The Social and Economic Impact of Digital Public Infrastructure based on Digital Public Goods

Methodology Document

September 2022

This note elaborates on the methodology and data used in this analysis of the human and economic impact of digital public infrastructure. The analysis was conducted by the United Nations Development Programme (UNDP) and the Digital Public Goods Alliance (DPGA) with Dalberg Advisors. A comprehensive report will be released in the fall of 2022.

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Study context

Building inclusive, resilient and thriving societies in Low and Middle-Income Countries (LMICs) will require the development and adoption of digital public infrastructure (DPI). An approach that leverages digital public goods (DPGs), open-source software and even proprietary elements when needed, can lead to more locally-appropriate and efficient country-level implementation of DPI. However, the development and wide-scale adoption of DPI in countries has so far been hindered by a lack of awareness, capacity and support. Investing in DPI and DPGs can help LMICs leapfrog the delivery of essential services and unlock significant human and economic value, innovation and resilience. DPGs are critical to developing and customizing DPI in collaborative, coordinated and cost-effective ways that can benefit all countries and people.

The benefits DPI can be measurably seen in the expanded access to, as well as higher efficiency of public service systems and delivery. DPGs and DPI are also directly responsible for driving innovation and building systemic resilience, although progress in latter may be more difficult to measure or predict. Separately but simultaneously, DPGs and DPI can meaningfully contribute to a country's public governance ecosystem. When developed well, DPI can enhance society's trust in public institutions, by closing the promise-delivery gap in essential services, making services more inclusive and rights-based, as well as ensuring individual privacy and security. Lastly, building and deploying DPI can enable long-term sustainability of digital public infrastructure by ensuring interoperability and bypassing vendor lock-in in a rapidly changing digital landscape. The report aims to provide a compelling narrative of the quantifiable and qualitative impact that DPI can have on individuals, sectors and countries.

We selected sector-based DPI in **finance, climate,** and **justice** sectors to exhibit the potential scale of impact. This document describes detailed steps taken to develop the impact assessment models for DPI/DPG-based interventions and **complements the overall report (forthcoming, fall of 2022).**

Modelling approach

The overall modelling applies a mixed-methods approach that combines bottom-up estimation methods for deriving the impact figures with a top-down approach for triangulation. The modelling leverages *impact pathways*, each of which represents the logical series of steps, or mechanisms, through which a DPI intervention translates into real-world impact. Depending on the specific impact pathway, the estimates span a wide range of economic, ecological, social and human-centric metrics. These include increase in *GDP; improved credit access for micro, small, and medium-sized enterprises (MSMEs); reduction in carbon emissions*, *improved access to justice; increased income for smallholder farmers; better nutritional outcomes,* among others.

Model objectives: The primary aim was to model incremental impact of taking a DPI based approach, compared to the next-best plausible alternative (business-as-usually or digitalization without DPGs and open-source solutions) for LMICs, both mapped with a 2030 timeline. While in sectors such as finance, the next-best alternative includes digitally delivered services (for example, real-time point-of-sale payment systems such as those enabled by Mastercard), in the jusdicial sector it is more likely to be business-as-usual systems and processes (mainly offline, or in some cases, specialized dispute resolution services provided by companies such as SAMA in India or Consumidor.gov in Brazil).

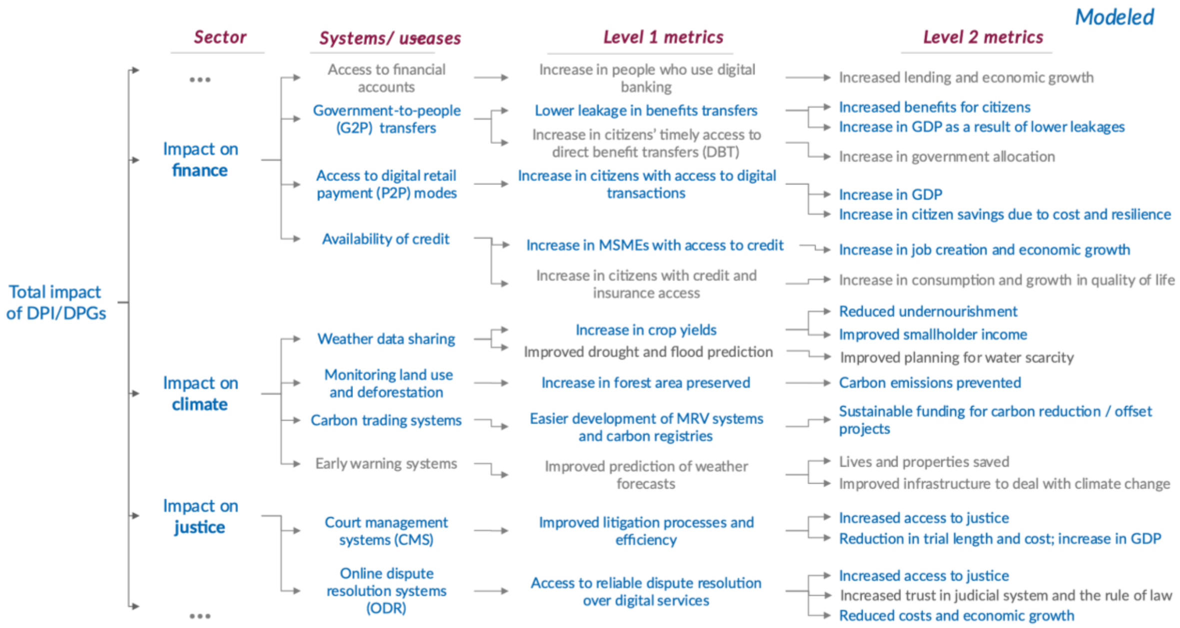
Model constraints: Though the aim is to estimate incremental impact of DPI over that of non-DPG-based and non-open-source solutions, there are limitations with the current availability and use of

