Italian G20 Presidency

G20 Policy Agenda on Infrastructure Maintenance

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Mending and regenerating our infrastructure systems

The increasing pressure exerted by the pandemic, with its repercussions for the demand and supply of infrastructure services, has made the **case for more resilient and reliable infrastructure systems compelling**. Even before the pandemic outbreak, most countries faced a combination of challenges, including vulnerability of infrastructure to natural and anthropogenic hazards and/or a significant share of their infrastructural stock nearing the end of life. Properly funded and optimally managed (ordinary and extraordinary) maintenance is essential to preserving infrastructure assets over their life-cycle, minimizing loss and disruptions, and securing the provision of safe, reliable and high-quality infrastructure services. **Maintenance can have a significant impact on social, economic, and environmental aspects,** while, if neglected, it may generate unnecessary costs (often opaque or underestimated) for families, firms and society at large.

Despite its vital importance, in a context of a widening infrastructure investment gap, **spending on maintenance has been far from adequate**. In fact, the debate about the persisting under-investment in infrastructure tends to be skewed towards new infrastructure capital, with maintenance of infrastructure often overlooked until disaster or failure occurs.

The current juncture offers **an opportunity to rethink** the way increasingly interdependent infrastructure systems are designed, built, operated and cared for. Regardless of income level, most countries are currently exposed to **major changes that closely interact with infrastructure systems**, including demographic and urbanization trends, evolving business models relying on global supply chains, disruptive technological innovations, and a widespread digitalization occurring across all aspects of life. Ultimately, a renewed attention to maintenance is consistent with a **shift of focus from assets to people**, since infrastructure systems are only resilient to the extent they can offer people the safe, reliable and high-quality services they need. From this perspective, adequately planning for assets management over their (finite) life and seeking to curtail the overuse or contamination of the planet's natural resources may be necessary to **ensure that the needs of future generations are met.**

The ***G20 Policy Agenda on Infrastructure Maintenance*** aims to emphasize how adequate planning, funding and implementing resilience and maintenance along the entire life of existing assets is critical and, for many countries, an urgent priority. At its core, there is a **menu of policy options structured around three macro areas of policy intervention**: i) better planning and institutional coordination across sectors and/or administrative levels; ii) measures to secure funding and financing; iii) approaches for effective delivery of maintenance.

The *G20 Policy Agenda on Infrastructure Maintenance* is informed by two main contributions: i) an Organisation for Economic Co-operation and Development (OECD) report, "*New Strategies for Strengthening Infrastructure Resilience and Maintenance*"; and ii) a World Bank report, "*Well Maintained: Economic Benefits from more Reliable and Resilient Infrastructure*". It is also accompanied by an *Annex of Case Studies* submitted by G20 members that promote knowledge sharing and illustrate concrete applications of a range of policy tools and levers, which may be adopted, depending on country-specific circumstances. To facilitate case studies gathering, an *Annotated Glossary on Infrastructure Maintenance* was also compiled and is included in the Annex.

Challenges, Opportunities and Expected Benefits of Maintenance

At a *micro* level of observation (i.e. the individual project level), **investing in adequate maintenance makes "good business sense".** Most infrastructure assets are made of materials with limited duration, which deteriorates at a non-linear rate; plus, over time, they may undergo utilization beyond the levels they were originally designed for (such as many over-exploited network structures in fast-growing cities). In fact, **postponing spending on maintenance at a given time may impose a heavier budgetary burden later**. Conversely, a well-maintained facility may retain its optimal operational performance (and its value) for a longer time.

Yet, the deferral of necessary maintenance remains common across countries and sectors, often due to challenges of non-technical nature: i) asymmetry of information about asset's status and performance; ii) unintended disincentives to proper care over the infrastructure asset's life ; iii) mismatch between evolving demand patterns and the capacity of existing infrastructure; iv) lack of public resources to keep up with too many competing projects; and v) human resources with inadequate skills to perform effective maintenance over an asset's life-cycle.

