GLOBAL INFRASTRUCTURE OUTLOOK

A G20 INITIATIVE

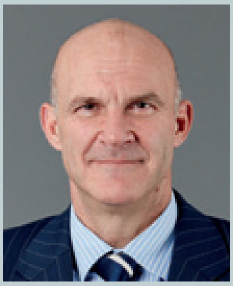
Global Infrastructure Outlook

Infrastructure investment need in the Compact with Africa countries

OXFORD ECONOMICS

Global Infrastructure Hub

FOREWORD



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THIS TIMELY UPDATE TO THE GLOBAL INFRASTRUCTURE OUTLOOK PROVIDES MUCH-NEEDED NEW DATA ABOUT THE INFRASTRUCTURE REQUIREMENTS IN 10 AFRICAN COUNTRIES.

These countries are participating in the G20 Compact with Africa (CWA), an ambitious yet practical effort to substantially increase investment in these countries. The Global Infrastructure Hub is pleased to contribute this new information to support the CWA, by identifying infrastructure investment needs in seven sectors over the next 25 years.

Infrastructure gaps continue to be significant in most African countries. According to our forecasts, current investment levels are sufficient to meet only 57 percent of infrastructure needs across the continent—compared with the global average of 81 percent. The need for much greater effort in infrastructure provision has long been well known, particularly among governments and local communities. We hope the country-level data that is now provided by Outlook will help to shine a light on those areas where the needs are especially great.

Infrastructure relative investment need for the 10 CWA nations up to 2040 is forecast to be almost US $ 2.0 trillion, when compared with best practice among their peer countries. This forecast increases to almost US $ 2.4 trillion to meet the United Nations' Sustainable Development Goals for electricity and water by 2030. Current levels of access fall short: on average 60 percent of residents of CWA countries have ready access to electricity, and 44 percent to piped on-premise water supply and improved sanitation.

Supporting these investment needs will make significant headway into lifting the prosperity of all 10 CWA countries. This report considers what investment is required across seven sectors, and what is likely to occur, based on a range of factors such as a country's historic spending levels, and how its population and economy is changing—hence identifying investment gaps.

The ability to forecast investment needs for each CWA country—particularly what is required to provide universal access to electricity, water and sewage—is a critical first step in helping governments, development partners and international organisations tackle infrastructure provision shortages, and in identifying opportunities for private-sector investors.

In so doing, we trust that Global Infrastructure Outlook can assist the community of infrastructure practitioners working towards meeting the critically important goals of the CWA.

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THE PLANNING AND DEVELOPMENT OF INFRASTRUCTURE IN AFRICA HAS LAGGED BEHIND THE REST OF THE WORLD, HINDERING THE CONTINENT'S ECONOMIC GROWTH.

This report seeks to quantify the full scale of its infrastructural challenges—and opportunities—by assessing the needs of 10 African countries from different regions and stages of their economic development, up to 2040.

Our original Global Infrastructure Outlook, published in 2017, was a response to the lack of consistent, detailed data about infrastructure investment around the world. Featuring analyses of 50 countries across seven key infrastructure sectors, it was the result of a year-long research collaboration between Oxford Economics and the Global Infrastructure Hub.

This new report builds on that research by providing detailed forecasts of infrastructure spending and need in the 10 Compact with Africa (CWA) countries, including six—Benin, Cote D'Ivoire, Ghana, Guinea, Rwanda and Tunisia—that did not feature in the original report. Our study estimates how much each country will need to spend, relatively, on infrastructure in the years to 2040, to meet the standards of their best performing peer countries around the world.

Furthermore, we estimate the additional investment required for each country to meet the absolute benchmark of the UN's Sustainable Development Goals for electricity, water and sanitation by 2030. This metric is particularly important for these 10 African countries which, in many cases, face demanding investment targets to meet these goals.

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Executive Summary

INFRASTRUCTURE IS CRITICAL FOR ECONOMIC AND SOCIAL DEVELOPMENT THE WORLD OVER.

At the most basic level, people need access to clean, safe water for drinking and cooking, and power for lighting and heating their homes. Roads and railways enable them to get to work and thus provide for their families. Such transport infrastructure, as well as air- and sea-ports, also allows firms to reach the markets needed to trade their goods and services, including across international boundaries. In these ways, and many more, infrastructure is vital to economic development.

In many parts of Africa, however, a lack of infrastructure is hindering development. Across the continent, people still survive without access to the utilities required to meet their fundamental needs. This means that, as more infrastructure is put in place, the effects can be seismic—transforming ways of life and families' future prospects.

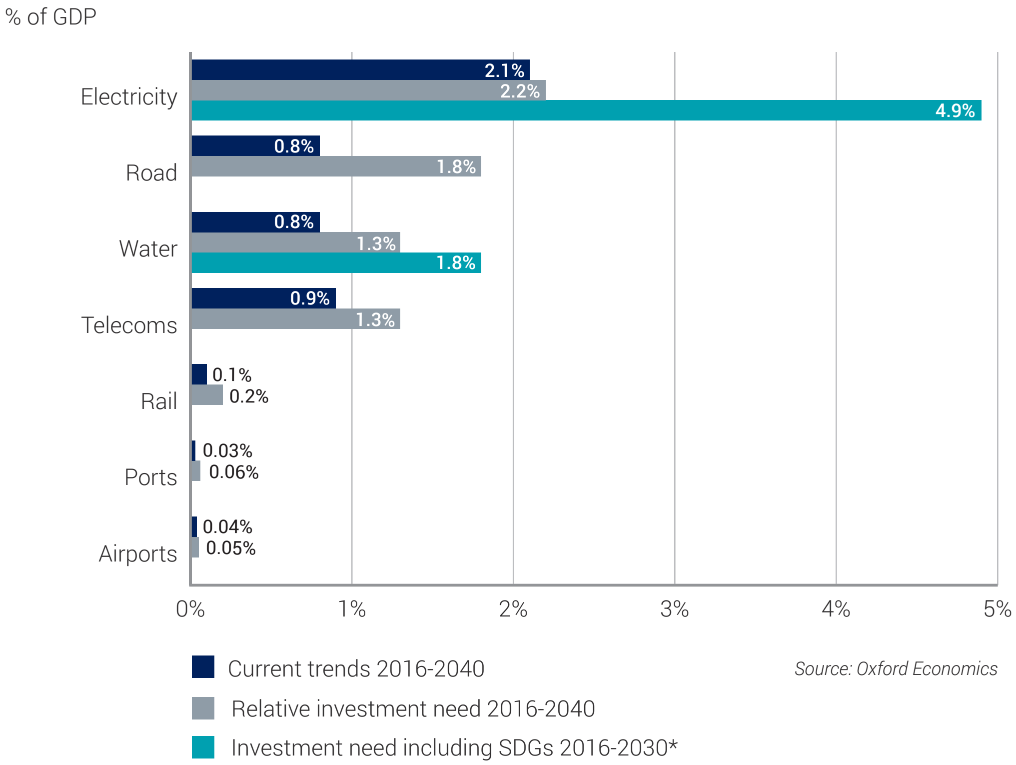
In 2017, the Global Infrastructure Hub, in partnership with Oxford Economics, launched the Global Infrastructure Outlook study to explore how much the world needs to invest in infrastructure in the years to 2040, and in which sectors this investment would be needed. **This paper extends the Global Infrastructure Outlook research to cover 10 of the G20's 'Compact With Africa' (CWA) countries.**[1]

In the first part of our analysis, **we estimate the total infrastructure investment needs of the 10 CWA countries between 2016 and 2040 to be US $2.0 trillion**. This is 39 percent higher than will be delivered under current investment trends, and is equivalent to 6.8 percent of total projected GDP for the 10 countries over that period. The US $2.0 trillion finding represents what would be delivered if the CWA countries could increase their investment to match that of the 2017 study's best performing low- and lower-middle income countries, after taking into account the specific characteristics of each country. It therefore represents a relative assessment of infrastructure need.

In the second part of our analysis, we adopt a different modelling approach to examine the CWA countries' needs for power, water and sanitation infrastructure, and assess the investment required to meet the absolute benchmark of universal provision by 2030, in line with the UN Sustainable Development Goals. We find that for the 10 CWA countries to meet the goals for universal access to electricity, water and sanitation, it would cost US $621 billion between 2016 and 2030. Three-quarters of this figure relates to electricity, and one-quarter to water and sanitation. **This means an additional US $383 billion of investment would be needed between 2016 and 2030, over and above that implied by our "relative investment need" scenario**.

[1] The 2017 edition of Global Infrastructure Outlook presented data for four of the CwA countries, namely Egypt, Ethiopia, Morocco and Senegal. This update adds data for six additional CwA countries: Benin, Cote D'Ivoire, Ghana, Guinea, Rwanda and Tunisia.

Fig. 1. *Infrastructure investment needs in the 10 CWA countries, 2016-2040*



*SDG requirement calculated for electricity and water only

1. Introduction

1.1 CONTEXT AND RATIONALE FOR THIS REPORT

Infrastructure is critical for economic and social development the world over. At the most basic level, people need access to clean, safe water for drinking and cooking, and power for lighting and heating their homes. Roads and railways allow people to get to work and thus provide for their families. Such transport infrastructure, as well as air- and sea-ports, also allows firms to reach the markets they need to trade their goods and services, including across international boundaries. In these ways and many more, infrastructure is vital to people's quality of life, and nations' economic development.

In Africa, however, the development of infrastructure has lagged behind, hindering the continent's economic development, and meaning many people must still survive without access to the water, sanitation and power infrastructure required to meet their basic needs. As such, there is a huge opportunity here. When infrastructure is developed, the impact can be seismic—transforming an economy, and the prospects of a nation's citizens, as roads are built and utilities put in place.

Yet, there is often a tendency to under-invest in infrastructure–with several factors at play.[2] Firstly, infrastructure typically involves making large up-front investments, while returns may take decades to accrue. Secondly, the risk of uncertain returns can make raising finances challenging. Thirdly, the benefit to society of an infrastructure project may often be greater than the private returns generated for the operator (infrastructure creates so-called "positive externalities")–meaning infrastructure may be under-provided if left to the market. Lastly, short-term political considerations and government borrowing constraints may hinder consistent long-term planning and investment.

While these challenges apply the world over, they are particularly acute in Africa.

The Compact With Africa (CWA) was launched in 2017 during the German Presidency of the G20. It seeks to "promote private investment in Africa, including in infrastructure".[3] To support this initiative, the Global Infrastructure Hub is developing a base of evidence on infrastructure markets within 10 countries participating in CWA.

As part of that process, we have produced this extension to our 2017 Global Infrastructure Outlook study, which sought to address the lack of consistent and detailed information relating to global infrastructure markets.[4] The 2017 study included four CWA countries (Egypt, Ethiopia, Morocco and Senegal). This new report expands the coverage of the Global Infrastructure Outlook research by developing comparable forecasts for an additional six CWA countries (Benin, Cote D'Ivoire, Ghana, Guinea, Rwanda and Tunisia).

1.2 THE STRUCTURE OF OUR ANALYSIS AND REPORT

The first element of our analysis, presented in Chapter 2, assesses the **level of infrastructure investment that is expected within each CWA country up to 2040 under current trends**, and the extent to which provision could be increased if the country **raised its game to match its best performing peers,** in terms of the resources they dedicate

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[2] IMF, *World Economic Outlook: Legacies, Clouds, Uncertainties* (Washington, 2014).

[3] G20, "Compact with Africa" < https://www.compactwithafrica.org/content/compactwithafrica/home.html> [accessed 9 May 2018]

[4] Global Infrastructure Hub and Oxford Economics, *Global Infrastructure Outlook,* (Sydney, 2017).

to infrastructure. This "relative investment need" forecast controls for differences in the economic and demographic characteristics of each country, and takes into account the current quality of infrastructure. Peers were defined as the 75th percentile of performers amongst countries with similar income levels from the 2017 study.[5]

This part of the analysis thus aims to explore not just what a "business as usual" scenario might look like, but also to identify how much it would cost to raise the game across the board, to a situation in which countries with similar characteristics dedicated a similar amount of resources to infrastructure.

The ability to compare forecasts of spending under current trends to the spending which would occur if each country matched the observed performance of its best performing peers was a central innovation in our 2017 study. **These forecasts provide an indication of relative infrastructure investment needs, taking into account each country's stage of development**. The difference between the "current trends" and "relative investment need" forecasts enables us to estimate the "investment gap" for each country, and for each of the country's seven infrastructure sectors included in our analysis.[6]

In many cases, however, raising a CWA country's investment levels to match those of its best performing peers will still not be enough to ensure universal access to water, sanitation and electricity by 2030, as proposed in the UN Sustainable Development Goals. The second part of the analysis, in Chapter 3, explores the implications of these targets in detail, and estimates the value of investment required for each country to meet the *absolute* benchmark of universal provision by 2030.

A summary of results for each of the 10 CWA countries is presented in Chapter 4. Full details of our methodology, assumptions and data sources are presented in the technical appendix.

We have, as far as possible, followed the same methodologies and principles developed for the 2017 study, and the results for the six additional countries have been developed to be as consistent as possible with those generated during the original study.

The consistency of approach also means that the same caveats apply to this extension as to our 2017 report. In particular, it is important to recognise that there is no single, consistent source of data on infrastructure investment by country and sector. We have augmented the database developed in 2017 with new data for the six additional CWA countries. The Global Infrastructure Hub engaged with its development partners and relevant ministries within the CWA countries as part of the data collection process. Nevertheless, our results should be treated with a degree of caution, particularly in countries and sectors where data are poorest and the need to estimate missing values was greatest.[7] Our findings should not be regarded as a substitute for more detailed, country-specific analysis.

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[5] While an implicit underlying assumption of our analysis is that 'more is better', we mitigate the risk of encouraging inefficient over-investment in two ways. Firstly, we benchmark performance against the 75th percentile of each peer group, as defined at the time of the original study, to avoid linking the forecasts to countries with unusually high rates of investment. Secondly, we take account of current infrastructure quality, so that our model does not propose large amounts of additional investment where provision is already good.

[6] A simplifying assumption within our analysis is that a country will need to invest more to close its infrastructure gap. That is, our forecasts implicitly assume that the *efficiency* of investment remains constant. In reality, it may sometimes be possible to increase infrastructure provision by increasing the efficiency, rather than the *volume,* of investment.

[7] The technical appendix provides details of the sources and quality of data available for each country and sector.

COVERAGE

The results presented in this report are unchanged from those presented in our 2017 report for the four CWA countries included in that study:

- Egypt
- Ethiopia
- Morocco
- Senegal

The six new CWA countries incorporated into this extension are:

- Benin
- Cote D'Ivoire
- Ghana
- Guinea
- Rwanda
- Tunisia

The research covers seven infrastructure sectors as outlined below:[8]

- Roads, including roads and bridges;
- Railways—fixed assets which form an integral part of rail networks (such as tracks, signalling and stations), including urban rail networks;
- Airports—fixed infrastructure such as terminals, runways, aprons, etc;
- Sea ports—fixed infrastructure for sea ports;
- Electricity, including generation, transmission and distribution;[9]
- Water, including infrastructure used for the collection, treatment, processing and distribution of water and sewerage;
- Telecommunications—physical infrastructure required for the provision of fixed line, mobile and broadband services.

Our data and forecasts relate to capital expenditure on both new and replacement infrastructure, but exclude ongoing operation and maintenance costs.

Values throughout the report are presented in US dollars at 2015 prices and exchange rates, unless otherwise stated.

To enable comparability with the 2017 report, where we present totals for Africa and the low and lower-middle income group, these are based on the sample of countries included in the original study. In the case of Africa, the totals for the countries in the sample were scaled up to account for countries not included in the sample, based on GDP data.

The full dataset has been made available at **outlook.gihub.org** to enable governments, investors and other stakeholders to explore the findings and undertake their own analysis.

[8] Here we present our preferred definition of each sector. However, the precise coverage for each country and sector will vary according to what is captured within the underlying data sources.

[9] We decided to exclude natural gas distribution infrastructure. Experience from earlier research suggests that data can be particularly difficult to obtain for this sector.

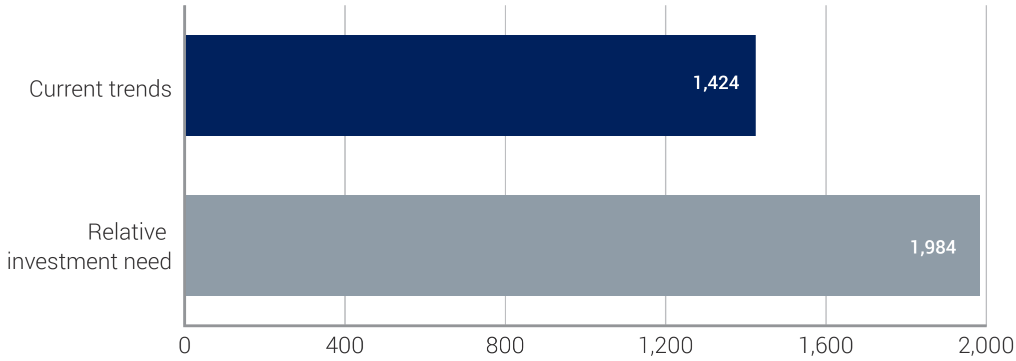
2. CWA Spending Needs

Under current trends, the 10 Compact With Africa (CWA) countries are projected to invest a total of US $1.4 trillion in infrastructure between 2016 and 2040, or US $57 billion per year. However, if the countries could increase their investment in infrastructure to match that of their best performing peers, the estimated *relative* investment need would be US $2.0 trillion, an increase of 39 percent.

Total infrastructure investment in the 10 CWA countries was equivalent to 4.9 percent of their combined GDP between 2007 and 2015, and our "current trends" forecast implies maintaining spending at this level. However, our "relative investment need" forecast would require the 10 countries to increase the proportion of GDP dedicated to infrastructure investment to an average of 6.8 percent. This would entail a step-change in investment: amongst the 10 countries, only Ethiopia invested more than 5.5 percent of GDP in its infrastructure between 2007 and 2015.

***Fig. 2.** Total infrastructure spending needs of the 10 CWA countries, 2016-2040*

Billion US$, 2015 prices and exchange rates



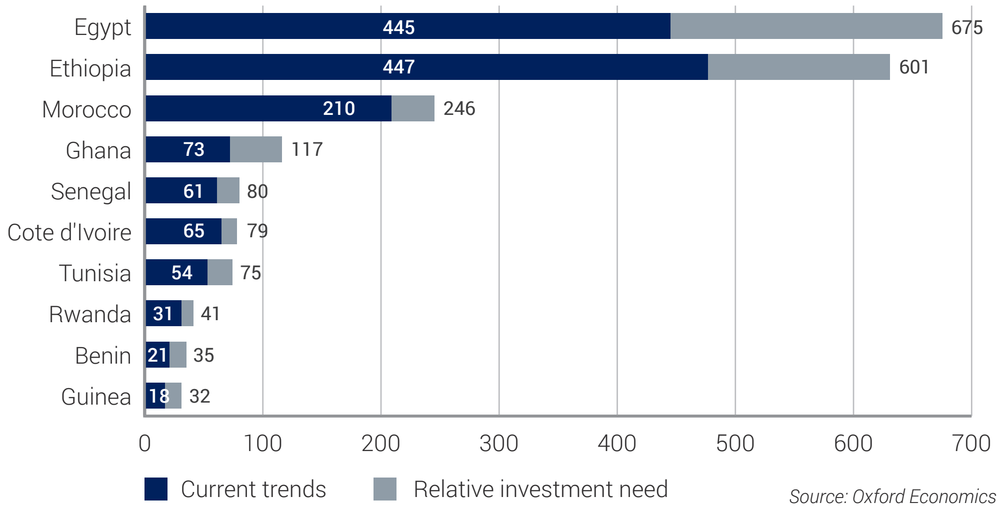
Source: Oxford Economics

Our forecasts for each country are presented overleaf (see Fig. 3), and show that the total spending requirements for this group of countries are dominated by Egypt and Ethiopia, which each account for more than 30 percent of the CWA total under both the current trends and relative investment need scenarios.