DPGs. Understanding the impact of DPI enabling fully or mostly DPGs and open-source solutions is further limited by their recency and lack of rigorous evaluation for some pathways. To address this, reasonable proxies have been used to estimate the part of the market that is currently unrealized and presents potential for impact by DPG or DPI. For example, we note that approximately 1 in 5 individuals who face a civil legal challenge and do not go through the formal legal system nonetheless seek legal advice,[1] and can be assumed to be potential adopters of online dispute resolution (ODR). Due to similar limitations with the availability of evidence, two explicit design choices / trade-offs are employed: (I) the avoiding false precision by excluding nuances not backed by evidence, and (ii) when evidence is limited, identifying a lower threshold for our assumption, ensuring that our estimates are conservative. To develop the model, below is the four-step process used:

STEP I: IDENTIFYING AND PRIORITISING SECTOR-SPECIFIC IMPACT PATHWAYS

For each of the three sectors, a long list of potential impact pathways was identified (Exhibit 1). These pathways are rooted in existing and well-established literature and are widely recognized by subject matter experts.

Exhibit 1: Impact pathways for DPI (Non-comprehensive)



For example, easier government-to-people (G2P) payments can translate into macroeconomic benefits through social protections and services that are less costly to administer, more accessible, and delivered more effectively. Improvements in the administration of social safety nets are most important in the face of crises and shocks that require rapid and reliable response from public institutions. Similarly, adopting DPI-based national online dispute resolution systems (ODRs) for civil litigations can expand access to justice to people who are currently unreachable through the formal judicial system, while providing a cheaper and more time-efficient alternative to others. These changes are likely to deliver better systemic judicial outcomes as well as macroeconomic impacts for all.[2] Likewise, linking carbon markets using a DPI-based platform can create consistency and transparency of carbon accreditation,

[1] WJP, Access to Civil Justice surveys (2019)
[2] Lorizio, Gurrieri, (2014) Efficiency of Justice and Economic Systems. Available here

spurring greater co-operation in use of carbon markets and carbon offset projects, and unlocking additional climate financing.[3]

From this longer list of impact pathways, the research team prioritised eight systems / use–cases and subsequent impact as anchor pathways for further modelling (Exhibit 2). Prioritisation of these impact pathways was based on a combination of three factors: (i) their impact potential, (ii) real-world examples to enable assumptions rooted in evidence, and (iii) directness and attributability of impact to the digital solution (greater degree of separation implies more assumptions and therefore less reliability).

Exhibit 2: List of DPG based systems/ use-cases based on the eight prioritised anchor pathways for

Finance	Climate	Justice
Government-to-people (G2P) payments	Agriculture and early warning systems (EWS)	Court management system (CMS)
Retail (P2P) payments	Forest watch	Online dispute resolution (ODR)
Access to credit	Carbon credits trade	

STEP II: BUILDING DETAILED MODELS FOR EIGHT ANCHOR PATHWAYS

The research included four types of analysis to develop models for the shortlisted anchor pathways:

First, we defined a logical mathematical relationship between the DPI and the impact to be estimated. For example, to estimate the impact of easier retail payments on GDP growth we used the following:

Exhibit 3: High-level mathematical formula for estimating GDP unlocked through DPG solutions in transforming retail payment

High-Level Formula

Due to increased transaction volume | Due to increased savings and income

Total Increase in GDP = (GDP of selected countries × % Growth in transaction volume × % Increase in GDP per 1% growth in transaction volume) + ((Increase in income due to economic resilience + Increased transaction cost savings) × GDP-to-GNI ratio)