The issue of maintenance ought to be observed also at a *macro* level, because infrastructure networks are – by their very nature – **interconnected and interdependent**. Therefore, neglecting one specific asset or falling behind on a scheduled project is bound to bring about cascading repercussions (e.g. poorly maintained canals and drainage systems may damage the wastewater treatment facility down the line due to abnormal contamination). Often, the **institutional arrangements governing infrastructure are not set up to match this factual interdependence** among different types of assets and their interaction with natural resources. In sum, **managing infrastructure maintenance requires feeding project-level efficiency considerations into a system-wide perspective.**

I. Challenges and emerging opportunities

The complexity of infrastructure asset management is linked to various factors: the long-term perspective, the uncertainty due to the demand for future services or unpredictable shocks, and budget constraints in the face of competing needs. Different challenges may impact individual countries to a variable degree, depending on the specific context, development level, institutional set up, and stakeholders concerned. However, the ones listed below are some **common root issues** that have emerged from the literature and empirical observation.

- Lack of consistent, accessible and comparable data related to infrastructure assets (i.e. age, location, condition, performance, exposure and vulnerability to hazards) – which are vital for assessing the optimal level of expenditure required for maintenance.
- Inadequately and/or inconsistently reported maintenance expenditure in public accounts – often combined with other consumption expenditure items, amounts spent for ordinary maintenance may be especially hard to disentangle.
- Weak capacity for planning and contract management, as well as a poor coordination among involved entities and across administrative levels – which can make public infrastructure spending shortsighted and inefficient.
- Inadequate funding sources (e.g. limited government budget contended by competing demands or unsteady user charges) or inefficient public spending – resulting in neglected or inadequate maintenance.
- Inherent project implementation and technical difficulties (including the asset's extended life, or excessive burdensome authorization requirements) – which can discourage proper care for existing infrastructure systems or make it difficult to fix or retrofit dated assets.

- Political "short-termism" or other adverse incentives and/or bias in favor of greenfield projects – which can relegate spending on maintenance to low priority.

On the positive side, there are a number of opportunities that can be exploited to make maintenance spending more efficient and to ensure that interventions are handled in the most timely, smart and least invasive way. Among them: i) digitalization and data-driven advances in monitoring for "smarter", better targeted maintenance; ii) technical and scientific innovations enabling cheaper, faster and less invasive repair interventions; iii) NbS (Nature-based Solutions) and "green" infrastructure that rely on natural ecosystems to deliver (or integrate) services traditionally assigned to man-made ("gray") infrastructure.

II. Expected benefits

In light of the challenges discussed above, neglecting or deferring maintenance may appear an easy option, but it inevitably ends up bringing additional, preventable costs and generating negative externalities. Conversely, there are **clear benefits that can be linked to proper and timely infrastructure maintenance.** These expected benefits may manifest both at the micro (individual project), as well as at a macro, systemic level. The table below illustrates them synthetically.

Micro level benefits (or avoided costs) highlight how strengthening the resilience and maintenance of an individual infrastructure asset or facility pays off, especially when considering its economic efficiency in a life-cycle perspective. **Macro level benefits** (or reduced negative externalities) focus more on the infrastructure assets in their interaction with people served through them and with the environmental resources utilized to or affected by infrastructure systems operations.

MICRO LEVEL BENEFITS	MACRO LEVEL BENEFITS	
Project-level positive impact	Socio-economic impact and quality of service delivered to users	Environmental impact
• Reduced direct costs due to accident/malfunction/disaster • Maximization of utilization and efficiency of asset • Extended useful life of infrastructure asset (and value) • Increased reliability of infrastructure systems	• Avoided mortality and morbidity (plus related medical costs) • Safety and security • Availability, continuity and quality of service • Avoided coping costs (e.g. electricity generators, alternative drinking water purchases) • Local economy development • Employment opportunities and easier access to jobs (e.g. accessible and reliable urban transportation) • Higher productivity and competitiveness in international markets	• Higher energy efficiency • Higher noise protection • Curbed CO2 emissions • Reduced waste of treated water • Improved water quality (by optimal wastewater treatments) • Reduced damages resulting from extreme natural hazards (like floods or earthquakes)

It is also worth noting that there are many examples in which **working on infrastructure to carry out repair and renovations has allowed to improve the asset** in the form of extra "side benefits"– e.g. in terms of digitalization, alignment to new demand, re-purposing of an asset, or adding an additional use of a facility/network. An example of this is the re-fitting of traditional street lighting with LED lamps that gave an opportunity for installing distant monitoring sensors.