A small gap between the current trends and relative investment need scenarios indicates that a country is already performing well, given its economic and demographic characteristics, whereas a large gap suggests the country is lagging behind its best performing peers. We find that this "infrastructure gap" is proportionately greatest for Guinea, where the investment need forecast is more than 80 percent greater than what would be spent under current trends. The gaps for Benin and Ghana are both in excess of 60 percent; for Cote D'Ivoire and Morocco, they are around 20 percent.

Fig. 3. *Africa infrastructure spending needs, 2016-2040 (cumulative)*

Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

The relative infrastructure need forecasts for Cote D'Ivoire, Tunisia and Egypt amount to no more than 3.4 percent of GDP in the current trends scenario, or 4.9 percent in the relative investment need scenario (see Fig. 4).

In contrast, relative investment needs are highest as a proportion of GDP in the case of Ethiopia (17 percent), Guinea (10 percent) and Benin, Rwanda and Senegal (all around eight percent). For all of these countries except Ethiopia, this relative investment need would represent a noticeable uplift over the investment achieved in recent years (the strong past trend for Ethiopia reflects exceptionally strong spending in the electricity and water sectors).

Further insights into the situation in each country can be obtained by analysis of results by sector, which are presented below.

Our model suggests that **roads** provision in many of the CWA countries lags behind that in the best performing low and lower-middle income countries, after controlling for the characteristics of each country. As such, there is a need to increase spending in eight of the 10 CWA countries. Most notably, in Egypt, Benin, Ghana, and Tunisia, the relative investment need forecast implies that investment should more than double compared to what would be delivered under current trends. Overall, we find that roads account for around half of the entire infrastructure spending gap for the 10 CWA countries.

One exception to this overall trend for the roads sector is Ethiopia, where data from the International Road Federation and World Bank suggest that investment was extremely strong between 2007 and 2015. Indeed, the World Bank reports that Ethiopia increased the length of its road network by 70 percent between 2005 and 2012.[10] Given this recent focus on road development, Ethiopia is assessed to meet its road infrastructure needs through a continuation of current trends. The relative investment need forecast is also aligned with the current trends forecast for Rwanda: while it has not seen such strong investment as Ethiopia in recent years, our modelling suggests Rwanda's value

[10] World Bank, *Ethiopia Public Expenditure Review 2015* (Washington DC: World Bank Goup, 2016), pp.4.

of road stock is high relative to other low and lower-middle income countries, taking into account the country's economic and demographic characteristics. The relatively good state of roads in Rwanda is also indicated by its score on the World Economic Forum's road infrastructure quality indicator.

Six of the CWA countries are assessed as needing to increase their investment in **rail** infrastructure above what would be delivered under current trends (no data could be identified on Rwanda's rail infrastructure on which to base an assessment). The exceptions are Morocco, Egypt and Tunisia, which are estimated to meet their rail infrastructure requirements through a continuation of current trends. In the cases of Egypt and Morocco, the estimated value of rail infrastructure stock is estimated to be relatively high, given the economic and demographic characteristics of these countries. In the case of Tunisia, the available investment and infrastructure quality data suggest that the country has achieved a high quality of infrastructure relative to the amount invested, implying that a continuation of recent trends will be sufficient to meet Tunisia's needs in this sector.

Airport infrastructure spending needs are no more than around 0.1 percent of GDP in most of the 10 CWA countries. In this sector, Egypt, Tunisia, and Ethiopia appear to be on track to meet their needs under current trends. While Ethiopia has seen improvements to its airport infrastructure over the last decade, its spending is estimated to have been the lowest amongst the 10 CWA countries as a proportion of GDP. Nonetheless, given Ethiopia's stage of development, maintaining current investment trends should be sufficient to meet airport infrastructure needs throughout the forecast period once the current quality of infrastructure is taken into account. Egypt is estimated to have a high value of airport infrastructure stock relative to other low and lower-middle income countries and is on track to meet its future needs under current trends. For Tunisia, the situation is similar to that for the country's rail infrastructure: quality data suggest the country has achieved a high quality of infrastructure relative to the amount spent, pushing its performance score above the 75th percentile threshold for the low- and lower-middle income group.

Data challenges were particularly acute for the **ports** sector, and so we must rely on estimated values for all eight of the CWA countries with coastlines. Nonetheless, our analysis suggests that all of these countries will need to increase their investment in ports to match the best performing low- and lower-middle income countries in the Global Infrastructure Outlook model.

Guinea, Rwanda, Senegal and Benin have all invested more than one percent of GDP in **telecoms** infrastructure in recent years. However, the number of connections per capita in these countries is less than would be expected in light of the strong value of past investment. Once this is taken into account, our model suggests that all four of these countries will need to increase investment in telecoms to meet their relative infrastructure needs. Investment in telecoms infrastructure has been equivalent to less than one percent of GDP in Ethiopia, but here too the investment appears to have delivered fewer connections than would be expected and the country will need to increase spending to meet future needs. In contrast, Egypt, Morocco and Tunisia are amongst the top-performing low and lower-middle income countries for telecoms infrastructure, and are on track to meet their future infrastructure needs under current trends.

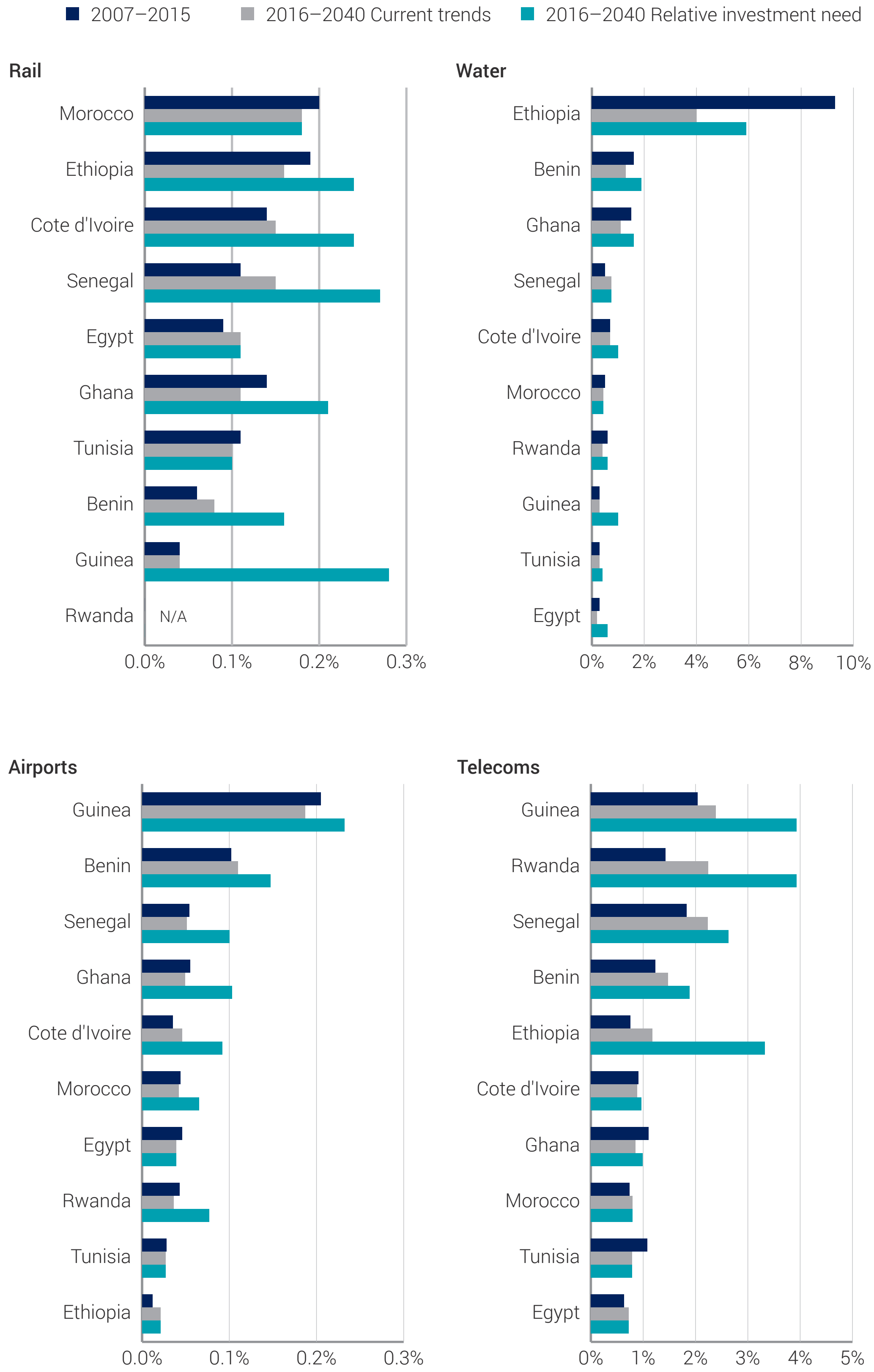
In the **electricity** sector, the value of electricity infrastructure stock is relatively high *given each country's stage of development and demographic characteristics.* As such, the gap between the current trends and relative investment needs forecasts is comparatively small across almost all of the 10 CWA countries. Closer inspection of the data reveals that the performance of a number of countries improves once the quality of infrastructure relative to the amounts invested is taken into account (Benin, Cote D'Ivoire, Ghana, Senegal and Tunisia). This is most clearly the case for Cote D'Ivoire, where the available data suggest that recent investment in electricity infrastructure has been extremely low. However, the World Economic Forum quality of electricity supply rating is high relative to the amounts invested, suggesting that very good outcomes have been achieved for the apparently low value of spending. Guinea is a notable exception within the electricity sector: the country would need to increase the share of GDP dedicated to electricity infrastructure to more than two percent, compared to the 0.4 percent estimated for 2007-2015, to match the best performing low- and lower-middle income countries in the Global Infrastructure Outlook model.

Finally, in the **water** sector, Ethiopia is estimated to have spent extremely strongly in recent years, and has achieved a noticeable increase in the proportion of its population with access to an improved water source—from 42 percent in 2007 to 57 percent in 2015. Ethiopia spent an estimated US $3.9 billion per year on water infrastructure between 2007 and 2015; this is an exceptionally high amount, particularly in relation to the size of the Ethiopian economy, and may be difficult to sustain in the longer term. While most of the other CWA countries will need to slightly increase the share of GDP dedicated to water infrastructure to meet this relative investment need, Morocco and Senegal are estimated to meet theirs by continuing with their current investment trend.

It is important to re-iterate that the assessment of relative investment needs in this section of the report is based on benchmarking the 10 CWA countries against best performing low- and lower-middle income countries from the 2017 study. Therefore, where a country is assessed as being on track to meet its relative investment needs, this is based on what other countries at similar income levels (and controlling for other characteristics) have actually spent in the past. This approach therefore applies an achievability criterion. In other words, countries at a similar level of development and with similar characteristics have demonstrated that spending at this higher level is achievable.

However, this is not to say that meeting the relative investment need forecast will lead to infrastructure provision which is "good" in an *absolute* sense. Indeed, even where countries meet their relative infrastructure needs, the basic needs for power, water and sanitation may not be met for everyone in the population. In the next chapter, we consider this point further, by assessing countries' investment needs against the more demanding *absolute* objective of meeting the UN Sustainable Development Goals for universal access to electricity, water, and sanitation, irrespective of the achievability of the levels of spending implied.

Fig. 4. Africa infrastructure spending needs by country and sector, 2007 to 2040 (% of GDP)


2007–2015
2016–2040 Current trends
2016–2040 Relative investment need
Rail
Morocco
Ethiopia
Cote d'Ivoire
Senegal
Egypt
Ghana
Tunisia
Benin
Guinea
Rwanda
N/A
0.0%
0.1%
0.2%
0.3%
Water
Ethiopia
Benin
Ghana
Senegal
Cote d'Ivoire
Morocco
Rwanda
Guinea
Tunisia
Egypt
0%
2%
4%
6%
8%
10%
Airports
Guinea
Benin
Senegal
Ghana
Cote d'Ivoire
Morocco
Egypt
Rwanda
Tunisia
Ethiopia
0.0%
0.1%
0.2%
0.3%
Telecoms
Guinea
Rwanda
Senegal
Benin
Ethiopia
Cote d'Ivoire
Ghana
Morocco
Tunisia
Egypt
0%
1%
2%
3%
4%
5%

3. Sustainable Development Goals

The United Nations has identified a package of Sustainable Development Goals (SDGs) for the global economy to achieve by 2030, to stimulate action in five areas: people, planet, prosperity, peace and partnership.[11] In some cases, meeting these goals will require infrastructure investment to ensure that all of a country's residents are able to access basic services. Of particular interest to our Global Infrastructure Outlook research are the stated objectives for provision of water and power:

- SDG 6: "Ensure availability and sustainable management of water and sanitation for all";
- SDG 7.1: "Ensure access to affordable, reliable, sustainable and modern energy for all".

For the 2017 report, we developed models to estimate how much the countries in our study might need to spend on electricity and water infrastructure to meet these objectives. To do this, we adopted a different analytical approach to the first part of our analysis, in order to create a direct link between the value of spending, expected population change, and access to electricity, water and sanitation.

In contrast to the "current trends" and "relative investment need" forecasts presented in the previous chapter, our SDG forecasts assess how much a country would need to spend to reach an *absolute* level of provision—that of universal access.

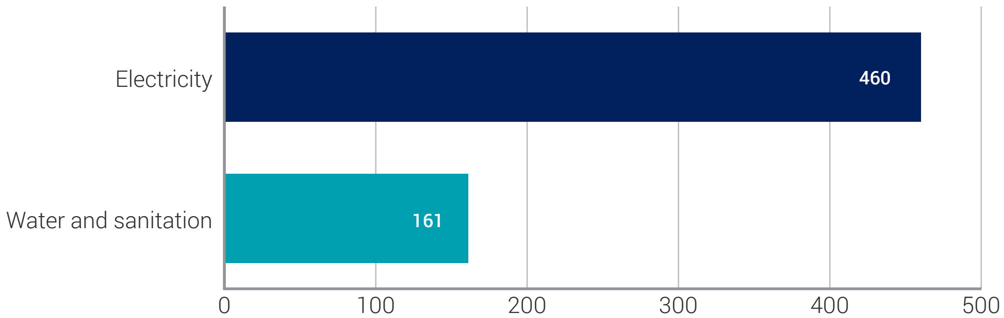
For this extension, we have applied exactly the same approach to assessing SDG investment requirements for the CWA countries as was used in our 2017 report. The values for the four CWA countries included in the original study are unchanged from the original report. Further details of the methodology are presented in the technical appendix.

3.1 OVERVIEW

Our modelling suggests that for the 10 CWA countries to meet the SDGs for universal access to electricity, water and sanitation it would cost a total of US $621 billion between 2016 and 2030. Three-quarters of this figure (US $460 billion) relates to electricity, and one-quarter (US $161 billion) to water and sanitation (see Fig. 5).

***Fig. 5.** Investment required by 10 CWA countries to meet SDGS for electricity, water and sanitation, 2016-2030*

Billion US$, 2015 prices and exchange rates



Source: Oxford Economics

[11] United Nations, "Sustainable Development Goals" <http://www.un.org/sustainabledevelopment/sustainable-development-goals/> [accessed 19 May 2017]

We can also assess the extent to which the spending required to meet the SDGs would be delivered under the "relative investment need" scenario presented in the previous chapter. The figures shown in Fig. 5 are not directly comparable with those in the previous chapter, because they relate only to the investment required to meet households' electricity and water needs, whereas our other scenarios relate to the investment required to meet the needs of all sectors of the economy, including agriculture and industry, for example.

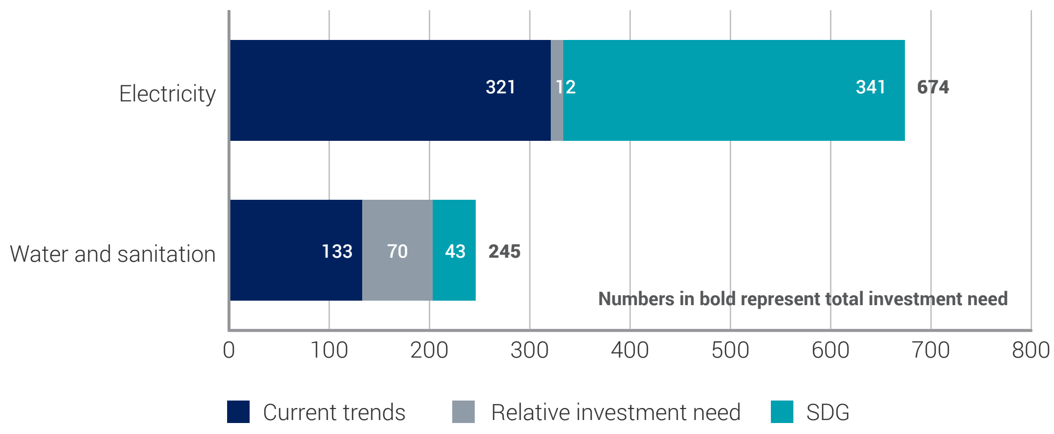
We have therefore undertaken further analysis to estimate the share of electricity and water investment in our relative investment need scenario which relates to household demand. This enables us to assess, for any given country, whether the SDG requirement would be delivered by the investment estimated in our relative investment need forecast.

We estimate that for the 10 CWA countries to meet the SDG for universal access to electricity, an additional US $341 billion of investment would be required between 2016 and 2030, over and above that implied by the relative investment need scenario presented in the previous chapter. For water, an additional US $43 billion would be required (see Fig. 6).

Bringing these results together, the total investment need for the electricity and water sectors between 2016 and 2030 increases from US $536 billion to US $919 billion when the goal of meeting the SDGs is included—an increase of 72 percent. That is, **the investment need for the 10 CWA countries between 2016 and 2030 would be US $383 billion higher if it included the cost of meeting the SDGs for universal access to water and electricity**.

