World Bank report on infrastructure investment needs

The infrastructure gap is large: 1.2 billion individuals are without electricity, 663 million lack improved drinking water sources, 2.4 billion lack improved sanitation facilities, 1 billion live more than 2 km from an all-weather road, and uncounted numbers are unable to access work and education opportunities due to the absence or high cost of transport services. The developing world’s infrastructure falls short of what is needed for public health and individual welfare, environmental considerations, climate change risks, let alone economic prosperity or middle-class aspirations.

The solution, many argue, is to spend more. Thus, the question of how to attract more resources to infrastructure (in particular from the private sector) has dominated much of the conversation in international fora such as the G20. SDGs and rising concerns about the urgency of action on climate change goals have added further impetus to the debate about how to entice the private sector to invest more in infrastructure.

But the story is not so simple. First, because the focus should not be on an investment gap but on the *service* gap. The question of “how much is needed?” should always be accompanied by a clarification as to the “for what?” And the answer to the “for what” question lies with countries’ contexts, aspirations in terms of economic growth and social and environmental objectives, as well as with the choices they make regarding the relative role of infrastructure and other investments in achieving those aspirations. Households in Malawi will never need as much heating as the Swedes. A preference for ecosystem conservation can reduce the needs for flood protection infrastructure, while dense housing reduces the need for transport and water infrastructure but limits the available living space per capita.

Second, the investment gap approach focuses attention on the new investments that are needed and neglects the resources required to maintain existing and future infrastructure. In Fiji for instance, the Government has recently invested billions in new roads and bridges and is now struggling to find the resources to maintain its transport network (The World Bank 2017). In many places around the World, the amount of money needed to maintain the existing infrastructure network is higher than what is needed for future investments.

Third, the investment gap approach necessarily focuses attention on the question of raising more resources. In particular, climate change mitigation and adaptation are always presented as extra-costs for infrastructure needs. But closing the service gap should not—and, indeed, cannot—be just about spending more. Efficiency and demand management policies have the potential to significantly reduce infrastructure needs and close service gaps much more efficiently than with new infrastructure investments alone. For instance, reducing peak electricity demand with smart meters can remove the need for new power plants. In many places, reducing greenhouse gases emissions mostly entails redirecting investments rather than increasing them, and resilience to climate change impacts can be built in at a negative cost with good planning exercises (Bonzanigo et al. 2015). And even when more investment in infrastructure is needed, it is not always easy to spend more. A case in point is Brazil, whose budget execution rate fell to less than 50 percent in 2013 after it attempted to increase public spending in infrastructure (Marianne Fay et al. 2017).

Fourth, there are large uncertainties associated with the assumptions driving investment needs estimates—and these uncertainties are seldom clearly spelled out even as they would usefully inform policy choices. For instance, the impacts of climate change that the water sector needs to adapt to are highly uncertain and yet can have a large impact on investment needs. Future demand for different transport modes depends on urbanization patterns, globalization and technological change – all highly uncertain as well. There are also choices, some to do with the analysis (what discount rate to use?) and some to do with the strategy – notably the path chosen to get to the objectives. Flood protection can be achieved through dikes and seawalls – which implies large infrastructure investment and maintenance costs – or through smarter land-use planning – which requires strong institutions and may lead to higher housing prices but much lower investment costs.

The World Bank Sustainable Development Chief Economist’s office is working on a report to address these issues. The ambition of the report is to help shift the debate around the investment gap away from a simple focus on spending more, and towards spending better on the right objectives using relevant metrics. The latter is a broad agenda that requires work on many fronts. The specific contribution of the present work will be to offer a careful and systematic approach to investment needs estimates, moving away from single estimates to highlight both the importance of clearly defining the vision and the sensitivity of the results to assumptions—about pricing, technology, demand, climate change and climate policy, and other key factors that can help inform policy choices.

The final output will include a set of investment needs estimates, structured in an “if-then” framework (*if* this is what is wanted and these are the assumptions made, *then* this is how much it would cost) along with an analysis of cost drivers. This work will identify the main threats to the achievement of infrastructure-related SDGs. Finally, it will propose a methodological framework and best practice advice on how to present and use investment needs estimates to help inform the choices that governments make. The deliverables will include an overview report, as well as a set of background papers that offer sector-specific estimates (for water and sanitation, irrigation, transport, energy, and flood protection).

# The value of the current infrastructure stock and maintenance needs

The report will use the best available global databases to estimate the value of the existing infrastructure stocks (roads, power plants, water supply and sanitation, coastal defenses), their condition, and the cost of maintaining it. Preliminary estimates suggest that the cost of maintaining the current infrastructure stock in developing country in the next decades is higher than investment needs for new infrastructure.