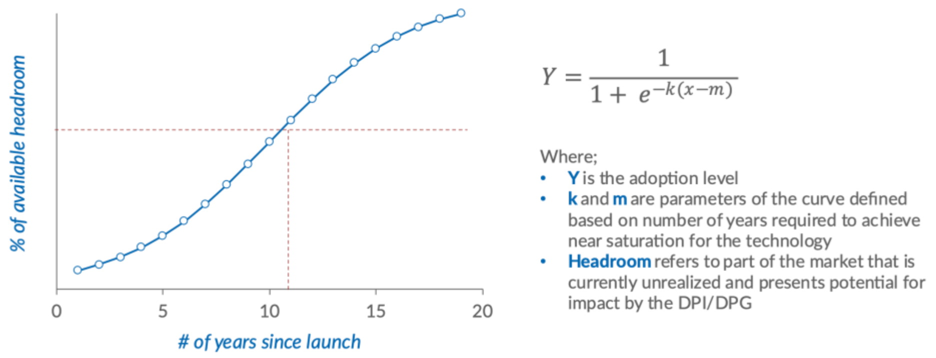
***Interpretation**: Three key levers drive the increase in GDP through DPG/DPI in the retail payments space: i)the increased economic activity enabled by increased volume of transactions, ii) the savings enabled by reduced transaction costs, and iii) increased income due to greater resilience to shocks (easier access to savings and remittance). All three levers can be expressed as a function of retail payments adoption until 2030. The next step describes this adoption in greater detail.*

Second, the Impact up to 2030 was then forecasted based on an adoption curve for the DPG- based DPI. We created a time series of the expected growth trajectory based on the likely speed and scale of adoption of the sector-based DPI. We applied a sigmoid function to mimic an S-shaped adoption curve for individuals and institutions (Exhibit 4). Diffusion of new technologies is known to mimic an S-shaped curve based on the behaviour of innovators and imitators in the market.[4] The research team assumed a similar adoption behaviour amongst nations and institutions (such as

[3] TaskForce on Scaling Voluntary Carbon Markets (2021). Available here
[4] Brown, Cox (1970) Empirical Regularities in the diffusion of Innovation. Available here

judicial systems), as well, driven by reduced barriers to adoption and network effects of digitalisation. To estimate the duration required to achieve population scale adoption for these technologies, several relevant proxies were examined. These proxies covered adoption by **individuals** (e.g., adoption of internet and digital payments, services such as UPI in India and PIX in Brazil, usage of fertiliser per hectare), **businesses** (e.g., growth in Net-Zero emission pledges), and **governments** (e.g., growth in e-governance).

Exhibit 4: General shape of the adoption curve for technologies (enabling DPI) amongst people and institutions



Third, the incremental impact, i.e., the impact DPI vs. that of the next-best plausible alternative was defined: This was done using data from real-world proxies for both the DPI and the next-best alternative. For some pathways, such as the use of court management systems, business-as-usual is largely offline, and thus the incremental impact can be attributed mostly to digitalisation led by DPI approaches, and the resulting acceleration in adoption rates. For other sectors, such as in finance, ample non-DPG based digital solutions exist. The research team therefore estimated the incremental impact over and above those existing digital solutions.

- *Example 1: The research team* **determined the impact of the DPI that provide credit to MSMEs** by calculating the additional number of MSMEs that have access to credit compared to business-as-usual, the resulting improvements in revenues, and subsequent increases in GDP levels over time. A DPI approach is likely to reduce the negative effects of information asymmetry on MSMEs and therefore decrease the cost of lending, thereby shrinking the credit gap for MSMEs when compared to existing digital solutions.[5] This improved access to credit for MSMEs creates subsequent positive externalities, including enterprise and revenue growth, with knock-on effects of generating employment opportunities and greater household consumption, as well as increasing overall GDP.

- *Example 2:* The research team **calculated the impact of reliable localized weather forecasts on food security and smallholder income** based on estimates of resulting agricultural yield improvement. Most farmers in LMICs, and especially smallholder farmers, do not have access to reliable weather forecasts for their location. When available, these forecasts are often limited by the range of meteorological stations and the forecasting algorithms used. The lack of accurate information restricts farmers from maximising their productivity. To estimate the impact of weather monitoring and information systems, we compared business-as-usual growth for cereal crops against growth with the introduction and adoption of local weather monitoring DPGs. With DPGs, farmers can better plan cropping cycles and protect