Fig. 6. *Investment needs in the 10 CWA countries for electricity and water, including SDGs, 2016-2030*

Billion US$, 2015 prices and exchange rates

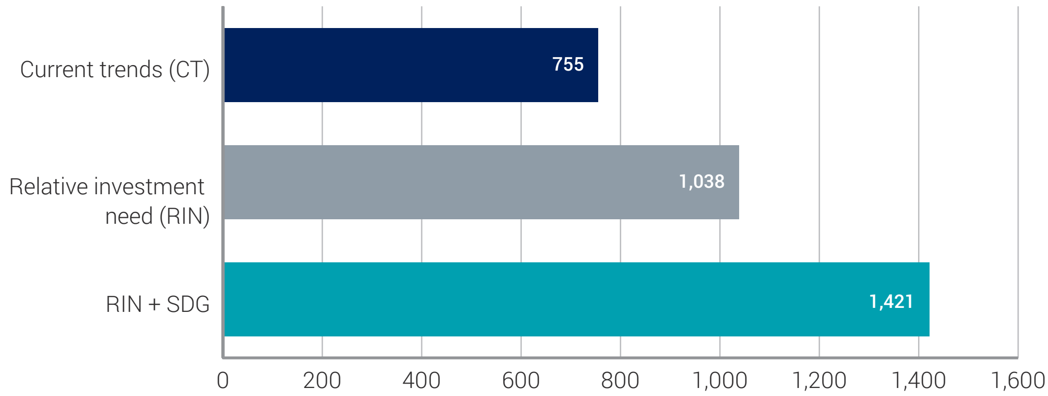


Source: Oxford Economics

Once the additional spending needed to achieve the SDGs for electricity, water and sanitation is factored into our calculations, the total infrastructure spending requirement to 2030 for the 10 CWA countries across all sectors increases to US $1.4 trillion. This is 88 percent higher than would be delivered under current trends.

***Fig. 7**. Total investment needs in the 10 CWA countries, including SDGs, 2016-2030*

Billion US$, 2015 prices and exchange rates



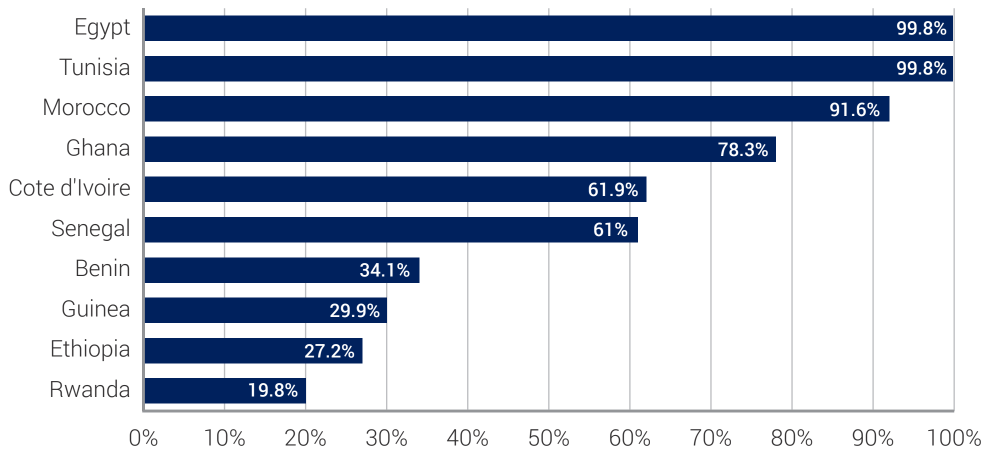
Source: Oxford Economics

In the following sections, we explore these findings for each CWA country.

3.2 ELECTRICITY

Electricity access levels vary considerably across the 10 CWA countries, and in 2014 ranged from 20 percent in Rwanda to virtually 100 percent in Egypt and Tunisia (see Fig. 8).

Fig. 8. *Proportion of population with electricity access, 2014*[12]

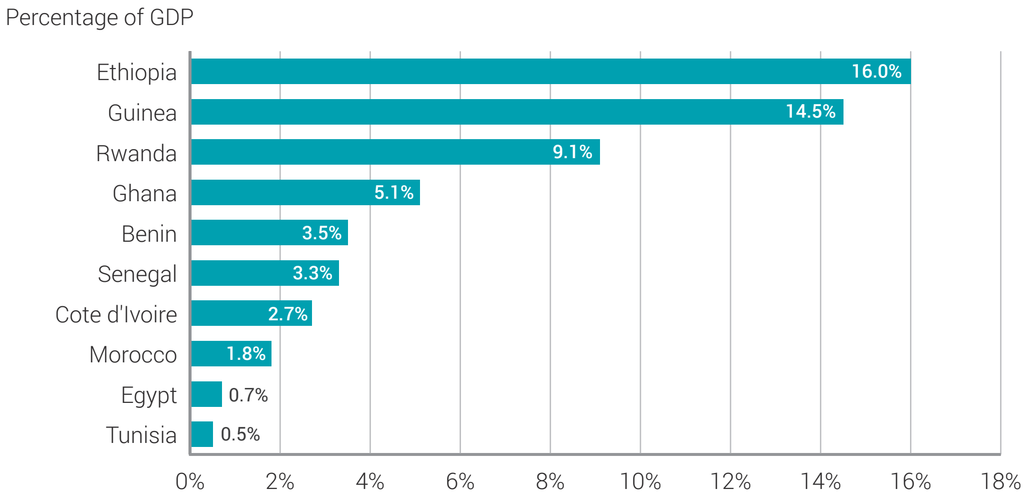


Source: World Bank World Development Indicators

As previously noted, we estimate that the 10 CWA countries would need to spend US $460 billion between 2016 and 2030 to achieve universal electricity access. To consider the degree of challenge this will represent for each CWA country, we can look at this spending requirement as a proportion of GDP (see Fig. 9). The challenge is greatest for Ethiopia and Guinea, which would need to dedicate 16 and 14 percent of their respective GDPs to domestic electricity access between 2016 and 2030. Achieving this SDG appears most affordable for Egypt, Morocco and Tunisia, reflecting that these countries will primarily need to focus on investment to support population growth, and replacement investment to ensure high access levels are maintained.

[12] We present values for 2014 to facilitate comparison with the 2017 Global Infrastructure Outlook report, which was also based on values as at 2014. More recent data have since been released which show that Egypt, Morocco and Tunisia have now achieved 100 percent access.

***Fig. 9.** Investment required to meet the SDG for universal access to electricity, 2016-2030 (percent of GDP)*



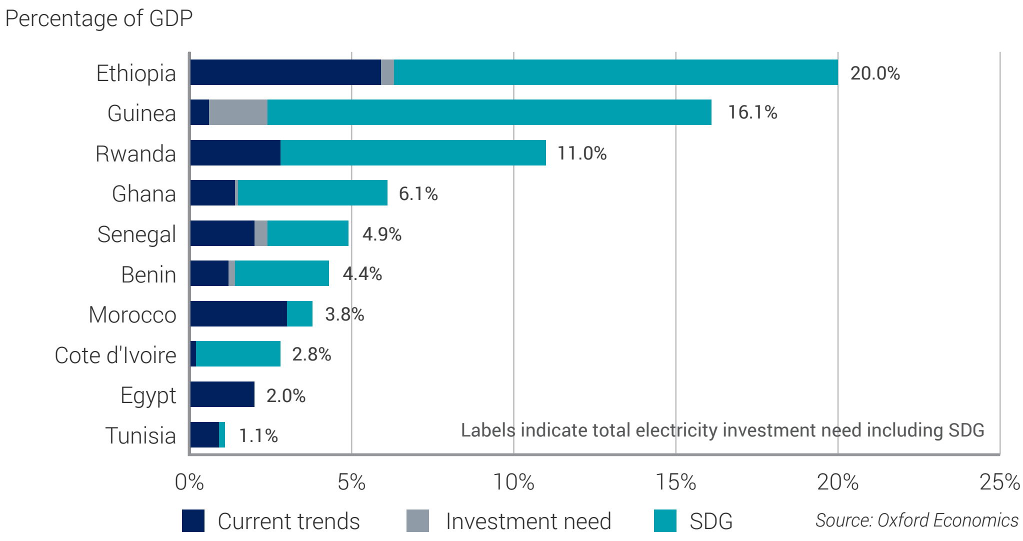
Source: Oxford Economics

We can also assess the extent to which the estimates of "relative investment need" presented in the previous chapter would increase if the requirement to achieve the electricity SDG is included. To do this, we needed to estimate the share of our main scenario forecasts which would be dedicated to fulfilling households' electricity needs (as opposed to those of industry or other sectors). Consistent with our 2017 study, we assumed that the share of investment going to household provision was equivalent to the household share of electricity consumption in each country.

This analysis confirms the scale of the challenge faced by certain CWA economies. When investment need is assessed relative to the countries' peer group, Ethiopia was estimated to need to spend just over six percent of GDP on electricity infrastructure between 2016 and 2030. This increases to 20 percent if the SDG is to be met (see Fig. 10). For Guinea, it increases from 2.4 percent to 16.1 percent, and for Rwanda from 2.8 percent to 11 percent. At the other extreme, we estimate that Morocco and Tunisia would need to spend less than an extra one percent of GDP to ensure the electricity SDG is met in 2030, while Egypt would meet the target if investment continues in accordance with recent trends.

Also noticeable in this analysis is that the difference between the "current trends" and "relative investment need" scenarios is frequently small, relative to the challenge of meeting the SDG requirement. That is, increasing investment performance to match the best performing peers would have comparably little impact on the investment requirement to achieve the SDG for many countries. This reflects differences in approach to the two forecasts. Our "relative investment need" scenario is benchmarked against what the best performing low and lower-middle income countries have actually achieved. It controls for achievability, but does not determine the spending required to deliver universal access, or any other absolute level of provision. In contrast, the SDG modelling focuses on the spending required to achieve universal access in each country, regardless of the performance of other countries or affordability.

Fig. 10. Total electricity infrastructure investment needs, including to deliver universal access to electricity, 2016-2030 (percent of GDP)



3.3 WATER AND SANITATION

The UN identifies a number of targets and indicators within SDG 6.[13] We focus on two of the targets which are most directly linked to investment in infrastructure:

- SDG 6.1: "By 2030, achieve universal and equitable access to safe and affordable drinking water for all";
- SDG 6.2: "By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations".

To assess current provision for each of these indicators, we referred to data from the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation.[14] For access to drinking water, we looked at access to a piped on-premises water supply, and for sanitation we looked at access to improved sanitation.[15]

As with electricity, there is wide variation in access levels across the 10 CWA countries (Fig. 11). Once again, Egypt and Tunisia rank highest on the water and sanitation indicators. In contrast, access levels are particularly low in Ghana, Benin and Guinea,

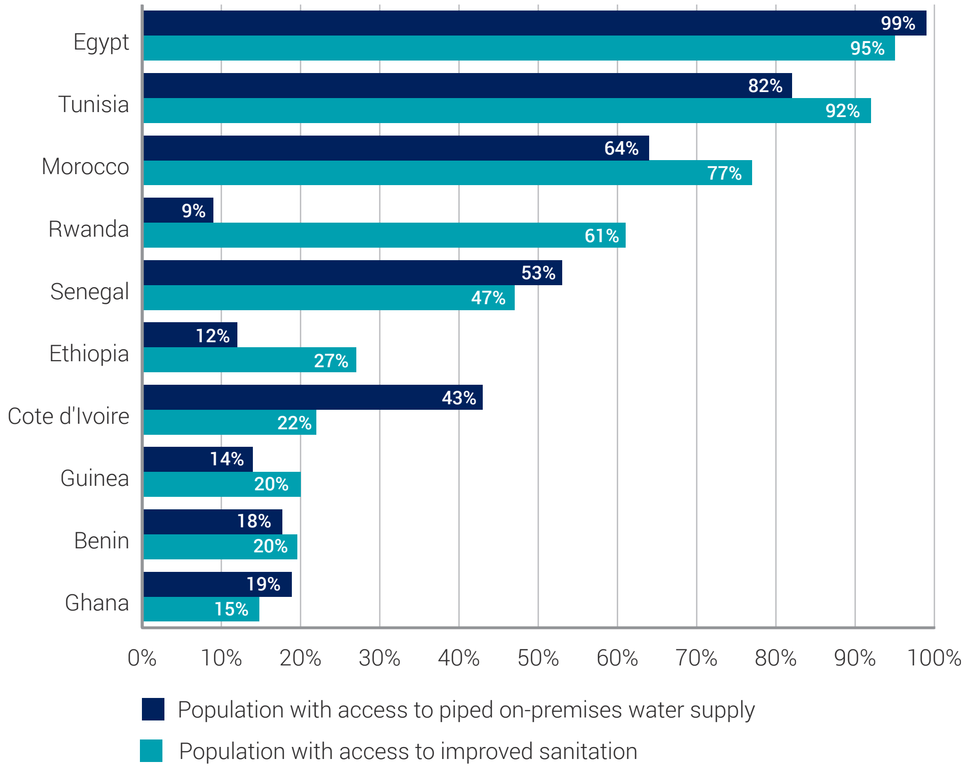
[13] United Nations, "Sustainable Development Goals" <http://www.un.org/sustainabledevelopment/sustainable-development-goals/> [accessed 9 May 2018]

[14] WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation <https://www.wssinfo.org/data-estimates/tables/> [accessed 28 April 2017]

[15] A piped on-premises water supply is a "piped household water connection located in the users' dwelling, plot or yard". Improved sanitation facilities are "designed to hygienically separate excreta from human contact". Since the Global Infrastructure Outlook models were developed, the UN has updated its definitions of how the water and sanitation SDGs are to be assessed such that they are to be monitored based on the population with access to 'safely managed' services. However, the data available from the Joint Monitoring Programme do not yet permit the modelling to be updated in line with the new definitions for many of the countries in our research. For comparability with the 2017 study we have retained the definitions used previously. An initial review of the impact of the new definitions suggests that our estimates of sanitation infrastructure requirements, in particular, may be conservative in light of the new definitions. We recommend further research into this issue as data availability improves.

where no more than 20 percent of the population has access to an on-premises water supply or improved sanitation.

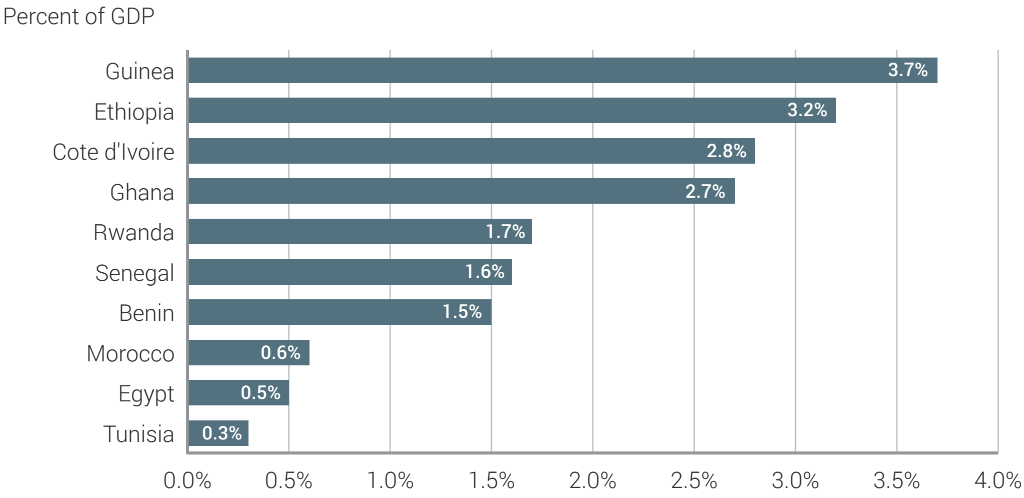
***Fig. 11.** Proportion of population with access to a piped on-premises water supply and improved sanitation, 2015*



Source: WHO/ UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation

In total, the 10 CWA countries would need to invest US $161 billion in domestic water and sanitation infrastructure between 2016 and 2030 to ensure universal access to both clean drinking water and sanitation. Relative to the size of each economy, needs are greatest in Guinea, which would need to dedicate 3.7 percent of GDP between 2016 and 2030 to domestic water infrastructure to meet the SDG (see Fig. 12). The requirement is also in excess of two percent of GDP for Ethiopia, Cote d'Ivoire and Ghana.

Fig. 12. *Drinking water and sanitation infrastructure spending requirements to meet SDGs, 2016-2030 (percent of GDP)*



Source: Oxford Economics

As with our analysis of electricity provision, it is informative to consider the incremental value of water and sanitation investment required, over and above what would be delivered under the "relative investment need" scenario discussed in the previous chapter. To do this, we disaggregated the relative investment need forecast to separately identify the portion of investment that is required for domestic purposes. As with our 2017 study, this was estimated based on data from the Food and Agriculture Organization of the United Nations on the proportion of water consumption by the agricultural, industrial, and municipal sectors.[16]

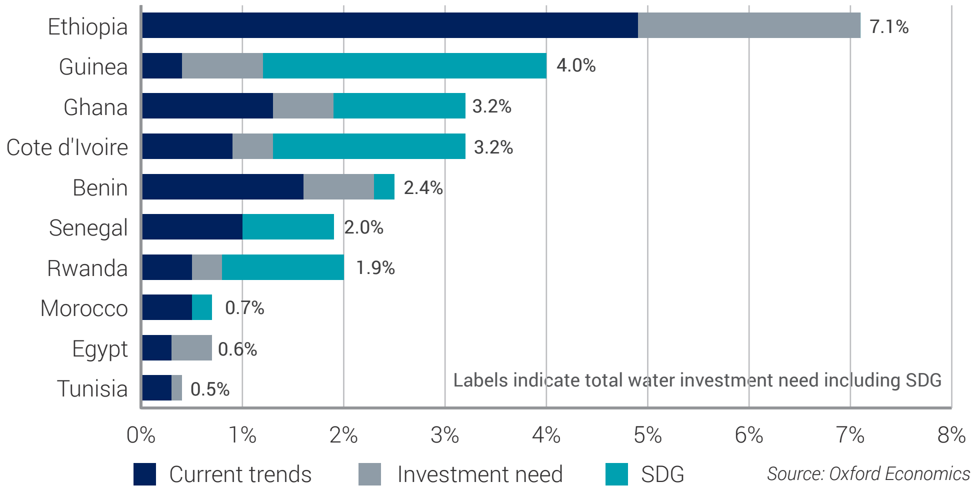
We find that the incremental investment requirement to deliver universal access to clean water and sanitation, over and above what would be delivered under our relative investment need scenario, is more modest than for the electricity access SDG. Most of the countries would, nonetheless, need to further increase their investment in water and sanitation infrastructure beyond what is implied by the relative investment need forecasts in the previous chapter—as denoted by the grey-coloured section of bars in Fig. 13.

This is most noticeably the case for Guinea, which, when compared to other countries with similar characteristics, was assessed as needing to invest 1.2 percent of GDP in water infrastructure between 2016 and 2030. This would increase to 4.0 percent if the country is instead assessed against the absolute benchmark of universal access to water. Introducing the SDG benchmark also sees the investment need for Cote d'Ivoire increase from 1.2 percent of GDP to 3.2 percent.

An exception to this trend is Ethiopia, which is projected to meet the water and sanitation SDGs by 2030 if it delivers the level of investment suggested by our relative investment need scenario. This would, however, involve dedicating more than seven percent of GDP to water infrastructure between 2016 and 2030—the highest proportion of GDP required among the 10 CWA countries, and, indeed, the 50 countries included in the 2017 study.