# Assessing future infrastructure investment needs: a framework

The report proposes a framework to help decision makers build a vision of what they want to achieve with infrastructure investments and how they can reach this vision. The framework rests on four components: (i) the multiple objectives infrastructure investments aim for, and the multiple metrics that need to be used to assess the success of the investments; (ii) the investment and policy options that are available to reach the objectives; (iii) the exogenous factors that can influence the cost and success of the investments; and (iv) the complex relationships that determine how options can help reach the objectives given constraints and uncertainties.

## The objectives of infrastructure investment

There is an extensive literature on the growth benefits of infrastructure investments. However, it is very hard to disentangle the links and causality between infrastructure investment and economic growth (M. Fay and Yepes 2003). Besides, public infrastructure investments have multiple objectives, including non-economic ones like physical and social integration of a country, public health and safety objectives. Therefore, assessing infrastructure investment needs requires to first build a vision of what the investments are meant to achieve, along several dimensions, using multiple metrics. Below are examples of objectives for infrastructure investments. Note that ICT investment needs are not included.

* Infrastructure services as inputs to the production process
  + Energy supply
  + Mobility (with a distinction between passenger and freight, and urban and inter-urban).
  + Water supply (irrigation + industry)
* Households consumption of infrastructure services (SDGs, improved human capital)
  + Energy services (light, electricity for appliances)
  + Domestic water and sanitation
  + Mobility (for leisure and access to basic needs)
* Physical and social integration, inclusiveness
  + Connectivity
  + Accessibility
* Safety, comfort
  + Protection against natural hazards
* Political success/acceptability
* Cost-efficiency (along the investment life-cycle), fiscal sustainability
* Environmental Sustainability (including climate change mitigation)
* Robustness/resilience

In addition, each infrastructure service (transport, energy, water, flood protection) can be monitored along the four following dimensions: (i) number of people with access, (ii) quantity of service per capita, (iii) quality of service, and (iv) reliability of service. For each service, all these metrics need to be monitored to ensure the objectives are reached.

## The types of options available to reach the objectives

There are multiple options available to decision-makers to reach the objectives described above. In each sector, many technologies are available, as well as policies that can influence demand and choices.

* Traditional hard infrastructure vs softer solutions (nature-based)
* Irreversible investments vs flexible choices
* Demand management vs increased provision of services (which includes land-use planning to reduce mobility needs or flood protection needs)
* Centralized, integrated networks vs polycentric cities, micro grids, autonomous buildings, off-grid drinking water

## The Uncertainties or threats

There are also external factors, that are somewhat out of the control of decision-makers, that can challenge decision-making because they influence the performance of the different options, their cost and their ability to reach their objectives.

* Technological disruptions/future cost of different technologies
* Preferences and values
* Future demand (volume, structure)
* Future stresses (e.g. climate-related)
* Financial resources (e.g. fiscal space, ability to mobilize private capital)

## The Relationships

Many complex relationships shape how the different options allow reaching the objectives, subject to uncertainties. Those relationships exist between the options, the constraints, and the objectives, between the different objectives, and between the different sectors.

* Synergies and trade-offs between food and energy demand for water
* Synergies between transport investments and irrigation investments
* Links between technology choices for mobility and energy demand
* Rebound effects
* Network effects (non-linearity in the effects of the investment)
* Cascading failures (for instance through electrification of transport and buildings)

# Description of undergoing quantitative assessments

Accordingly, there is no quantitative framework able to represent all the factors described in the previous section together for all infrastructure sectors and decide, at a global level, the infrastructure that the world should invest in. Besides, most of the factors in the four categories above are context-specific, and the vision and pathways that should be built for investing in infrastructure need to follow a participatory approach.

However, it is possible to select sub-sets of these factors to assess future infrastructure investment needs at the global or regional level, and the main determinants of these needs. In this report, we work with eight quantitative assessments of future infrastructure needs anchored in this framework. Most of these assessments isolate one sector – energy, water, transport, or flood protection – and are designed to deal with the issues related to this sector. For instance, as it is difficult to agree on what the objectives of transport investments should be, we propose three different assessments of future transport investment needs, each working with different sub-sets of objectives and constraints.