Policy Options to Improve Timeliness, Efficiency and Effectiveness of Infrastructure Maintenance: from Planning to Delivery

Infrastructure maintenance is a **complex and multi-faceted topic** which encompasses multiple disciplines and it generally falls under the purview of a multiplicity of Ministries and Government entities. The *G20 Policy Agenda on Infrastructure Maintenance* tackles the topic primarily from the **point of view of Ministries of Finance and Central Banks**, while acknowledging policy aspects that pertain to other line Ministries or public agencies but may have important repercussions on public spending.

The *G20 Policy Agenda* is **consistent with efforts by the G20** in response to the COVID-19 crisis, as reflected the *G20 Action Plan*, in which G20 members committed to "*build on G20 infrastructure efforts to increase the resilience of infrastructure against risks*". It is in line with the *G20 Roadmap for infrastructure as an asset class*, endorsed under the Argentinian Presidency in 2018 to catalyse long-term private investment in infrastructure and it is also consistent with other G20 initiatives, such as the *G20 Principles for Quality Infrastructure Investment*, endorsed under the Japanese G20 Presidency in 2019, promoting quality infrastructure investments for the delivery of better social, economic and environmental outcomes, as well as the *InfraTech Agenda*, endorsed by the G20 in 2020 under the Saudi Presidency, as infrastructure technology can play a role in making maintenance more targeted, affordable and effective.

Given the complexity of the challenges and the multiplicity of stakeholders involved, the *G20 Policy Agenda on Infrastructure Maintenance* proposes **a menu of non-binding and voluntary policy options** that represent possible choices and are proposed for countries' consideration and are subject to countries conditions and circumstances. The Policy Agenda is accompanied by cases submitted by member countries (see *Annex of Infrastructure Maintenance Case Studies*), that refer to either high level programs or individual projects. These policy options are organized around three macro policy areas.

I. Better planning and institutional coordination across sectors and/or administrative levels

A necessary building block for resilient and reliable infrastructure systems is **fixing the wide underlying information deficit in infrastructure,** by mainstreaming the capacity to analyze performance and predicting risks of various natures deriving from "normal" usage of infrastructure and from "abnormal" shocks. In turn, risk assessments must feed budgeting decisions, via a **prioritization of works** aligned with each country's predefined minimum acceptable standards. In addition, considering the extended life span of most infrastructure assets, it is important to design and manage them **in line with long-term sustainable development goals**, anticipating (to the extent possible) the key socio-economic drivers of future service demands. Increasing institutional coordination, **breaking silos** and **introducing a life-cycle perspective represent** additional effective options. When applicable, the **simplification of regulatory frameworks and standards**, may help balance the needs to ensure fair competition and oversight, with the goal of encouraging private sector participation.

Illustrative policy options[1]:

- ***Better and systematically collected data on infrastructure (e.g. census of assets, status, risks, performance).*** Setting up periodic surveys of the infrastructure stock, accompanied by the creation of data repositories, is a key prerequisite for planning and budgeting decisions and the identification of critical assets. Information systems showcase increasing sophistication and can now integrate Geographic Information System (GIS)-based data, digital models and multimedia content.

[1] Policy options for all three macro-areas are informed by the case studies submitted by G20 members - see Annex of Infrastructure Maintenance Case studies.

- ***Strategic plans addressing infrastructure assets management, maintenance and repairing.*** Policymakers may define "strategic plans" focused on a sector, a selection of critical infrastructure, or on other desired goals (e.g. circular economy, life extension for aging infrastructure, smart and/or resilient cities). Such plans may encompass targets and guidelines related to resilience and optimal life-cycle operations or reaching "state of good repair" objectives and should entail both recurrent, ordinary and extraordinary maintenance interventions.

- ***Definition and adoption of domestic minimum levels of maintenance standards/goals (e.g. on asset safety, performance, quality); Monitoring and Evaluation (M&E) frameworks focused on maintenance backlog and budgeting.*** These options provide the concrete technical specifications needed to implement strategic plans in practice. Defining minimum acceptable infrastructure quality levels (i.e. on safety, accessibility, sustainability, resilience) depends on country-specific circumstances and requires viable information-gathering systems to monitor adherence to them. New solutions can also improve M&E processes (e.g. crowdsourcing data from mobile devices, web scraping or sensors).

- ***Regulatory innovations (e.g. favoring Life-Cycle Cost approaches, adopting predictive models and warning systems).*** These policy tools capture the adjustments applied to the institutional framework that sets, monitors and enforces rules overseeing infrastructure asset management, services delivery and relative accounting. Options include: i) setting up incentives to private investment into public projects also on maintenance; ii) adopting a common, country-wide, standardized asset management framework; iii) improving the allocation of scarce resources via market design reforms; iv) tariffs or subsidy setting aligned with social inclusion, cost-recovery, resource conservation or other goals.