[16] Food and Agriculture Organization of the United Nations, "Aquastat", in FAO <http://www.fao.org/nr/water/aquastat/data/query/results.html?regionQuery=true&yearGrouping=SURVEY&showCodes=false&yearRange.fromYear=1958&yearRange.toYear=2017&varGrpIds=4250%2C4251%2C4252%2C4253%2C4257&cntIds=&regIds=9805%2C9806%2C9807%2C9808%2C9809&edit> [accessed 12 June 2016]

Fig. 13. Total water infrastructure investment needs, including to deliver universal access to clean drinking water and sanitation, 2016-2030 (percent of GDP)



Source: Oxford Economics

4. Country Profiles

In this section, we present a summary of key findings for each of the 10 Compact with Africa countries, which are presented in alphabetical order.

Benin

KEY ASSUMPTIONS

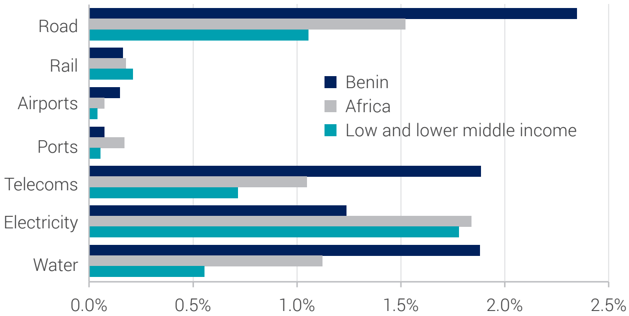
	2015	2040	Av. annual growth
GDP (Billion $US)*	8	31	5.4%
GDP per head ($US)*	779	1,649	3.0%
Population (000s)	10,880	19,050	2.3%
Urban population (% of total)**	44.0%	54.6%	0.9%
Population density (persons per km²)	96	169	2.3%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

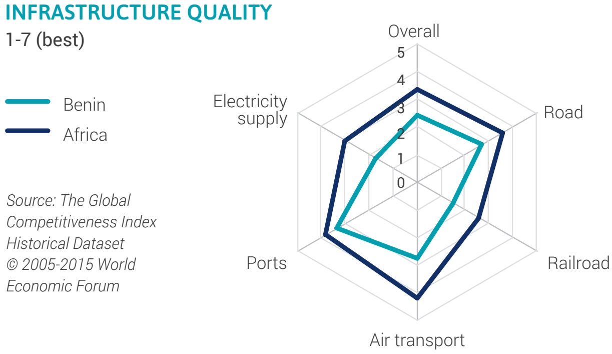
Percent of GDP

Source: Oxford Economics



INFRASTRUCTURE QUALITY

1-7 (best)

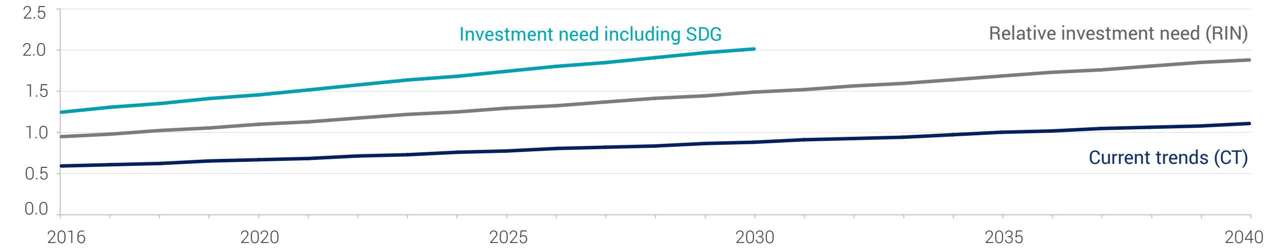


Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

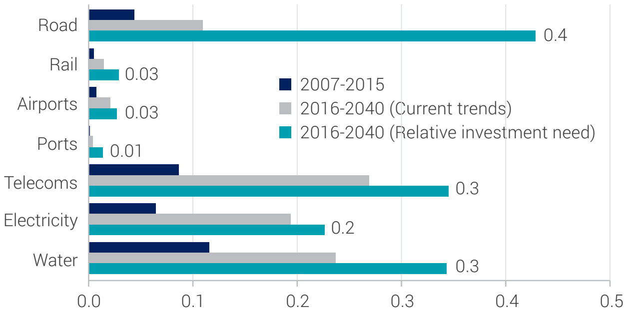
Billion US$, 2015 prices and exchange rates

Source: Oxford Economics



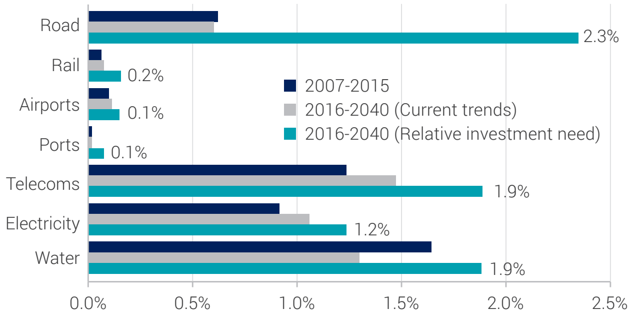
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



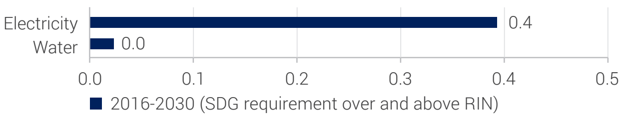
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



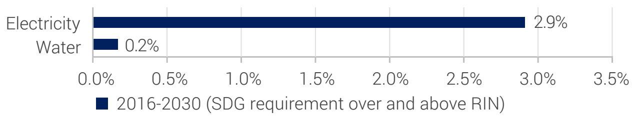
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	2.7	0.3	0.5	0.1	6.7	4.8	5.9	21.1
2016-2040 Relative investment need (RIN)	10.7	0.7	0.7	0.3	8.6	5.7	8.6	35.3
2016-2030 SDG requirement over and above RIN						5.9	0.3	6.2
2016-2030 Gap (RIN+SDG-CT)	4.1	0.2	0.1	0.1	0.9	6.3	1.7	13.4

Cote d'Ivoire

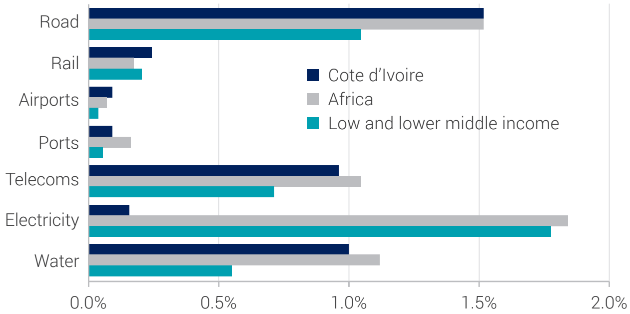
KEY ASSUMPTIONS

	2015	2040	Av. annual growth
GDP (Billion $US)*	32	141	6.2%
GDP per head ($US)*	1,399	3,543	3.8%
Population (000s)	22,702	39,882	2.3%
Urban population (% of total)**	54.1%	70.6%	1.1%
Population density (persons per km²)	71	125	2.3%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

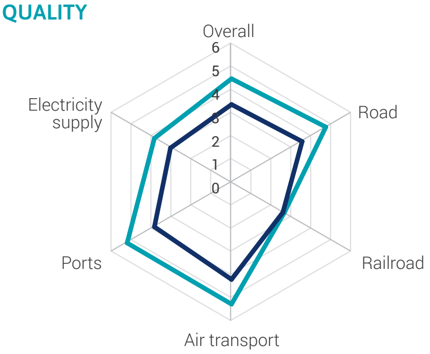
Percent of GDP *Source: Oxford Economics*



INFRASTRUCTURE QUALITY

1-7 (best)

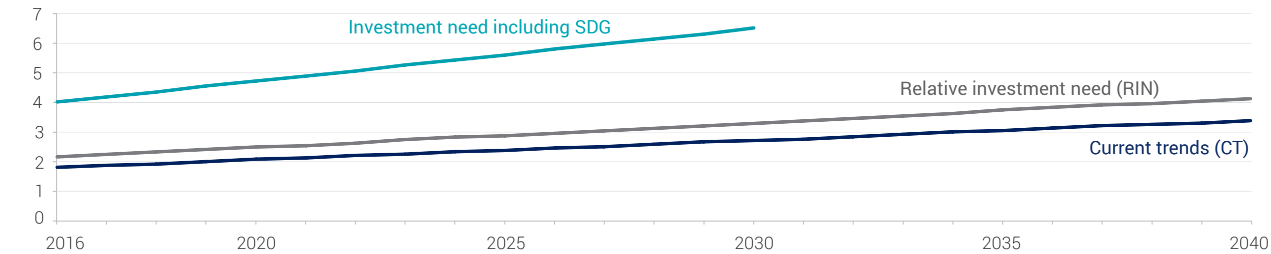
Cote d'Ivoire
Africa



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

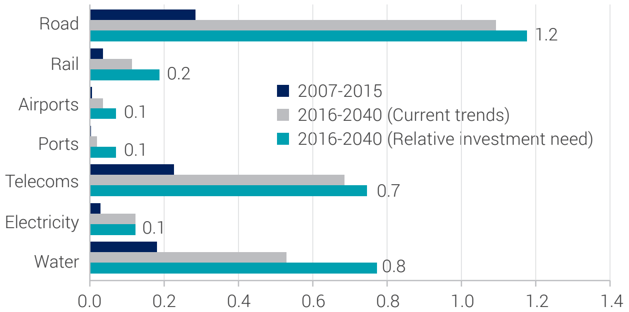
TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

Billion US$, 2015 prices and exchange rates *Source: Oxford Economics*



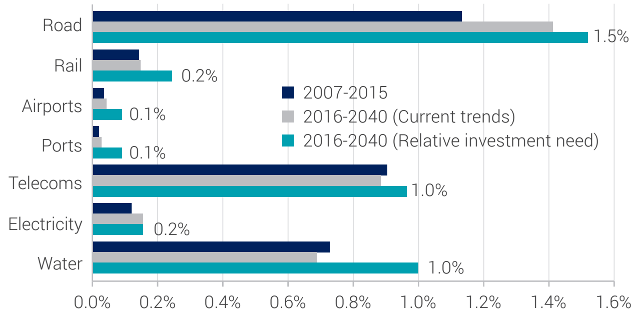
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



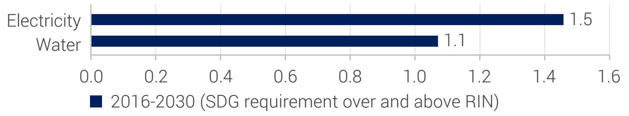
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



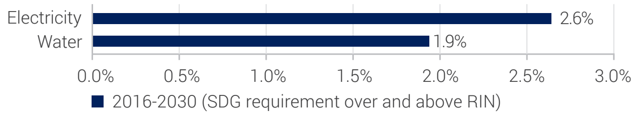
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	27.3	2.9	0.9	0.5	17.2	3.1	13.3	65.2
2016-2040 Relative investment need (RIN)	29.4	4.7	1.8	1.8	18.7	3.1	19.4	78.8
2016-2030 SDG requirement over and above RIN						21.9	16.0	37.9
2016-2030 Gap (RIN+SDG-CT)	1.1	1.0	0.4	0.6	0.7	21.9	19.1	44.8

Egypt

KEY ASSUMPTIONS

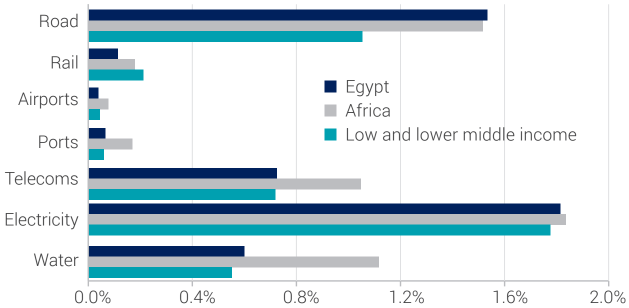
	2015	2040	Av. annual growth
GDP (Billion $US)*	318	842	4.0%
GDP per head ($US)*	3,472	6,263	2.4%
Population (000s)	91,508	134,428	1.6%
Urban population (% of total)**	43.1%	45.7%	0.2%
Population density (persons per km²)	92	135	1.6%

*2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

Percent of GDP

Source: Oxford Economics



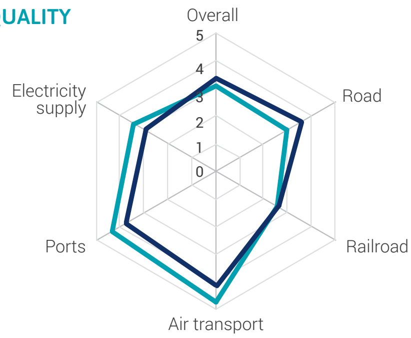
INFRASTRUCTURE QUALITY

1-7 (best)

Egypt

Africa

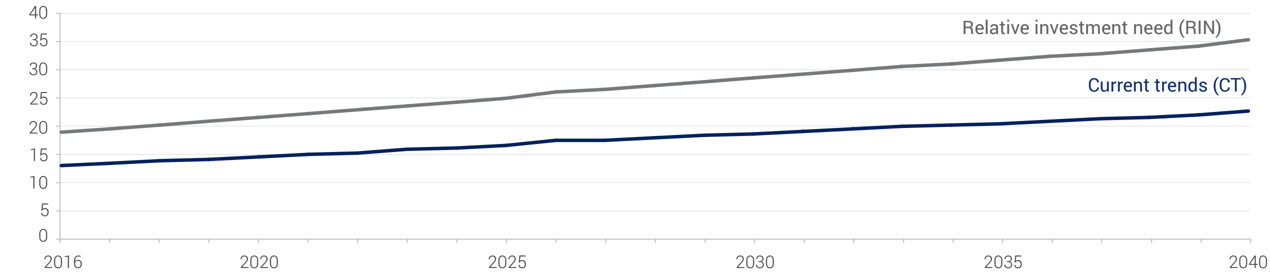
Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum



TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

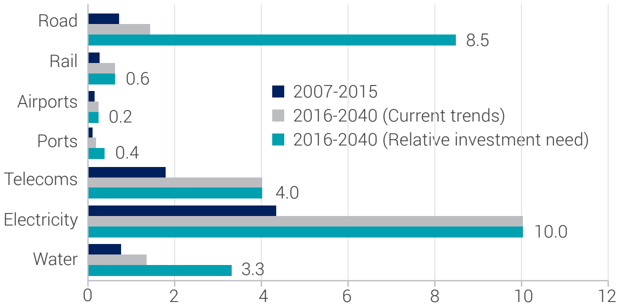
Billion US$, 2015 prices and exchange rates

Source: Oxford Economics



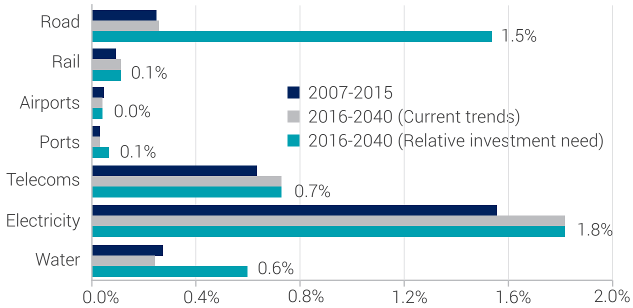
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	35.5	15.3	5.4	4.2	100.1	251.1	33.4	445.0
2016-2040 Relative investment need (RIN)	212.1	15.3	5.4	9.0	100.1	251.1	82.4	675.4
2016-2030 SDG requirement over and above RIN						0.0	0.0	0.0
2016-2030 Gap (RIN+SDG-CT)	90.2	0.0	0.0	2.4	0.0	0.0	25.0	117.6

Ethiopia

KEY ASSUMPTIONS

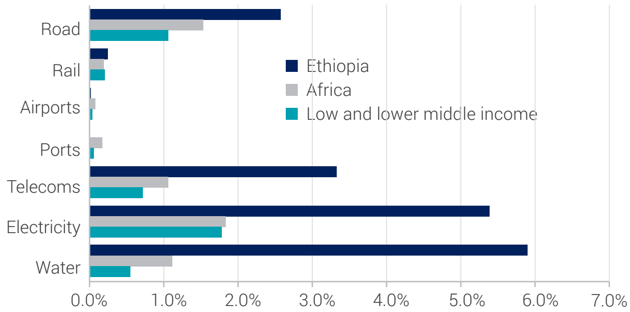
	2015	2040	Av. annual growth
GDP (Billion $US)*	60	238	5.7%
GDP per head ($US)*	601	1,446	3.6%
Population (000s)	99,391	164,270	2.0%
Urban population (% of total)**	19.3%	30.1%	1.8%
Population density (persons per km²)	99	164	2.0%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

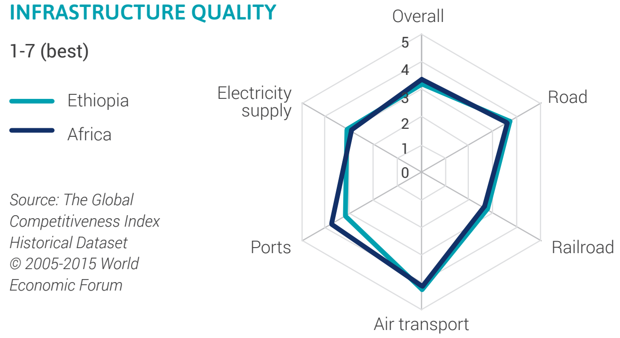
Percent of GDP

Source: Oxford Economics



INFRASTRUCTURE QUALITY

1-7 (best)

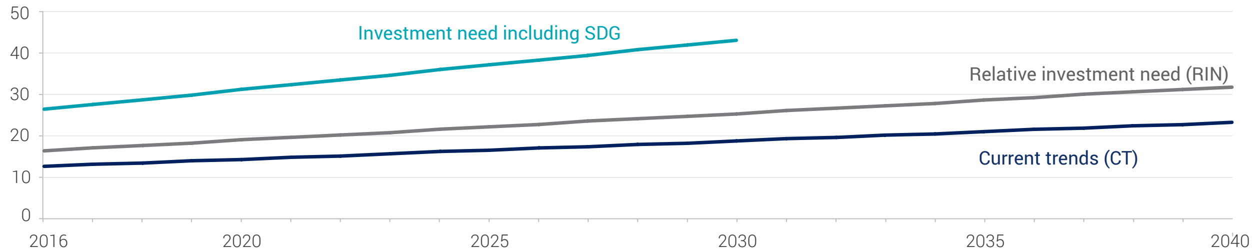


Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

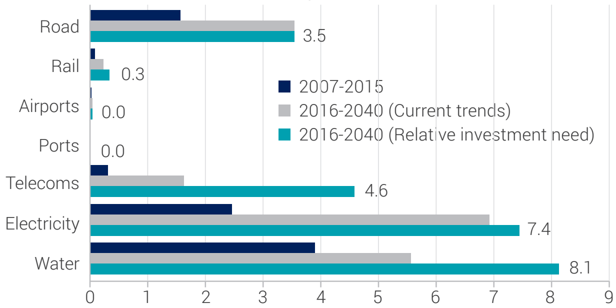
Billion US$, 2015 prices and exchange rates

