESCAP's guidebook for assessing SDG investment needs argues that costing is needed for implementing even those goals whose achievement depends on non-monetary factors (40). Investments towards universal access goals or infrastructure can contribute to the pursuit of other goals such as social and economic equity, which may not have investments directly attributed to otherwise. Estimates derived from integrated approaches using socio-economic scenario drivers can thus address more goals than those explicitly achieved through the investments.

The SDGs represent complex environmental, social, and economic needs. Targets related to urgent developmental goals in the short term are often in conflict with those related to medium-to-long term sustainability goals. An emerging body of literature highlights these interlinkages among the SDG targets themselves. Studies quantifying investment needs increasingly account for such interlinkages by addressing groups of multiple SDGs together Table 1. Moreover, the recent literature reviewed in this study cover a broad range of valid potential solutions to achieve the targets both individually and in conjunction with others. The associated investment needs thus vary regardless of the estimation methods used, reflecting the multiplicity of valid pathways to reach the goals.

Targeted public investments implementing robust social protection policies form a significant part of the estimated needs to achieve developmental outcomes such as eradicating hunger, universal access to education, water and modern energy to billions of people in low- and low-to-middle-income countries. Even taken together with ambitious levels of distribution infrastructure for piped water, safe sanitation and full grid access to power, overall investment needs remain modest in studies which concern mainly with attaining developmental targets (universal and equitable access to basic services). However, achieving the developmental outcomes in a sustainable way also requires significantly higher investments in critical infrastructure in renewable energy, urban air pollution control, deployment of energy-efficient technology, water effluent treatment and desalination, etc. Beyond differences in costing methodology, data and assumptions, this marks a clear shift in recent literature from the previous literature covered in ST15 and WIR14, which address developmental targets in relative isolation from sustainability ones.

The estimates presented are typically in the form of additional annualised investments needed to reach the SDGs. While the overview presented in this study marks an improved and updated understanding of the costs involved to achieve the SDGs, the numbers must be interpreted with some caution since they are not always comparable. While most included studies annualise the need over the 2015 to 2030 period, some take a longer-term approach till 2040 or 2050 to account for longer system lead-times and delayed consequences. However, some recent studies annualise the needs over a shorter term to capture present gaps to the 2030 targets. Another reason for caution is that the assumed baseline over which the additional investment needs are estimated are often unclear. Where specified, the assumed baselines vary from the then-latest domestic sectoral investments for which data is available to the then-current overseas development aid (ODA) targeted by sector. Studies using IAMs often forego such static, measured baseline data favouring

assumed time-dynamic business as usual projections as scenarios that can be contrasted with alternate scenarios to infer the investment gaps. The assumed baseline investments can strongly influence the assessed gaps since the total investment needs can be up to an order of magnitude higher, as evidenced by the presented estimates towards SDG 9 targets presented in this study.

Another challenge in analysing and interpreting the reviewed literature into a robust understanding of the investment needs is that the estimate data collected may not be sufficient and consistent to draw statistically significant conclusions, especially in light of the variations seen among the studies producing them. The variations are often compounded by unclarity or opaqueness in the methodological details, baseline investments considered, year at which the estimates are indexed, target metrics, scenario assumptions etc., posing further difficulty in interpreting the limited data. The search process itself often points to a fragmented body of literature. It is difficult to find global investment needs estimates to meet SDGs because of how the body of literature is organised and the heterogeneity in terminology for SDGs. Assessment of interventions and, therefore, associated investment needs estimates are often carried out at local scales, meeting specific local needs, including national, sub-national studies, or case studies that are narrower in scope. Assessments are often siloed in their research or policy field, but a trend towards more and increasingly integrated assessments aid in mitigating these limitations.

5 CONCLUSIONS

This study has identified the required investment levels to achieve different SDGs as reported in the literature. The values for SDGs 13 and 6 are the highest. For mosts SDGs, costs are in the order of hundreds of billion USD annually. The range of estimates for different SDGs indicates that the greatest additional financial resources will be needed to reach SDGs 6 and 13 – around USD 1 trillion each annually. SDGs 3 and 6 show the biggest increase in the required investments to achieve compared to previous estimates. Total investment needs to achieve transport and telecommunication infrastructure targets in SDG 9 are also high. Their implementation can influence other SDGs. Estimates towards each goal covered vary widely among studies, with a particularly wide range of estimates in SDGs 9, 6, and 13. On the other hand, estimates for SDG 4 and SDG 2 and access for related targets in SDGs 3, 6, and 7 find greater agreement.

Estimates of total global investment needs are difficult. With increased interconnections, uncertainties, and implementation pathways to account for, it is hard to arrive at a reasonably meaningful value for the aggregated investment estimate to achieve the SDGs than for the MDGs that preceded them – although it is clear that total investment needs are in the range of trillions USD annually. The surveyed literature shows a research field in flux, constantly experimenting and changing rapidly to address the challenges of performing such an exercise. Integrated approaches (e.g. using IAMs) and multi-model comparisons are increasingly being used, leading to a clear ongoing trend of growing consensus on methodology, scoping, and results. While by no means exact or certain, resulting estimates are more comprehensive, nuanced, representative, and consistent with one another compared to previous estimates from back of the envelope calculations.

Avenues for developing better investment needs estimates are highlighted in this study. Still, it is critical that the progress represented by the current state of the art be taken into account in the planned mobilisation of financial resources if the Goals are to be met as adopted.

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