- ***Strengthening institutional framework (e.g. new planning agency or administrative coordination mechanisms).*** In some cases, strategic plans can be accompanied by the establishment of a dedicated entity or inter-agency coordination body and effective working relations between agencies responsible for infrastructure network management and sectoral line Ministries. This can also be complemented by efforts towards simplification of bureaucratic processes that may represent an unintended incentive to neglect.

- ***Strengthening institutional capacity and governance (e.g. measures improving coordination, risk allocation, stakeholders' engagement).*** Possible options encompass securing openness and transparency of procurement; working closely with regulators to foster coherent, efficient and predictable regulatory frameworks; strengthening public sector project and risk management capacity; and improving and speeding up approval processes.

II. Measures to secure funding and financing

An adequate share of spending for public works should be allocated to maintenance (both ordinary/routine and extraordinary) to maintain an acceptable "performance" level that ensures the delivery of quality services to the public over time. **Streamlining the reporting of maintenance spending** (according to clear and consistent accounting criteria) is a crucial prerequisite for better planning and to provide reliable and comparable data. Furthermore, especially in the current recovery phase, **investing in maintenance might bring quicker and greater returns** (including in the form of job creation and productivity boost) compared to other options of allocation of stimulus packages resources. Efforts to secure **adequate funding of maintenance can take advantage of many levers**: creation or identification of dedicated revenue streams, increasing the efficiency of maintenance spending, or creating new mechanisms to capture value from infrastructure projects. It is also important to ensure the conditions that can **mobilize diverse, available sources of financing**, especially channeled to infrastructure maintenance (e.g. contractual partnership with the private sector, harnessing financing from multilateral development banks or institutional investors' and asset managers).

Illustrative policy options:

- ***Earmarking of funding sources for maintenance (e.g. a targeted share of tax revenues or dedicated funds in local budgets); coordinated allocation of various available sources of funds, including supranational ones.*** Adequate funding sources must be identified, sufficiently disbursed over time, and linked (to the extent possible) to ensure that assets remain in a serviceable condition. Options include dedicated maintenance funds or allocation of specific taxes and levies revenues. Alternatives include funds from post-COVID stimulus packages or supra-national programs allocating to maintenance programs, connected to quality infrastructure and/or resilience goals.

- ***Regulation and practices to account for actual and deferred maintenance expenditure in agencies' balance sheets.*** Along with more transparent and granular infrastructure spending reporting, public expenditure accounting can be used to raise accountability for maintenance backlog accumulation (e.g. by letting performed maintenance be reflected as an increase in value/reduction in depreciation of the asset stock; by recognizing deferred maintenance obligations as liabilities in agencies' balance sheets).

- ***Innovative funding sources for delivering maintenance of public infrastructure.*** These may be in the form of ancillary business revenue, i.e. income derived from provision of goods and services that are not a core business operation directed to operating and maintaining the core infrastructure asset. Also, direct cost recovery from user charges or congestion charges are sources of funding for O&M expenditure.

- ***Financing via private sector investments.*** When suitable to the context and properly designed to align financial interests, contractual models involving the private sector may encourage resource mobilization, provide better risk allocation, or improve the operational efficiency of maintenance projects. Options include new forms of guarantees, concessions, as well as different modalities for Public-private partnerships (PPPs), including Design-Build-Operate-Maintain (DBOM) contracts. Longer-term rewards offered to the private bidders, including through a stable revenue stream from the maintenance project, may offset perceived risks.

- ***Funding schemes incorporating preparedness to risk (e.g. risk insurance, built-in-flexibility in contracts, contingency plans).*** Approaches span from contractual agreements to technical solutions (prefabrication or redundancy at critical network nodes) and financial tools (insurance solutions, central-government guarantees, quick-disbursing financing mechanisms in case of disasters, ex-ante contingent financing instruments) to help mitigate the uncertainty factors affecting infrastructure management.

- ***Tax expenditures allocated to maintenance or rehabilitation purposes.*** Options include tax revenues that the government forgoes through selective measures (e.g. tax exemption/exclusion, reduction in taxable income or other tax schemes) in favor of certain groups of recipients and/or in relation to specific activities. These measures may be adopted to pursue various policy priorities including: social inclusion, housing and city planning, safeguard of the environment, preservation of cultural and landscape heritage.