Source: Oxford Economics



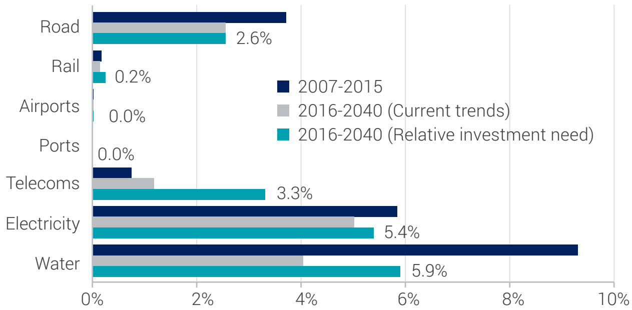
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



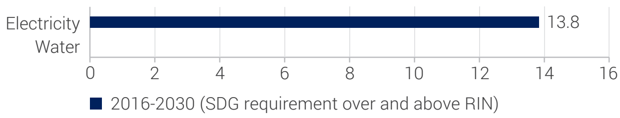
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



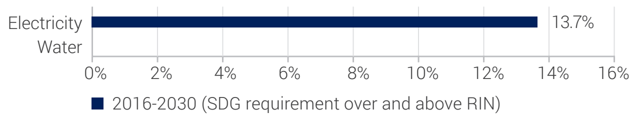
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	88.5	5.4	0.7		40.5	172.9	139.2	447.1
2016-2040 Relative investment need (RIN)	88.5	8.2	0.7		114.6	186.1	203.4	601.5
2016-2030 SDG requirement over and above RIN						207.7	0.0	207.7
2016-2030 Gap (RIN+SDG-CT)	0.0	1.5	0.0		36.6	214.3	32.8	285.1

Ghana

KEY ASSUMPTIONS

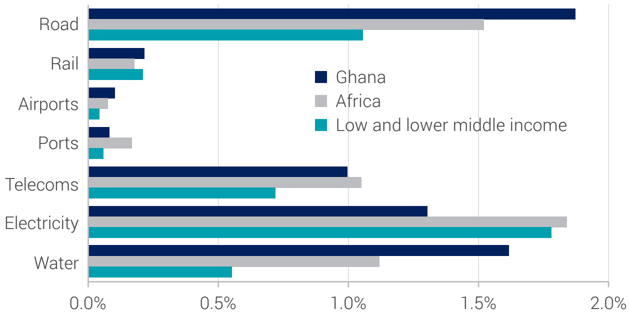
	2015	2040	Av. annual growth
GDP (Billion $US)*	37	127	5.1%
GDP per head ($US)*	1,339	2,923	3.2%
Population (000s)	27,410	43,454	1.9%
Urban population (% of total)**	54.0%	66.8%	0.8%
Population density (persons per km²)	120	191	1.9%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

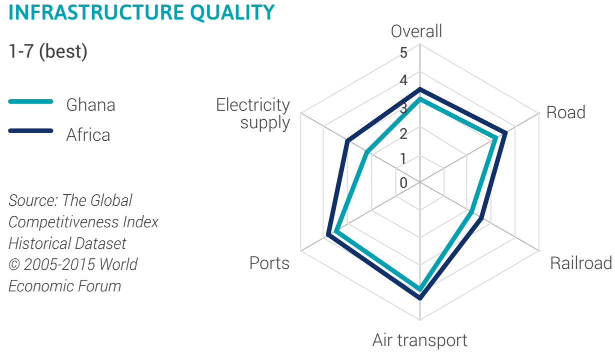
Percent of GDP

Source: Oxford Economics



INFRASTRUCTURE QUALITY

1-7 (best)

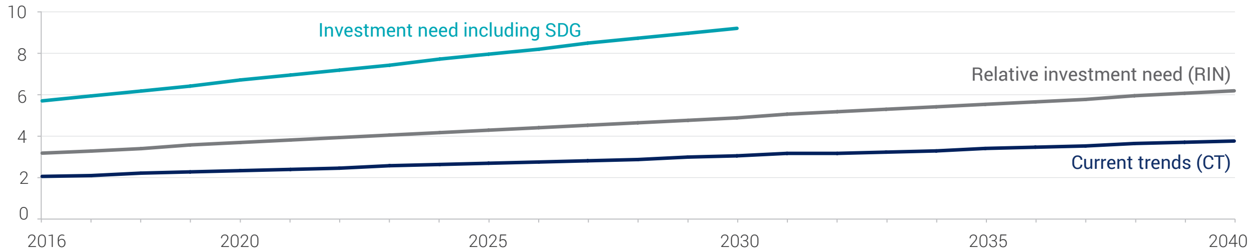


Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

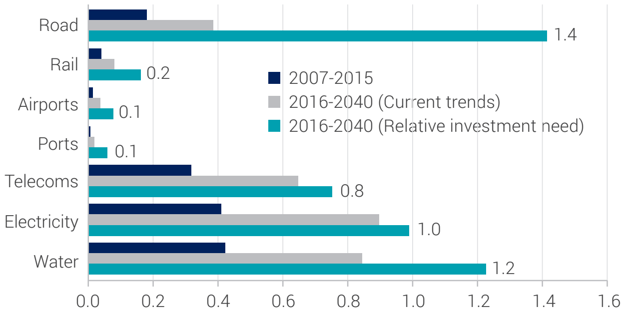
Billion US$, 2015 prices and exchange rates

Source: Oxford Economics



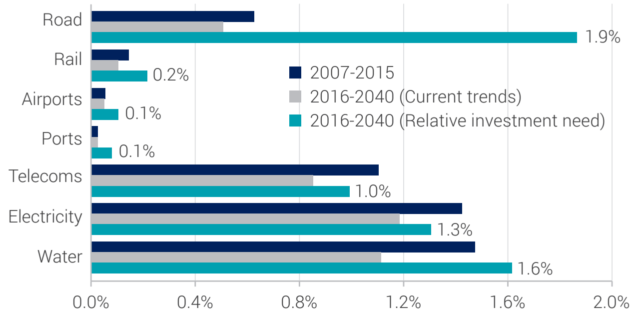
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



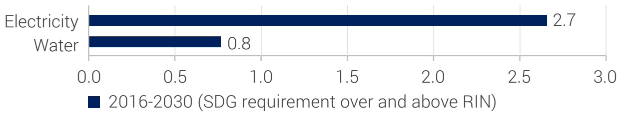
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



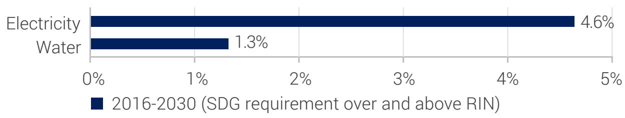
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	9.6	2.0	0.9	0.4	16.2	22.4	21.1	72.7
2016-2040 Relative investment need (RIN)	35.4	4.0	1.9	1.5	18.8	24.7	30.6	117.1
2016-2030 SDG requirement over and above RIN						39.9	11.4	51.3
2016-2030 Gap (RIN+SDG-CT)	13.2	1.0	0.5	0.5	1.3	41.0	16.3	73.9

Guinea

KEY ASSUMPTIONS

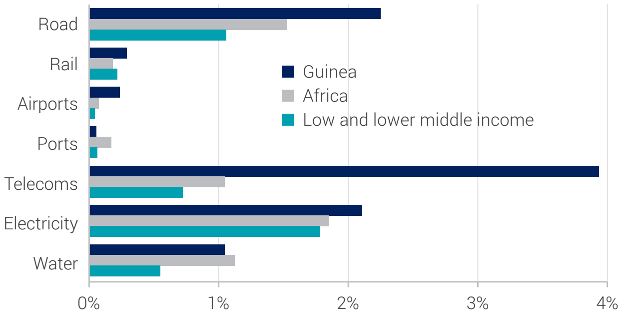
	2015	2040	Av. annual growth
GDP (Billion $US)*	7	22	5.0%
GDP per head ($US)*	531	991	2.5%
Population (000s)	12,609	22,700	2.4%
Urban population (% of total)**	37.2%	50.7%	1.3%
Population density (persons per km²)	51	92	2.4%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

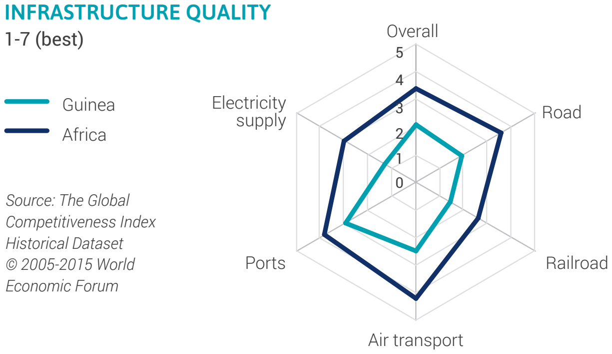
Percent of GDP

Source: Oxford Economics



INFRASTRUCTURE QUALITY

1-7 (best)

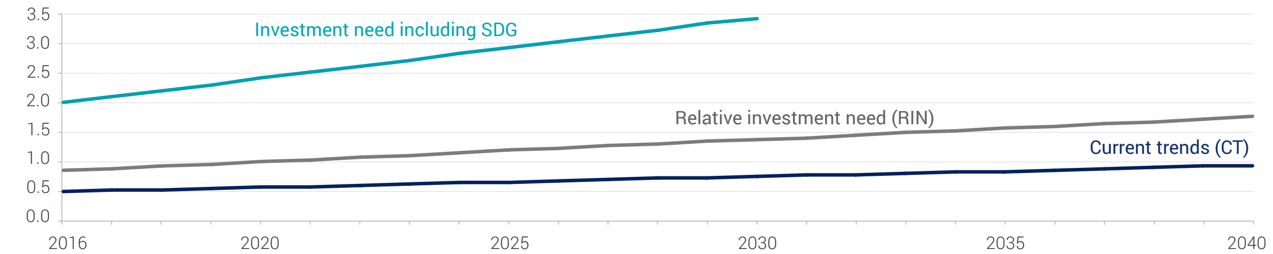


Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

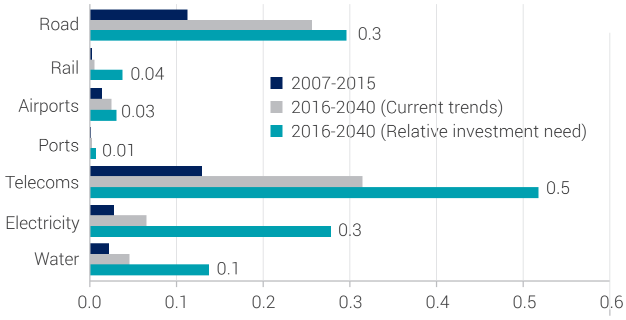
Billion US$, 2015 prices and exchange rates

Source: Oxford Economics



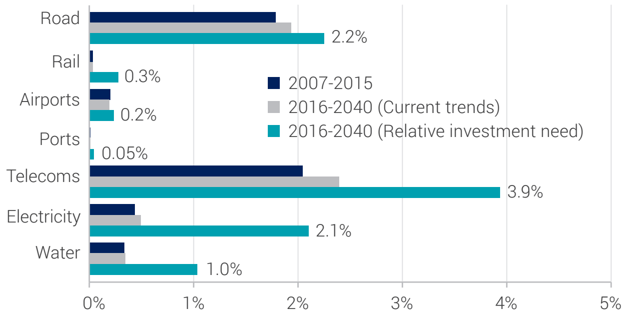
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



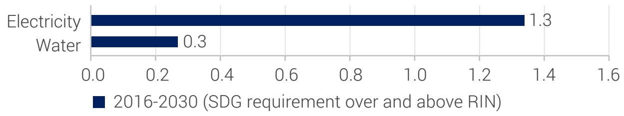
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



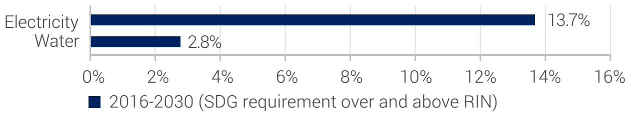
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	6.4	0.1	0.6	0.0	7.9	1.6	1.1	17.7
2016-2040 Relative investment need (RIN)	7.4	0.9	0.8	0.2	12.9	6.9	3.4	32.5
2016-2030 SDG requirement over and above RIN						20.1	4.1	24.2
2016-2030 Gap (RIN+SDG-CT)	0.5	0.4	0.1	0.1	2.5	22.8	5.2	31.5

Morocco

KEY ASSUMPTIONS

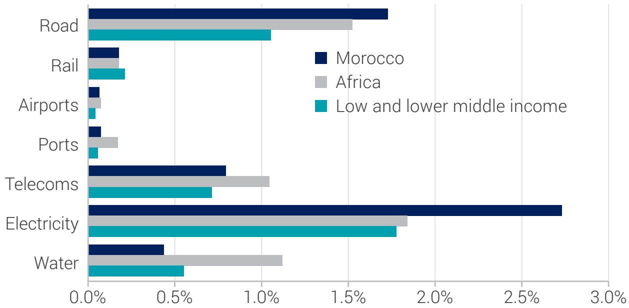
	2015	2040	Av. annual growth
GDP (Billion $US)*	100	243	3.6%
GDP per head ($US)*	2,919	5,761	2.8%
Population (000s)	34,378	42,148	0.8%
Urban population (% of total)**	60.2%	70.3%	0.6%
Population density (persons per km²)	77	94	0.8%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

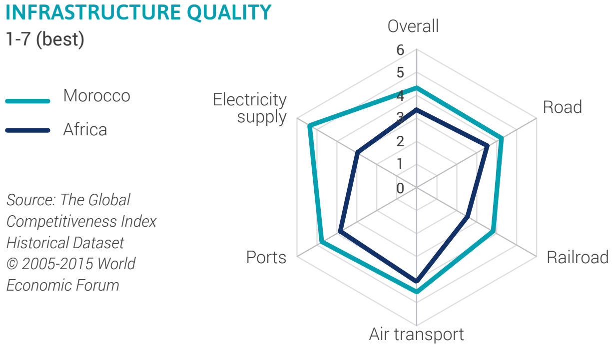
Percent of GDP

Source: Oxford Economics



INFRASTRUCTURE QUALITY

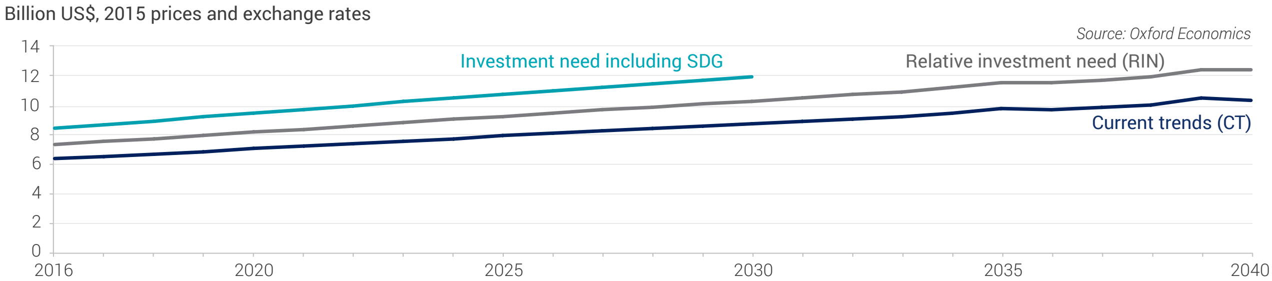
1-7 (best)



TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

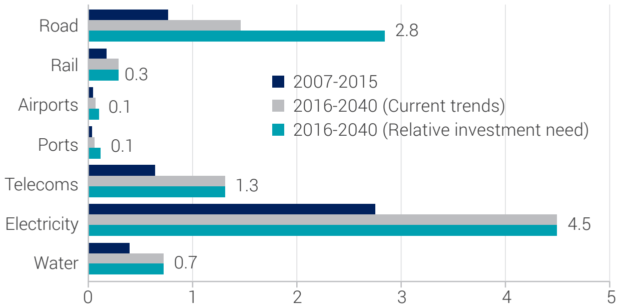
Billion US$, 2015 prices and exchange rates

Source: Oxford Economics



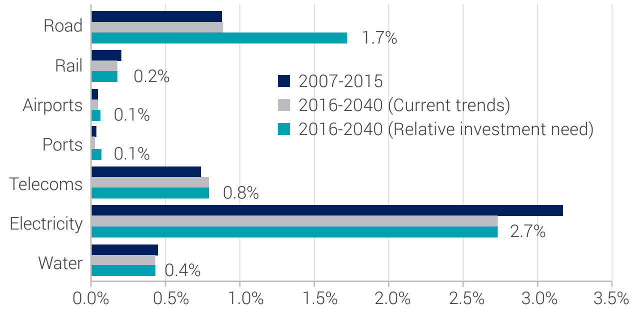
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



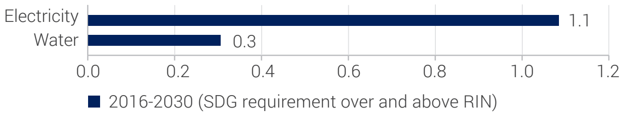
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



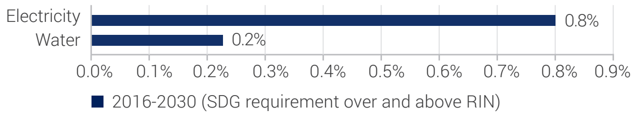
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	36.6	7.3	1.7	1.3	32.7	112.2	17.8	209.7
2016-2040 Relative investment need (RIN)	70.9	7.3	2.7	2.8	32.7	112.2	17.8	246.4
2016-2030 SDG requirement over and above RIN						16.2	4.6	20.7
2016-2030 Gap (RIN+SDG-CT)	17.5	0.0	0.5	0.8	0.0	16.2	4.6	39.5

Rwanda

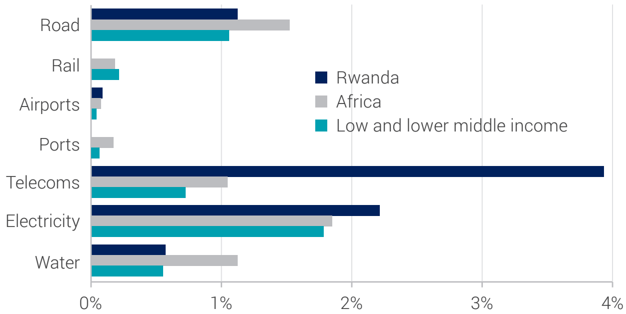
KEY ASSUMPTIONS

	2015	2040	Av. annual growth
GDP (Billion $US)*	8	39	6.5%
GDP per head ($US)*	697	2,113	4.5%
Population (000s)	11,610	18,644	1.9%
Urban population (% of total)**	28.2%	49.1%	2.2%
Population density (persons per km^2)	471	756	1.9%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