## Electricity investment needs in Latin America

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| **Objectives** | **Options available** |
| * Meet electricity services needs of the production process * Households electricity consumption through housing and mobility (access and price) * Quality of service (reliability any time of the day) * Cost-efficiency (along the investment life-cycle) * SDG: Climate change mitigation | Electricity production capacity with various energy mix (different technologies available with a focus on supply rather than peak demand management) |
| **Uncertainties** | **Model** |
| * Future cost of different technologies * Future demand (volume) – includes electrification of transport * Future stresses (availability of water for hydropower) * Discount rate (opportunity cost of capital) | Least-cost optimization model:  * Ability of each technology to produce electricity at any time of the day * Need for reserves |

## Global energy investment needs

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| **Objectives** | **Options available** |
| * Meet the energy demands of industrial production processes * Household energy consumption buildings and mobility * SDG: energy access (inclusiveness) * Cost-efficiency (along the investment life-cycle) * SDG: Climate change mitigation | * Energy production capacity (different technologies available for satisfying needs for mobility, heating, lighting, cooking) * Energy efficiency |
| **Uncertainties** | **Models** |
| * Future energy and climate policies as well as technology development * Future demand (based on demography, GDP growth and prices) * System behavior and dynamics (interactions between sectors) | Integrated Assessment models (MESSAGE and others):  * Investments into different portfolios of technologies to meet service demands and reach normative targets. * Links between technology choices for mobility, heating, lighting, cooking * Rebound effects |

## Global transport investment needs

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| **Objectives** | **Options available** |
| * Meet transport demand of the production process * Households mobility consumption * Cost-efficiency (along the investment life-cycle) * SDG: Climate change mitigation | * Transport infrastructure types (different modes available) |
| **Uncertainties** | **Model** |
| * Future cost of different technologies and fuels * Future demand (volume by mode) based on demography, GDP growth and prices * Transport energy and carbon intensity * Targeted infrastructure utilization rates | Integrated Assessment model (IMACLIM):  * Links between technology choices for mobility and energy demand * Rebound effects |

## Global urban transport investment needs

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| **Objectives/constraints** | **Options available** |
| * Meet urban transport services needs for a given growth rate * Households urban mobility consumption * Cost-efficiency * SDG: Climate change mitigation | * Transport infrastructure types (different modes available) * Land-use policies * Car use regulation |
| **Uncertainties** | **Model** |
| * Future cost of different technologies and fuels * Parking prices * Load factors * Transport energy and carbon intensity | ITF urban passengers model:  * Modal choice and mobility demand, as a function of costs, calibrated on past behavior |

## Global rural roads investment needs

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| **Objectives** | **Options available** |
| * SDG: rural accessibility (inclusiveness): number of people living within 2km of an all-weather road | * Rural roads upgraded to all-weather road |
| **Uncertainties** | **Model** |
| * Cost of an all-weather road * Climate change impacts * Urbanization patterns | GIS analysis using OSM and WorldPop:  * Distance between people and roads in rural areas * Only upgrade existing tertiary roads or tracks |

## Global water and sanitation investment needs

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| **Objectives/constraints** | **Options available** |
| * SDG: universal access to water and sanitation by 2030 | * Existing technologies |
| **Uncertainties** | **Model** |
| * Demography * Urbanization | * Simple costing of bringing water and sanitation to people who don’t have access by 2030 |

## Global irrigation investment needs

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| **Objectives/constraints** | **Options available** |
| * SDG: ending hunger * SDG: Climate change mitigation * SDG: Protection of terrestrial biodiversity * SDG: Inland waters biodiversity – environmental water flows * Cost-efficiency | * Multiple irrigation technologies * Land-use choices (including irrigated vs non-irrigated lands) |
| **Uncertainties** | **Relationships** |
| * Future demand (volume and structure – different dietary preferences and food waste management) * Speed of technological change (availability of water application efficient irrigation systems) * Climate change impacts on crop yields and on evapotranspiration * Degree of international trade integration * Irrigation investment cost sharing between farmers and governments | GLOBIOM (partial equilibrium) + irrigation investment module:   * Links between costs, technologies and crop characteristics for determining crop choices and irrigation systems |

## Global coastal protection investment needs

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| **Objectives/constraints** | **Options available** |
| Protection against coastal flooding with four alternative objectives:   * Maintain current protection levels (raising defences with sea level) * Maintain average annual losses for protected areas (considering sea-level rise and socio-economic developments) in absolute terms * Maintain average annual losses for protected areas (considering sea-level rise and socio-economic developments) in relative terms * Keep relative average annual losses below 0.01% percent of local GDP | * Sea dikes, river dikes, and surge barriers |
| **Uncertainties** | **Relationships** |
| * Sea level rise * Defense costs | DIVA model:   * Decision to invest based on coastal flood risks |

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