III. Approaches for effective delivery of maintenance

This macro area of policy intervention embraces solutions that have to do with **improving the efficiency of infrastructure delivery and maintenance and the implementation of actual projects**. For the purpose of this *G20 Policy Agenda on Infrastructure Maintenance*, what is most relevant are the ways in which an enabling environment can be created to promote the application of the emerging opportunities mentioned above. Of special interest are viable policy solutions aimed at making maintenance more cost-effective, which take advantage of **existing tools for effective delivery of maintenance**. These include new technologies, better asset management strategy, approaches incorporating NbS or different ownership-management contractual configurations. It is equally important to **create knowledge sharing spaces** and channels, so that successful solutions can be also shared and improved (see the *Annex of Infrastructure Maintenance Case Studies*). A greater **technical knowledge would be also beneficial if available to public administrations** "in-house", such that they could have personnel with up-to-date competences useful to planning and procurement decision-making phases.

Illustrative policy options:

- ***Solutions improving individual assets' maintenance plans, life-cycle asset management strategy, or risk management.*** Moving from *reactive* to *preventive* maintenance (i.e. maintaining assets at pre-scheduled time intervals) or, even better, *predictive* maintenance (i.e. enabled by advanced analytical methods that predict the likelihood of damage) can potentially minimize costs over time. Other information-based approaches include increasingly complex asset management systems which assess various details about the assets, their components and life-cycle cost analysis.

- ***Contractual provisions improving maintenance delivery (e.g. service level agreements, performance-based payments, or quality assurance requirements).*** Performance-based contracts can incentivize private operators' efforts towards rehabilitation and maintenance. Similar contractual and regulatory elements can increase the efficiency of service provision and boost the revenues of service providers while improving the quality of service (e.g. reducing electricity or non-revenue water losses). Alternatives include procurement incorporating bid awarding criteria referred to the efficiency and effectiveness of infrastructure maintenance.

- ***Adoption/sharing of Information and Communication Technology (ICT), data-driven and other technological innovations for maintenance (e.g. remote sensing, robotics, big data, Artificial Intelligence (AI), new materials, construction information modeling).*** The use of sensors, drones and satellite imagery can lower maintenance costs in roads, water and energy utilities, remotely pinpoint damage to networks, as well as enable faster and more targeted response to disasters. AI, cloud computing and machine learning can improve the information sharing and analytical tools for risk modeling or asset maintenance plans. Emerging engineering approaches or new construction materials can bring improvements at various stages of design, construction, operation that increase efficiency, effectiveness, timeliness, while minimizing disruption of service to stakeholders - e.g. augmented and virtual reality, "digital twin", 3D printing of prefabricate parts, or worksite sensors.

- ***Solutions improving maintenance cost management (including revising and adapting asset footprint compared to needs).*** Overinvestment in capacity at the construction stage may significantly increase maintenance costs down the line. Conversely, correct sizing of facilities and structures (based upon demand assessment) could be a source of efficiency and savings. Other ways to improve efficiency and reap savings include reducing cost overruns, avoiding delays in project implementation, and maintaining existing assets properly.

- ***Solutions integrating resilience into infrastructure intervention (design, modularity, retrofitting, repurposing/adaptation vs decommissioning).*** Increased redundancy elements (e.g. backup systems, robustness of materials) can enhance resilience. Distributed network with smaller decentralized units (e.g. *in situ* water treatment and recycling facilities) can be easier and cheaper to maintain.

- ***Resilience or maintenance solution relying on NbS.*** If synergistically integrated with traditional infrastructure, these solutions can significantly change the requirements, frequency and/or effort intensity of O&M. For example, green and flood retention spaces in urban areas help to alleviate storm water accumulation, thus help reducing drain and pump requirements; constructed wetlands can perform some wastewater effluent filtering and reduce treatment requirements; mangrove forests used to protect from coastal erosion and floods help lower embankment requirements.

- ***Training and upskilling of maintenance workforce.*** Policy measures to enhance skills and allowing workers to keep pace with technological developments will have the double benefit of creating quality jobs while allowing effective infrastructure maintenance efforts. Financing education and training in infrastructure maintenance are initiatives that should be put in place to retain critical skills.