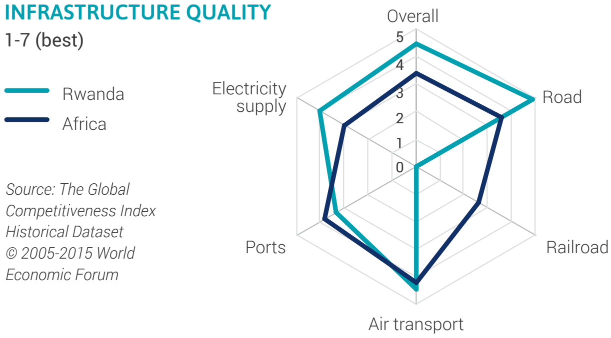
INFRASTRUCTURE INVESTMENT NEED, 2016-2040

Percent of GDP *Source: Oxford Economics*



INFRASTRUCTURE QUALITY

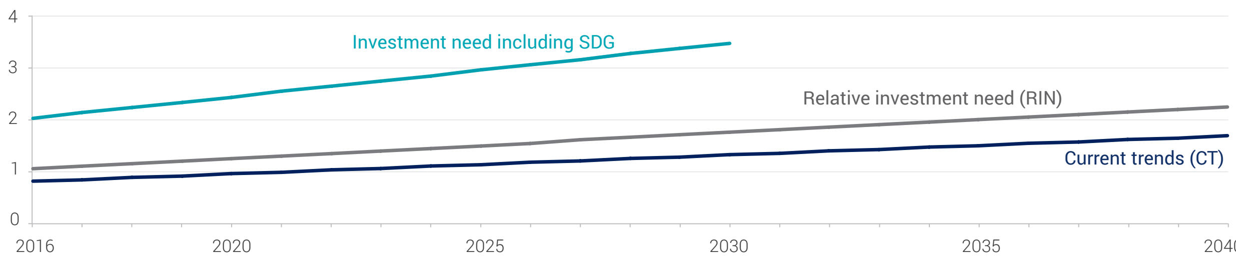
1-7 (best)



Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

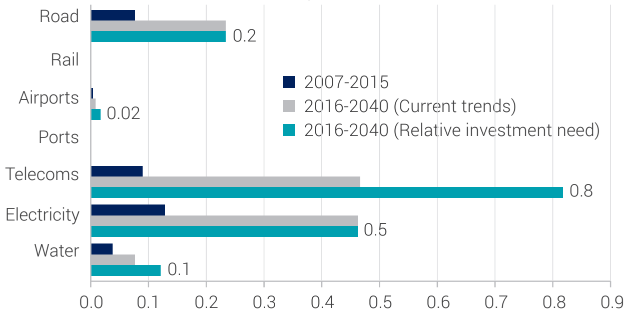
TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

Billion US$, 2015 prices and exchange rates *Source: Oxford Economics*



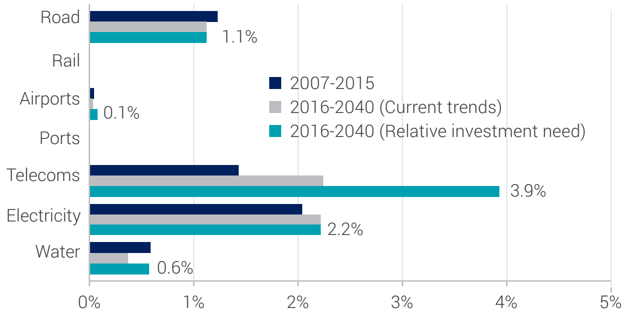
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



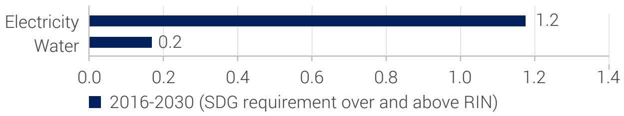
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



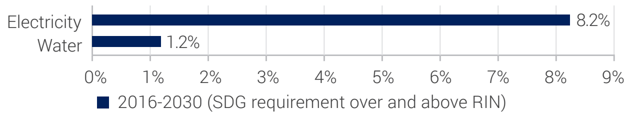
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	5.8		0.2		11.7	11.5	1.9	31.1
2016-2040 Relative investment need (RIN)	5.8		0.4		20.4	11.5	3.0	41.2
2016-2030 SDG requirement over and above RIN						17.7	2.6	20.2
2016-2030 Gap (RIN+SDG-CT)	0.0		0.1		4.3	17.7	3.1	25.2

Senegal

KEY ASSUMPTIONS

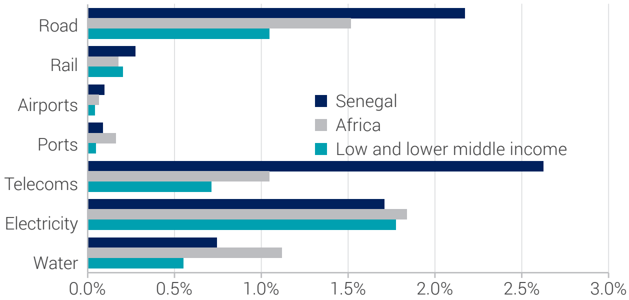
	2015	2040	Av. annual growth
GDP (Billion $US)*	14	89	7.7%
GDP per head ($US)*	917	3,048	4.9%
Population (000s)	15,129	29,086	2.6%
Urban population (% of total)**	43.6%	51.0%	0.6%
Population density (persons per km²)	79	151	2.6%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

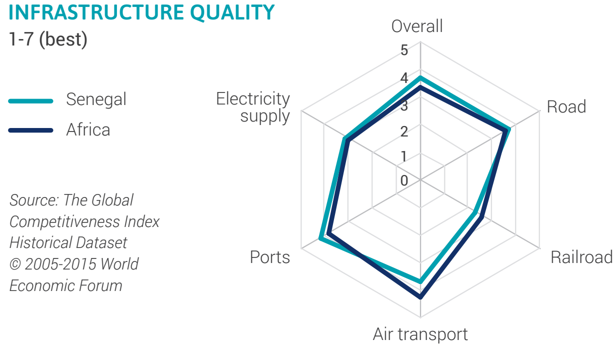
Percent of GDP

Source: Oxford Economics



INFRASTRUCTURE QUALITY

1-7 (best)

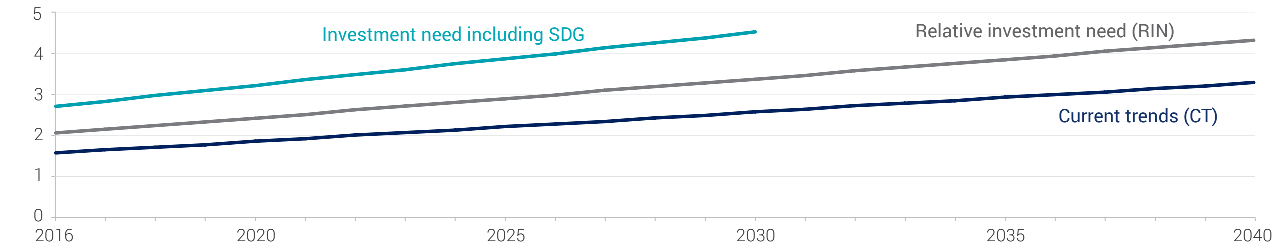


Source: The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

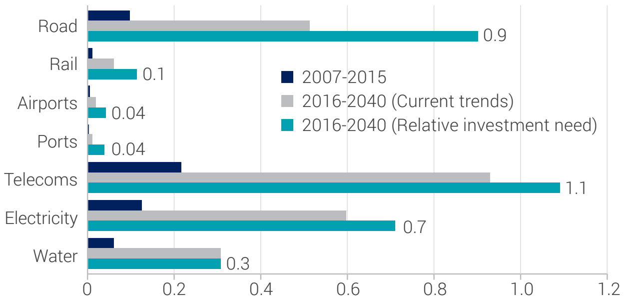
Billion US$, 2015 prices and exchange rates

Source: Oxford Economics



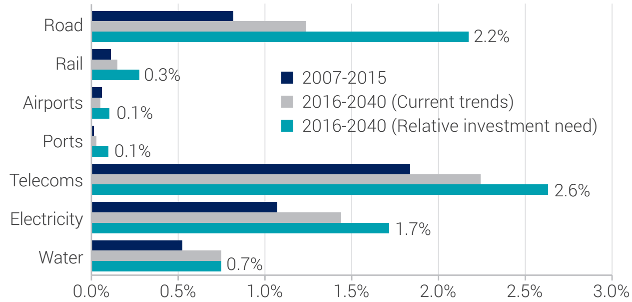
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



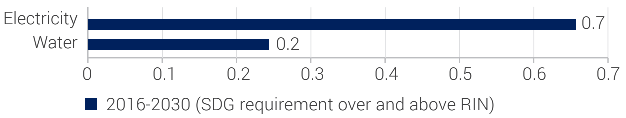
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



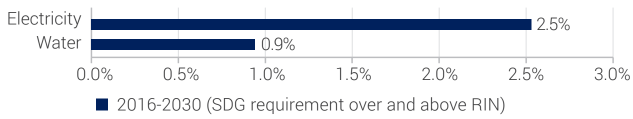
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	12.8	1.5	0.5	0.3	23.2	14.9	7.7	61.1
2016-2040 Relative investment need (RIN)	22.5	2.9	1.0	1.0	27.3	17.8	7.7	80.2
2016-2030 SDG requirement over and above RIN						9.8	3.7	13.5
2016-2030 Gap (RIN+SDG-CT)	5.0	0.7	0.3	0.3	2.0	11.2	3.7	23.1

Tunisia

KEY ASSUMPTIONS

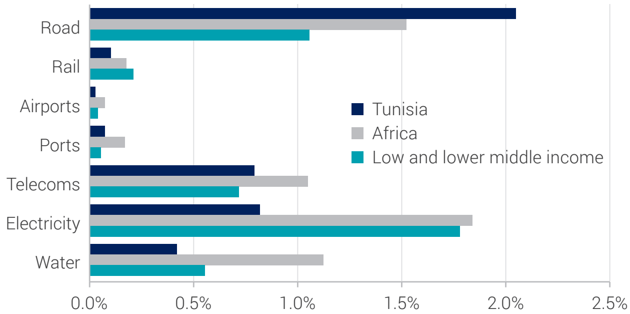
	2015	2040	Av. annual growth
GDP (Billion $US)*	43	109	3.8%
GDP per head ($US)*	3,822	8,309	3.2%
Population (000s)	11,254	13,166	0.6%
Urban population (% of total)**	66.8%	73.7%	0.4%
Population density (persons per km²)	72	85	0.6%

**2015 prices and exchange rates; ** Av. annual growth shows average annual change in urban share of population*

INFRASTRUCTURE INVESTMENT NEED, 2016-2040

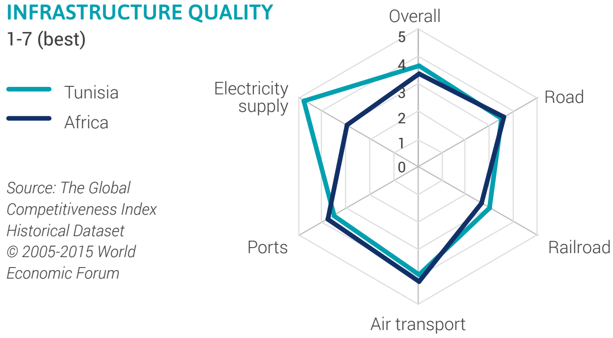
Percent of GDP

Source: Oxford Economics



INFRASTRUCTURE QUALITY

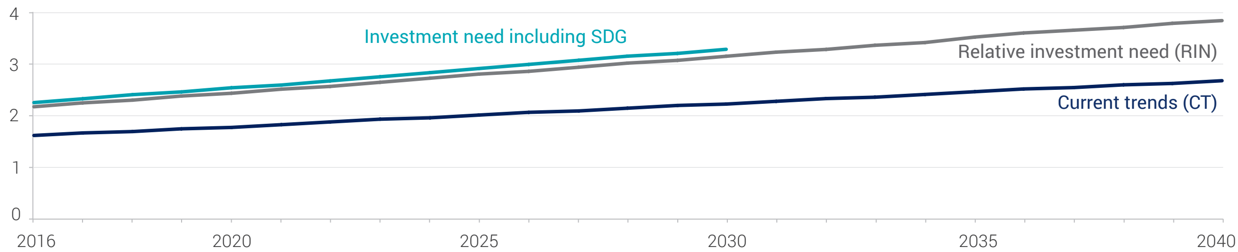
1-7 (best)



TOTAL INFRASTRUCTURE INVESTMENT 2016-2040

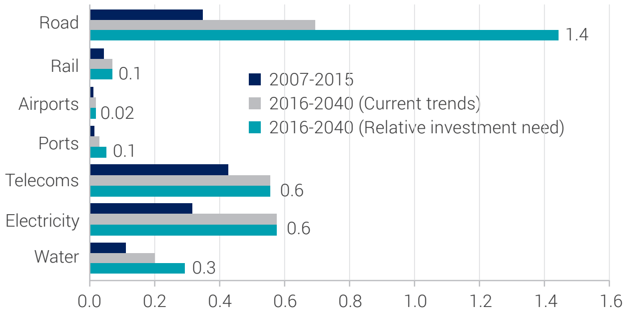
Billion US$, 2015 prices and exchange rates

Source: Oxford Economics



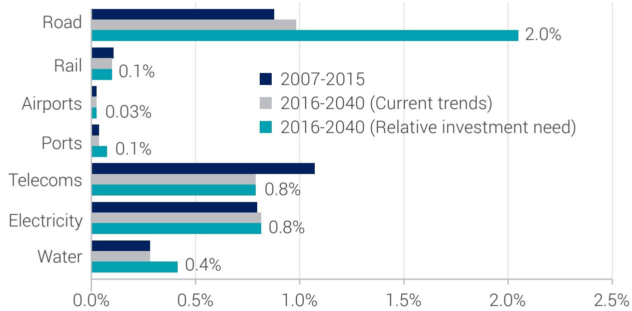
AVERAGE ANNUAL INVESTMENT

Billion US$, 2015 prices and exchange rates



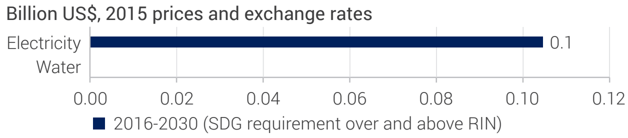
INFRASTRUCTURE INVESTMENT AS A PERCENTAGE OF GDP

Percent of GDP



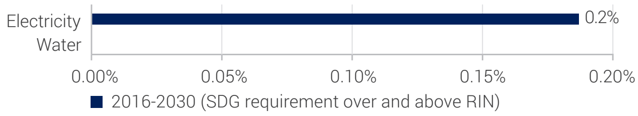
ADDITIONAL INVESTMENT TO MEET SDGs

Billion US$, 2015 prices and exchange rates



ADDITIONAL INVESTMENT TO MEET SDGs

Percent of GDP



CUMULATIVE INFRASTRUCTURE INVESTMENT

SDG results only shown where the SDG requirement would not be delivered under the investment need scenario

Billion $US, 2015 prices and exchange rates	Road	Rail	Airports	Ports	Telecoms	Electricity	Water	Total
2016-2040 Current trends (CT)	17.3	1.7	0.5	0.7	13.9	14.4	5.0	53.5
2016-2040 Relative investment need (RIN)	36.1	1.7	0.5	1.3	13.9	14.4	7.3	75.2
2016-2030 SDG requirement over and above RIN						1.6	0.0	1.6
2016-2030 Gap (RIN+SDG-CT)	9.6	0.0	0.0	0.3	0.0	1.6	1.2	12.7

5. Technical Appendix

5.1 DEFINITION OF INFRASTRUCTURE INVESTMENT

Our preferred definition of infrastructure investment is: "Gross Fixed Capital Formation (GFCF) by the public and private sectors on fixed, immovable assets that support long-term economic growth". GFCF is the measure of investment used to estimate GDP in national accounts. In addition to brand new investment, it includes replacement investment, and spending on maintenance where this will substantively extend the lifetime of an asset, but excludes land purchases. This concept is consistent with standard national accounting methodology adopted by most statistical agencies around the world.

While our definition of infrastructure spending is based on GFCF, infrastructure spending constitutes a subset of total GFCF in any economy in a given year. GFCF relating to non-fixed assets such as office equipment (computers and software) is generally excluded from our definition of infrastructure investment, as is GFCF relating to residential construction and other types of real estate such as office blocks. The term "gross" means that no adjustment is made for the depreciation of assets. Across the countries in our 2017 study, estimated infrastructure spending across the seven sectors was around 12 percent of total investment in 2015.

GFCF measures the cost of work done in any given year. For example, GFCF in the power generating industry would measure the investment in building a new power station, including the machinery and equipment needed to generate power. If the power station took five years to build and fit out, with an equal amount of spending in each year of the project, then the GFCF measure of investment would record a fifth of the total project amount per year over this period. This is different from the other principal approach to measuring investment in infrastructure, which is to measure the volume of deals agreed in any given year. Using the deals method in the example above, the investment would be recorded in the year the agreement to build the power station was signed, regardless of when (or indeed, even if) it was actually built.

Conceptually, these two approaches should be equal over the long run, assuming no projects are abandoned after being recorded. However, there will clearly be differences in the time profile of investment recorded. The case of an individual project has already been discussed, but the differences are also noticeable in aggregate. For example, deals typically pick up during periods of economic recovery, but dry up during recessions, and so can be highly cyclical. And even as deals pick up, the process of actually starting construction work may still lag behind. By contrast, GFCF numbers are not subject to the same uncertainty and volatility as deals data and so are better suited to the aims of the research.

It is important to note that while this is our *preferred* definition, it is necessary to collect data from a wide range of sources and definitions inevitably vary across those sources. Our objective in collecting data is therefore to identify the available data which align most closely with the definition above, but in the absence of a single consistent data source across countries and sectors it is not possible to obtain data fully aligned with our preferred definition in all cases.

5.2 DATA SOURCES

5.2.1 Overview

The data for Egypt, Ethiopia, Morocco and Senegal are unchanged from those used in the 2017 Global Infrastructure Outlook study.

Benin, Cote D'Ivoire, Ghana, Guinea, Rwanda and Tunisia were not included in the original study, and so we have gathered new data for these countries for the purposes of this 2018 extension. Our approach to collecting these data was largely consistent with that used for the main 2017 report, as described in section 11.2 of that paper, although the Global Infrastructure Hub also engaged with its development partners and ministries within each country to gather data for this extension. We have used data from international organisations and national governments and statistical agencies as far as possible. Data were collected between January and April 2018 and so reflect the latest values available at that time. These data were cleaned and missing values estimated in accordance with the principles described in section 11.2 of the 2017 report. We have used the same reference period as in the 2017 report, so the most recent year of historical data incorporated into our models is 2015.

Where no suitable sources could be identified values have been estimated using econometric techniques. For consistency with the 2017 study, these estimates were produced using the same econometric models developed for the 2017 study.[17]

The same caveats therefore apply as in the original study. In particular, even where high-quality data from official sources are available, time series are typically short and it was often necessary to estimate missing values. Limitations with the identified data sources, and the need to estimate missing values in cases where no suitable source could be identified, mean that the final dataset contains a large degree of 'noise' which is unavoidable in such circumstances. The historic and forecast estimates of infrastructure investment should be treated with a degree of caution, particularly in areas where data are poorest.

We hope that by presenting the best information we could identify for each country and sector we will stimulate discussion and debate amongst the Compact with Africa countries, and possibly lead to other data sources being suggested and made available. The framework we have developed can be updated and refined as new, and hopefully improved, data become available.

[17] We therefore make the implicit assumption that the relationships which explain infrastructure provision in the original 50 countries hold true for the six additional countries added in this extension.

5.2.2 Sources

We have categorised the data quality for this extension as green, amber or grey based on the same system used in the 2017 study:

- **Green (high quality)**: data on historical spending available from an official source (national statistics or an international organisation). Some estimation and interpolation may be necessary to develop a full time series.
- **Amber (medium quality)**: some relevant data identified, but the definition does not align well with our needs, the time series may be patchy or very short, or we may need to apply some sort of manipulation to produce an estimate of infrastructure investment. Substantial estimation is required.
- **Grey (no suitable data identified)**: very little or no official data available. Historical time series estimated using econometric estimation.

We strongly recommend that users refer to these ratings when undertaking their own analysis of the data. The tables below summarise the sources and quality of data identified for each country and sector.

Fig. 14. *Data sources: road*

Benin	World Bank Africa Infrastructure Country Diagnostic, average 2001-2005, Rehabilitation / capital expenditures on main road network
Cote d'Ivoire	World Bank Africa Infrastructure Country Diagnostic, average 2001-2005, Rehabilitation / capital expenditures on main road network
Egypt	International Road Federation, 2008-2010, Road construction spend
Ethiopia	International Road Federation, 2000-2003, World Bank Ethiopia Public Expenditure Review 2007-2013, Road capital expenditure
Ghana	International Road Federation, 2000-2005, Road construction spend
Guinea	Ministry of Economy and Finance, 2000-2015, project level investment data
Morocco	Econometric estimate
Rwanda	World Bank Africa Infrastructure Country Diagnostic, average 2001-2005, Rehabilitation / capital expenditures on main road network
Senegal	Econometric estimate
Tunisia	International Road Federation, 2005-2016 with gaps, Road construction spend

Fig. 15. Data sources: rail

Benin	Econometric estimate
Cote d'Ivoire	Econometric estimate
Egypt	Econometric estimate
Ethiopia	World Bank Ethiopia Public Expenditure Review, 2005-2012, ERC capital spend
Ghana	Econometric estimate
Guinea	Econometric estimate
Morocco	Econometric estimate
Rwanda	*No operational railway during historical reference period*
Senegal	Econometric estimate
Tunisia	African Development Bank appraisal report, 1997-2001, railway investments

Fig. 16. Data sources: airports[18]

Benin	Econometric estimate
Cote d'Ivoire	Econometric estimate
Egypt	Econometric estimate
Ethiopia	Estimated from web research of major investments
Ghana	Econometric estimate
Guinea	Econometric estimate
Morocco	Econometric estimate
Rwanda	Econometric estimate
Senegal	Econometric estimate
Tunisia	Tunisian Civil Aviation and Airports Authority, 2013 - 2015, Investment in airports

[18] While we did receive a small amount of information on investment in airports from the Guinea Ministry of Economy and Finance, this resulted in extremely low estimates of the value of airport infrastructure stock. It was therefore decided that data derived through econometric modelling would result in more reliable infrastructure need forecasts.

Fig. 17. *Data sources: ports*

Benin	Econometric estimate
Cote d'Ivoire	Econometric estimate
Egypt	Econometric estimate
Ethiopia	*Landlocked*
Ghana	Econometric estimate
Guinea	Econometric estimate
Morocco	Econometric estimate
Rwanda	*Landlocked*
Senegal	Econometric estimate
Tunisia	Econometric estimate

Fig. 18. *Data sources: electricity*

Benin	World Bank Africa Infrastructure Country Diagnostic, average over 2004-2008, Capital expenditure on power
Cote d'Ivoire	World Bank Africa Infrastructure Country Diagnostic, average over 2001-2008, Capital expenditure on power
Egypt	World Bank "Infrastructure and Economic Growth in Egypt", 1983-2007, Electricity infrastructure investment
Ethiopia	World Bank Ethiopia Public Expenditure Review, 2004-12, EEPCO capital spend
Ghana	World Bank Africa Infrastructure Country Diagnostic, average over 2001-2006, Capital expenditure on power
Guinea	Econometric estimate
Morocco	Econometric estimate
Rwanda	World Bank, 2001-2005, Capital expenditure on power sector
Senegal	World Bank, 2001-2005, Capital expenditure on power sector
Tunisia	National Statistics, 1995-2015, Fixed capital investment in electricity

Fig. 19. Data sources: water[19]

Benin	World Bank Africa Infrastructure Country Diagnostic, average over 2004-2008, Capital expenditure on WSS
Cote d'Ivoire	World Bank Africa Infrastructure Country Diagnostic, average over 2001-2008, Capital expenditure on WSS
Egypt	Econometric estimate
Ethiopia	World Bank Ethiopia Public Expenditure Review, 2008-12, Water supply and sanitation capital expenditure
Ghana	World Bank Africa Infrastructure Country Diagnostic, average over 2001-2006, Capital expenditure on WSS
Guinea	Econometric estimate
Morocco	Econometric estimate
Rwanda	Econometric estimate
Senegal	Econometric estimate
Tunisia	National Statistics, 1995-2015, Fixed capital investment in water and sanitation

Fig. 20. Data sources: telecoms

Benin	World Bank PPI, 2000-2014, Investment in telecommunications with private participation
Cote d'Ivoire	World Bank PPI, 1996-2014, Investment in telecommunications with private participation
Egypt	World Bank PPI, 1998-2014, Investment in telecommunications with private participation
Ethiopia	World Bank Ethiopia Public Expenditure Review, 2004-2012, ETC capital spend
Ghana	World Bank PPI, 1995-2014, Investment in telecommunications with private participation
Guinea	World Bank PPI, 1994-2014, Investment in telecommunications with private participation
Morocco	World Bank PPI, 1999-2015, Investment in telecommunications with private participation
Rwanda	World Bank PPI, 1999-2012, Investment in telecommunications with private participation
Senegal	World Bank PPI, 1997-2014, Investment in telecommunications with private participation
Tunisia	World Bank PPI, 2002-2014, Investment in telecommunications with private participation

[19] While we did receive a small amount of information on investment in water infrastructure from the Guinea Ministry of Economy and Finance, this resulted in extremely low estimates of the value of water infrastructure stock. It was therefore decided that data derived through econometric modelling would result in more reliable infrastructure need forecasts.

5.3 APPROACH TO ESTIMATING INFRASTRUCTURE NEEDS

5.3.1 Introduction

Economic infrastructure typically has a lifespan of decades, or sometimes even longer. Looking only at the flow of expenditure in recent years is therefore insufficient to understand the current state of provision within any given country and sector. To do so it is necessary to look at the accumulated stock of infrastructure.[20]

One possibility, often followed in previous research in this area, is to look at the volume of physical infrastructure stock in each country, using measures such as the length of road, length of rail lines, number of telephone lines, and so on.[21] We initially experimented with this type of approach, but were unable to obtain satisfactory results for individual countries and sectors. This appeared to be due to the fact that an approach based on physical measures ignores infrastructure quality—a km of road in the US may be very different to one in Sub-Saharan Africa; the service level provided by a km railway line in Japan may be very different to that available in some of the world's poorest countries, and so on.[22]

We therefore adopted a different approach based on estimates of the value of infrastructure stock, which should, at least in theory, incorporate information on both the quantity and quality of infrastructure.

In seeking to understand how much infrastructure investment will be 'needed' in the coming years—we look at the years to 2040—a central question is how we are determining the 'need' for infrastructure. This is not straightforward and will differ on a case-by-case basis. For example, even in countries with similar levels of economic development, policymakers may have very different objectives in providing infrastructure, based on demand from citizens, economic expediency and political outlook. This might, for instance, affect how much a government prioritises rail over road connectivity or transport investment as a whole vis-à-vis other needs, such as providing citizens with access to clean water etc. Undertaking individual country-specific assessments of infrastructure, however, is a complex exercise requiring considerable resources.[23] This was not possible within a global study so a broader approach was necessary.

5.3.2 Approach used during the 2017 study

Rather than look at each country individually, we made comparisons across countries to determine the infrastructure investment that each country is likely to make to accommodate future growth, under the assumption that countries' future investment

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[20] For a discussion of why investment stock should be considered rather than flows, see Michael Pettis, "How much investment is optimal", in Carnegie Endowment for International Peace <http://carnegieendowment.org/chinafinancialmarkets/52078> [accessed 12 May 2017]

[21] A key paper in this field is Marianne Fay and Tito Yepes, *Investment in infrastructure: what is needed from 2000 to 2010?* (Washington DC: World Bank, 2003).

[22] A secondary issue was that to move from estimates of physical infrastructure needs to spending needs requires estimates of the cost of building a unit of infrastructure (cost per km of road or km of railway line, for example). However, our research suggested that such costs are not widely available on a country-by-country basis leading, for certain sectors, to a reliance on averages which may not reflect the conditions within a specific country.

[23] For example, the UK government established a National Infrastructure Commission to look at this very issue: https://www.gov.uk/government/news/chancellor-announces-major-plan-to-get-britain-building

performance is either in line with current trends, or increases such that countries match the performance of their best performing peers in terms of the resources they dedicate to infrastructure investment. We refer to the latter scenario as 'relative investment need'.

The objective of our study was to forecast values of infrastructure spending, but doing so required us to first estimate the value of infrastructure stock. Our initial step **(1)** was, therefore, to estimate the value of infrastructure stock per person in our 50 countries (and in seven sectors within each country).

We then sought to understand which variables explained differences in the value of stock across the countries **(2)**.This included examining the importance of factors such as GDP per head, the sectoral structure of the economy, population density and so on, as well as a set of country-specific factors.

Having developed an explanatory model for each sector, we could forecast values of infrastructure stock per head through to 2040, based on forecasts of how each of the explanatory variables was expected to change over that period **(3)**. In this first set of forecasts (the *current trends scenario*), we assumed that the influence of country-specific factors would remain unchanged in the future, thereby exerting a similar influence on the accumulation of infrastructure through to 2040. This enabled us to forecast the infrastructure spending required in each country and sector to accommodate changes in all the other variables (i.e. the economic and demographic growth anticipated for the period to 2040).

Under this forecast infrastructure investment as a proportion of GDP can diverge from its historic trend, reflecting that the forecast takes into account changes in a number of economic and demographic characteristics, as well as a country's requirement for replacement investment. The current trends forecast is not, therefore, a simple extrapolation of infrastructure investment as a share of GDP.

This study aimed not just to explore what a 'business as usual' scenario might look like but also to identify how much it would cost to raise the game across the board, to a situation in which countries with similar characteristics dedicated a similar amount of resources to infrastructure. In effect, this meant understanding what the model predicts stock per head in 2015 *should* be given the country's characteristics **(4)**.

Comparing the 'actual' and 'expected' infrastructure stocks provided us with an indication of a given country's performance in terms of the resources it dedicates to infrastructure provision. This performance measure was adjusted to account for the current quality of infrastructure stock in each country and sector **(5)**, based on infrastructure quality indicators from the World Economic Forum Global Competitiveness Report. [24-25]

The 'quality-adjusted' performance measure was compared across countries, and allowed us to determine the spending required for a country to match the performance of its best performing peers—defined as the 75th percentile amongst countries with similar income levels. This is our *relative investment need scenario* **(6)**.

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[24] This reflected the observation that some countries are building on a longer legacy of investment than others or may be more efficient at developing infrastructure, requiring less investment to deliver a given quality of infrastructure, for example. We used evidence from sector-specific infrastructure quality indicators from the World Economic Forum Global Competitiveness Report to make these adjustments.

[25] The Global Competitiveness Index Historical Dataset © 2005-2015 World Economic Forum

It is important to note that alignment to the performance of the best of one's peers in the relative investment need scenario does not mean increasing stock per head to a certain specific amount. Rather it means the difference between what a country actually spends, and what it would be expected to spend, is in line with the best performer. This means raising the game across the board, but to a level that is appropriate to the circumstances of the country in question. The actual value of stock might well be lower or higher, reflecting country-specific characteristics—such as a different level of GDP per head, population density, and so on.

The ability to compare forecasts of spending under current trends to the spending which would occur if each country matched the observed performance of its best performing peers was a central innovation in our study.[26]

Comparing the spending requirements under the relative investment need and current trends scenarios allows us to assess the extent of the *'infrastructure investment gap'* for each country and sector.

Full details of our methodology and the associated limitations are set out in section 11.3 of the 2017 study. The results presented in this extension for Egypt, Ethiopia, Morocco and Senegal are the same as presented in the original report.

5.3.3 Approach to estimating infrastructure needs for additional Compact With Africa countries

Benin, Cote D'Ivoire, Ghana, Guinea, Rwanda and Tunisia were not part of the sample of 50 countries included in the 2017 study. We have therefore developed new estimates for this extension.

A central feature of our modelling approach is that forecasts are simultaneously determined for all countries within each of the seven sectors. However, time constraints meant that it was not possible to undertake a full update of the entire modelling framework to incorporate the six new countries. Instead, our objective was to develop forecasts for the new countries which were as consistent as possible with the results from the 2017 study, whilst leaving the findings from the original study unchanged. Our approach to doing this is described below.

Current trends forecast

Our starting point was to estimate values of infrastructure stock per capita for each sector. In cases where we had identified suitable investment data, these estimates were based on the same perpetual inventory methods described in section 11.4 of the 2017 study. Where no suitable investment data were identified, values of stock per head were estimated using the same econometric models developed for this purpose during the original study. We therefore implicitly assume that the relationships established for explaining the current value of infrastructure stock based on the original 50 countries also apply to the six countries in the extension.

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[26] Previous research has benchmarked infrastructure stocks against other countries and regions (see for example Daniel E. Perrotti and Ricardo J. Sanchez, "La brecha de infraestructura en America y el Caribe", *CEPAL - Serie recursos naturales e infraestructura,* 153 (2011). However, we believe this to be the first time that benchmarking has been undertaken in terms of performance, where the latter is assessed as actual –v- expected infrastructure stock.

To forecast stock per head in 2040 we used the exact same econometric models developed for the 2017 study, as described in section 11.3 of the 2017 report.

The models were based on a 'fixed effects panel data approach', and so estimate historic relationships across both time and countries. The fixed effects component means that the models control for unexplained country-specific factors which affect the value of infrastructure stock consistently over time. To generate forecasts for 2040 we needed to estimate a value for this fixed effect parameter for each of the six new countries.

If we were undertaking a full update we would re-estimate the model for each sector based on the enlarged sample of 56 countries. While this would generate the required fixed effect parameter for the six new countries, it would also slightly change the results for the existing countries, since the addition of new countries introduces additional information which influences the model coefficients. As such, the fixed effect values for the new countries from the 56-country model could not be directly compared to those obtained for other countries from the original 50-country model. To overcome this we adjusted the fixed effect values to simulate what the fixed effect parameters for each of the six new countries *could have been had they been generated within the original 50-country model specification.*

To do this we worked through the following steps for each country and sector:

(1) We ranked the fixed effect parameters from the 56-country model and identified the location in the ranking of each new country.

(2) We identified the nearest higher-ranked and nearest lower-ranked country from the original sample of 50 within the 56-country ranking, and calculated the proportionate distance of the new country between this pair of higher and lower ranking countries.

(3) We took the fixed effect parameters for the same two comparator countries from the original 50-country model, and estimated an adjusted fixed effect parameter for the new country based on its proportionate distance between those two values, as estimated from the 56-country model.

This process has the effect of re-scaling the fixed effect parameters for the new countries to account for differences between the 50-country and 56-country model specifications. In most cases the re-scaling has relatively little impact on the estimated fixed effect parameters for the new countries, reflecting that for most sectors the model coefficients changed only slightly when the new countries were introduced.

To understand the impact of the adjustment, we compared the ranking of fixed effect terms for low-income countries (the peer group within which all of the Compact with Africa countries are located) based on the 56-country model to that obtained from the 50-country model (the new countries were incorporated into the second ranking based on their adjusted fixed effects term). For six out of the seven sectors the ranking of the new countries changed by no more than one position between the two rankings, providing reassurance that the adjustment process was not heavily impacting on the estimated 'performance' of the new countries. In the case of roads, no country was no more than two ranking places different between the two rankings.[27]

[27] In this case we experimented with alternative model specifications for the 56-country model to ascertain whether the ranking differences could be reduced by including a different combination of explanatory variables. This revealed that the rankings obtained from the original model specification could not be improved.

As with the original study, we assumed that the country-specific fixed effects term remained unchanged for the current trends forecast. On that basis we generated forecasts for the value of infrastructure stock per head in 2040 by incorporating Oxford Economics' forecasts of the explanatory variables (typically the economic and demographic characteristics of each country) into the equations established in the 2017 study.

After generating forecasts for the value of infrastructure stock per head in 2040, we used perpetual inventory models to estimate the value of investment required to achieve the forecast 2040 stock value, accounting for replacement investment requirements.

Relative investment need forecast

A key innovation of the 2017 study was the 'stochastic frontier modelling' approach used to forecast relative infrastructure needs, based on comparing countries with their best performing peers, in terms of the value of resources dedicated to infrastructure after controlling for the specific economic and demographic characteristics of each country.

This part of the process centres on the country-specific fixed effects parameters discussed above, which allow us to calculate each country's 'performance' at building its infrastructure stock. To do this we followed the same process as in the 2017 study. Performance is calculated as the difference between a country's observed infrastructure stock in 2015, and the value of stock our econometric model "expects" it to have, given its economic and demographic characteristics. This follows the approach of Kumbhakar et al.[28]

Again consistent with the 2017 study, we applied a quality adjustment to countries' performance scores to reflect that some countries which are commonly regarded as having very good infrastructure were assessed as having a poor performance score within the econometric modelling. This may reflect that some countries are building on a longer legacy of investment than others or may be more efficient at developing infrastructure, requiring less investment to deliver a given quality of infrastructure, for example. The quality adjustment was based on sector-specific infrastructure quality measures from the World Economic Forum Global Competitiveness Report,[29] or proxies in sectors for which no World Economic Forum figure was available. No quality adjustment was applied in cases where no investment data could be identified from which to estimate stock values because, in most such cases, the WEF information had already been factored in to estimated values of stock per head. And no quality adjustment was applied to the roads forecasts for low and lower- middle income countries because no relationship could be established between the WEF indicator and our performance measure in this case.[30]

[28] Hung-Jen Wang and Alan P. Horncastle Subal C. Kumbhakar, *A practitioner's guide to stochastic frontier analysis using Stata* (New York: Cambridge University Press, 2015), pp. 271.

[29] Klaus Schwab and Xavier Sala-i-Martin, *The global competitiveness report 2015-16* (Geneva: World Economic Forum, 2015).

[30] See pages 192-193 of the 2017 Global Infrastructure Outlook report for further details of the quality adjustment process.

The quality-adjusted performance measure provides a basis for comparing across countries, and we can determine the extent to which any given country (for any given sector) needs to increase its infrastructure stock to match the performance of the best performers in its peer group. Best performing peers were identified as the 75th percentile in each income group. For this extension, the benchmark value was not adjusted to reflect the incorporation of the additional countries in the low and lower-middle income group as to do so would have led to changes in the results for the original sample of 50 countries, which we were seeking to avoid in this update. Once again, therefore, the objective was to assess the performance of the six new countries as consistently as possible with the original sample of 50.

Based on the performance comparison we estimated an 'uplift factor' for each of the six new countries. This was applied to the current trends forecast to determine a forecast of relative investment need. We again used the perpetual inventory models to determine the investment required between 2016 and 2040 to reach this uplifted stock value in 2040.

In adopting the approach outlined above, we have attempted to generate results for the six new countries which are as consistent as possible with those in the original research. To do this we have simulated what could have been determined had these countries been included from the outset, under the assumption that their inclusion does not affect the modelling coefficients. This is a simplifying assumption since the incorporation of additional countries brings additional information and would, in reality, impact on the results for all countries to some degree. We would therefore recommend that a full update of the models, incorporating all 56 countries, is undertaken when time permits to verify and validate conclusions for the enlarged sample.

5.3.4 Estimated values of infrastructure stock

The charts overleaf show the estimated values of infrastructure stock for the 10 Compact with Africa countries. Three values are presented in each case:

- The 2015 values are estimated using the perpetual inventory model (or through econometric estimation where no investment data were found).
- The 2040 current trends forecast is derived from the econometric model as described above.
- The 2040 relative investment need forecast is estimated to align each country's quality adjusted performance with the 75th percentile of each country's peer group as described above.

Values for Egypt, Ethiopia, Morocco and Senegal are unchanged from those presented in the 2017 study.

__Fig. 21.__ Infrastructure stock per person: US$, 2015 prices and exchange rates

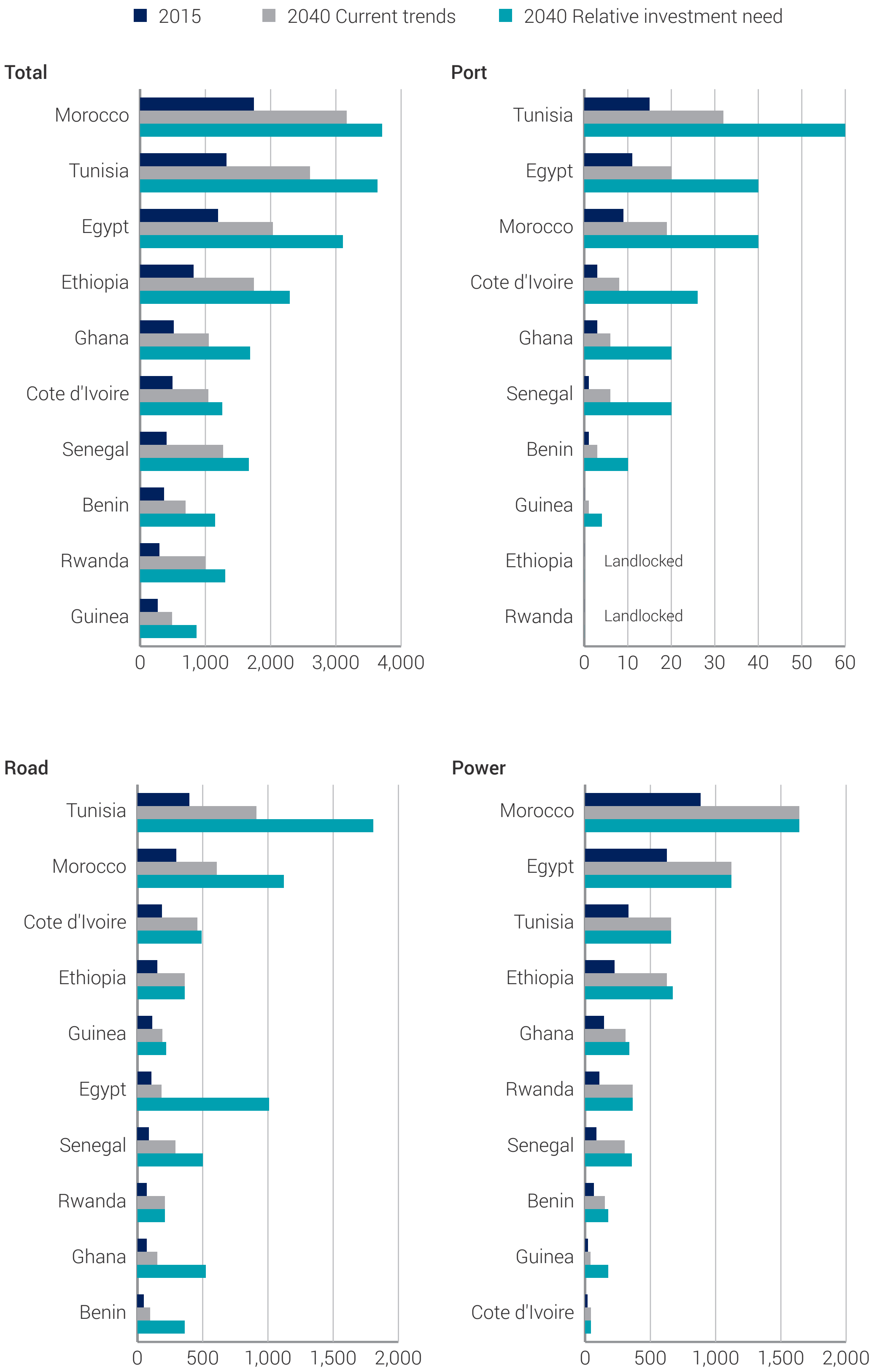


Fig. 21. Infrastructure stock per person: US$, 2015 prices and exchange rates

5.4 SUSTAINABLE DEVELOPMENT GOALS

5.4.1 Estimating the value of infrastructure investment required to meet SDG 7.1 for universal access to electricity

Our approach to estimating investment requirements to meet SDG 7.1 for universal access to electricity is fully consistent with that taken during the 2017 study, as discussed on pages 39-40 of the 2017 report.

Our cost estimates are therefore based on the assumption that there should be at least 0.2 kW of electricity generating capacity, plus associated transmission and distribution infrastructure, per person and for domestic purposes.

We estimated the additional capacity required in each country in two steps. Firstly, we calculated the capacity required to increase average provision amongst those who already have electricity access to 0.2 kW per person. Secondly, we calculated the requirement needed to provide 0.2 kW per person for residents expected to enter the population between 2015 and 2030.

The total capacity requirement was multiplied by estimates of investment costs per kW from the International Energy Agency (IEA).[31] The data are available for regions and a few large countries, so we matched the countries in our study with the appropriate region. [32] The cost data are also available for a number of different technologies. We calculated averages to obtain a single cost for each energy generation sector and a single energy cost per country was estimated using the country's generating mix. For simplicity, we assumed this mix to be unchanged throughout the forecast period. We then uplifted each estimate to account for transmission and distribution infrastructure, again using data from the IEA.[33]

Our model assumes that the net increase in capacity will be distributed evenly across the years from 2016 to 2030. As a final step we used the perpetual inventory model to estimate the value of replacement investment required over this period, to offset depreciation in both assets which are already in place, and in the new infrastructure to be built from 2016. [34]

5.4.2 Estimating the value of infrastructure investment required to meet SDGs 6.1 and 6.2 for water and sanitation

Once again, our approach is fully consistent with that taken in the 2017 study.

For access to clean drinking water, our starting point was data from the WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation on the proportion

[31] International Energy Agency, *World Energy Outlook 2016* (Paris: OECD/IEA, 2016). For simplicity we assume that the identified level of generating capacity needs to be provided within each country. In reality it may be possible for countries to increase access by importing electricity from other countries. To the extent that it is possible to import excess power from other countries, it may also be possible to meet the SDG requirement with less investment in generating capacity than is implied by our analysis.

[32] Where a country lies outside of the defined regions, we have used data for the closest region, geographically and economically.

[33] Op. cit.

[34] Consistent with the rest of our modelling approach above, we only calculate the replacement investment that is estimated to be required to serve domestic demand.

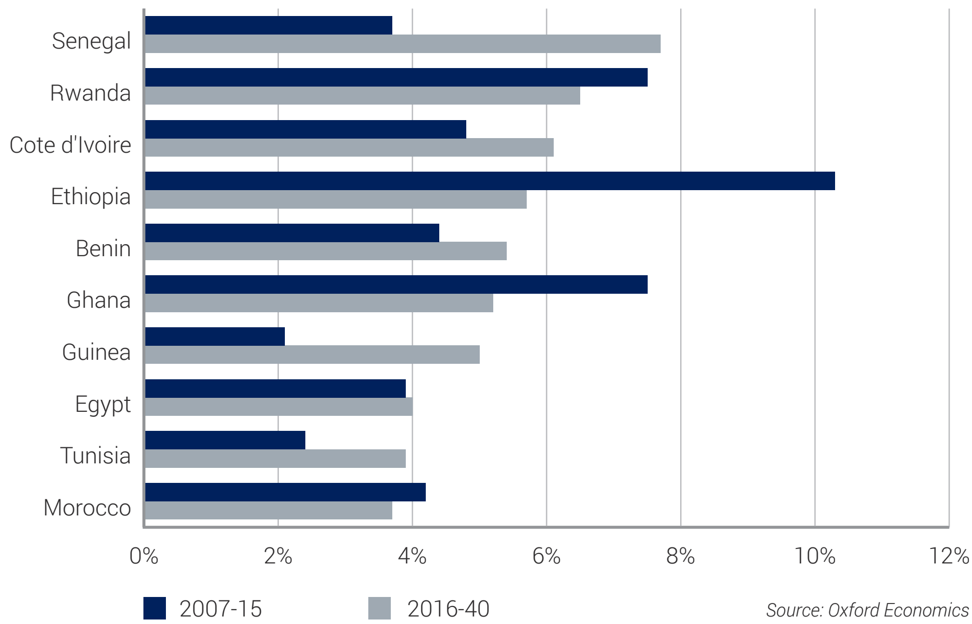
of the urban and rural population with access to a piped on-premises water supply. To identify the infrastructure needed to meet SDG 6.1, we estimated the net increase in the number of people who will need a water connection to achieve 100 percent coverage on this indicator by 2030, based on the current level of provision and expected population growth. The net increase in the number of people requiring access was multiplied by the cost of providing a connection. Costs were taken from previous research by Hutton and Varughese. [35]

For sanitation we took a very similar approach, but this time our starting point was JMP data on the proportion of the urban and rural population with access to 'improved sanitation'. We again estimated the number of additional people who will require access to meet the 100 percent target, based on current provision and expected population growth. For urban areas we used capital cost estimates from Hutton and Varughese for the cost of providing sewerage with treatment, while for rural areas we used estimates for the capital cost of providing a pit latrine with FSM.[36]

The last step was to use a perpetual inventory model to add an allowance for replacement investment, to replace both existing infrastructure which is in place at the start of the forecast period, and to offset depreciation in new infrastructure built between 2016 and 2030.

5.5 DETAILED FORECASTING ASSUMPTIONS

***Fig. 22.** Average annual GDP growth, 2007-2040*



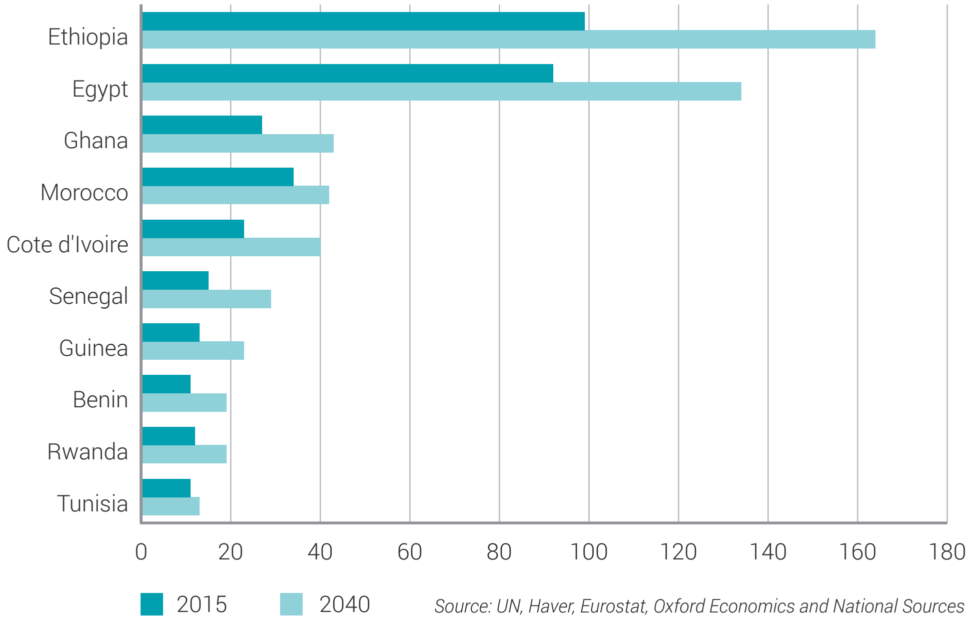
Source: Oxford Economics

[35] We adopt the 'advanced' drinking water cost estimates from Guy Hutton and Mili Varughese, *The Costs of Meeting the 2030 Sustainable Development Goal Targets on Drinking Water, Sanitation, and Hygiene* (Washington DC: World Bank, 2016).

[36] Faecal Sludge Management

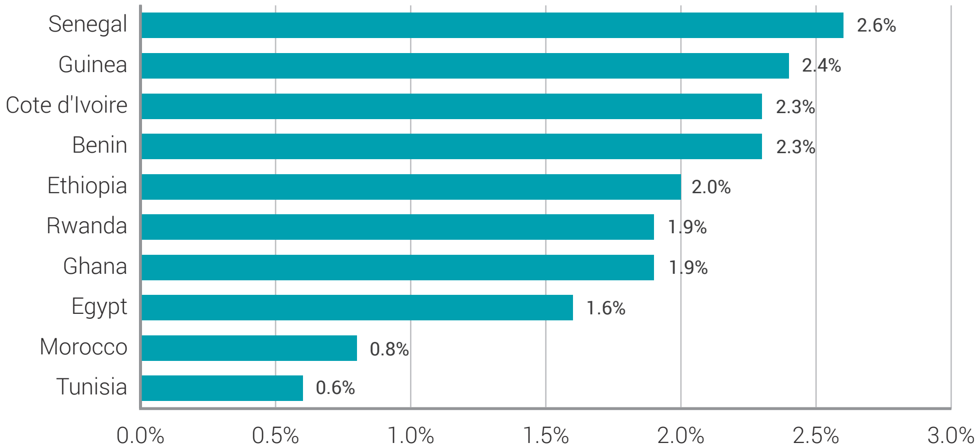
***Fig. 23.** Population, 2015 and 2040*

Millions



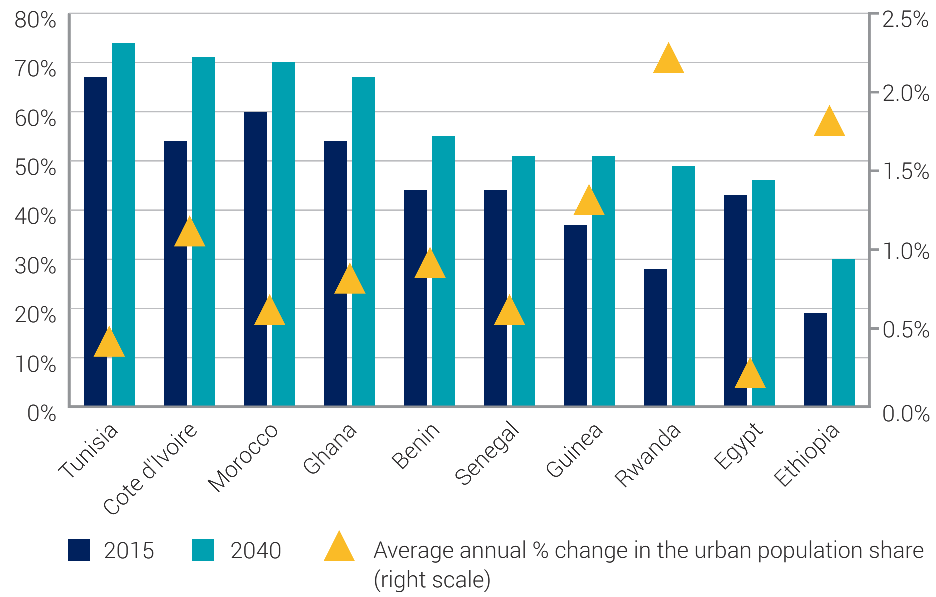
Source: UN, Haver, Eurostat, Oxford Economics and National Sources

***Fig. 24.** Average annual population growth, 2016-2040*



Source: UN, Haver, Eurostat, Oxford Economics and National Sources

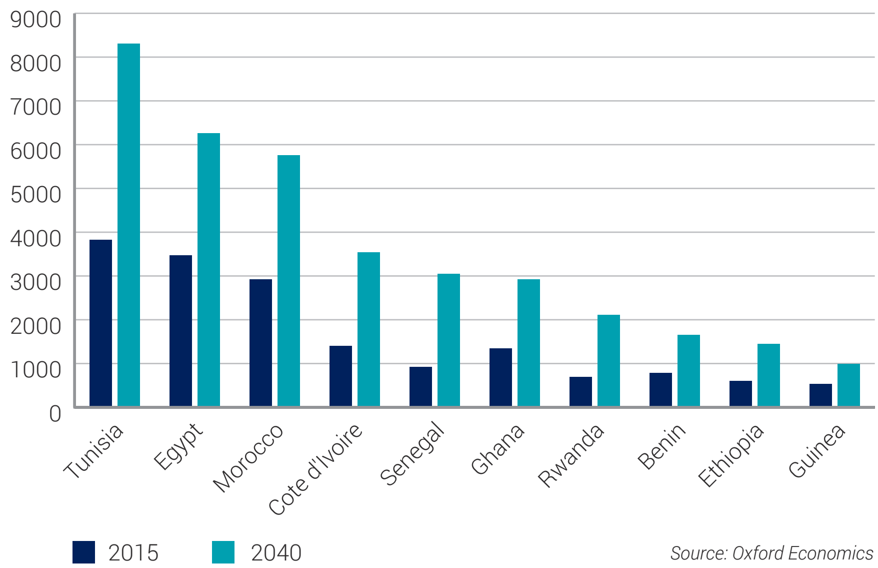
Fig. 25. *Urban share of population, 2015 and 2040*



Source: World Bank WDI

Fig. 26. *GDP per head*

US$ 2015 prices and exchange rates



Source: Oxford Economics

Oxford Economics

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JUNE 2018

The modelling and results presented here are based on information provided by third parties, upon which Oxford Economics has relied in producing its report and forecasts in good faith. Any subsequent revision or update of those data will affect the assessments and projections shown.

GLOBAL INFRASTRUCTURE OUTLOOK

A G20 INITIATIVE

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