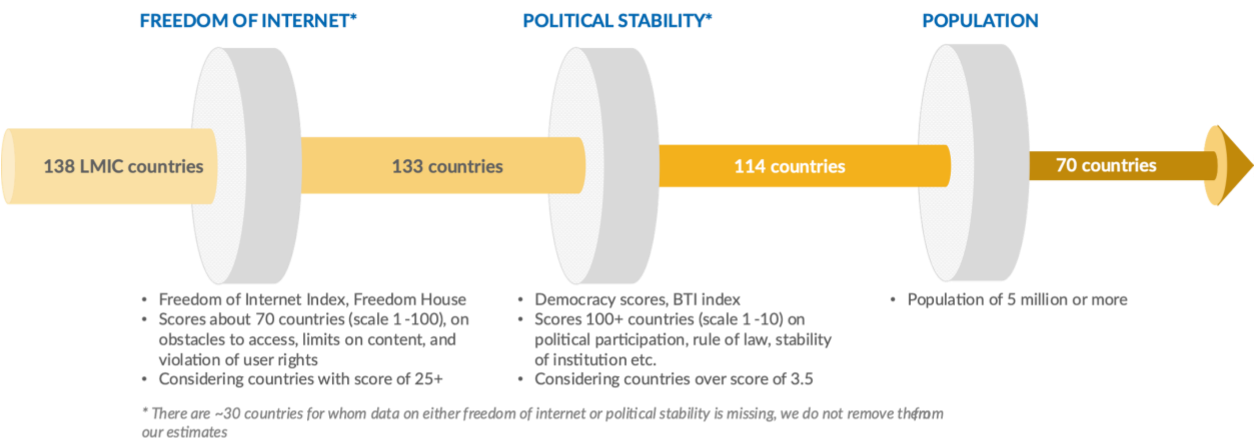
[5] Allianz trade SME outlook. Available here

against pest cycles and weather shocks. [6, 7] The resulting increase in yield, in-turn, can improve food security for populations facing undernourishment and lead to growth in income for smallholder farmers.

- *Example 3:* The research team **estimated the impact of the DPG-based online dispute resolution (ODR) DPI** based on the additional number of individuals who access ODR systems through a nationally provided ODR. This additionality is created by easier access, lower costs, and greater trust offered by the national ODR DPI as compared to proprietary and siloed ODR systems. To estimate this impact, a comparison is made against adoption of ODR systems in the business-as-usual scenario (i.e., without the presence of a nationally provided ODR DPI built using DPGs) based on a year-over-year growth rate that reflects historical growth rates for available ODR platforms. This compound annual growth rate (CAGR) will likely decline over time, but given the small starting base, we assume it will remain at this rate for the duration of our short-to-medium term forecast horizon of eight years. Alternatively, in the scenario with a nationally-provided ODR DPI, we assume that those who face a civil challenge and do not currently go through a formal legal system but actively look for legal advice are a likely target segment for the ODR system.[8] It is important here to note the absence of any real-world implementation at a national scale, which requires us to make an educated and supported assumption on the number of individuals who may eventually use ODR systems.

Lastly, the output from the preceding steps and project impact across the LMICs were combined. To achieve a reliable projection, the research team identified a shortlist of 70 countries from 138 LMICs[9] using three criteria: (i) freedom of internet, (ii) socio-political stability, and (iii) a reasonable population base (Exhibit 5). This smaller set allows for greater reliability of our assumptions**.**

Exhibit 5: Shortlisting of 70 LMICs for impact modelling



We developed three sector-specific segments for these 70 prioritised countries based on overall readiness for DPI, as well as a combination of **digital readiness** and **sector-specific criteria**. Digital readiness ensures the availability of necessary infrastructure required to adopt a DPI-based technology (for example, access to internet may be required for sharing data on weather patterns and pest cycles

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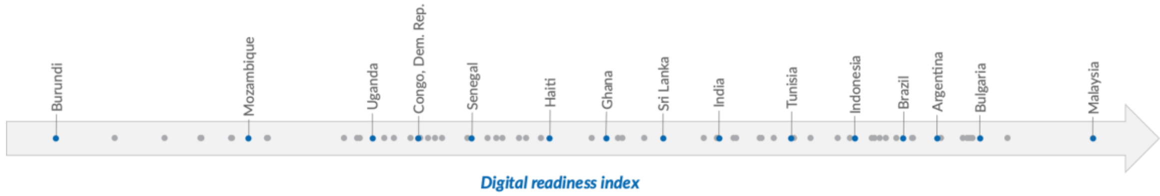
[6] African Development Bank Group; How seasonal weather information is helping farmers in Ethiopia. Available here
[7] AgroMet–IMD (2016); Farmers in Rural Maharashtra are Fighting Climate Change. With Just a Mobile Phone. Available here
[8] World Justice Project; Access to Civil Justice surveys (2019)
[9] World Bank Income Classification (2022)

with smallholder farmers). Similarly, sector-specific criteria assess whether there are adequate enabling conditions for the country to successfully adopt and benefit from the DPI. For example, a country actively making efforts to reduce its carbon footprint is more likely to link carbon markets using a DPI-based platform than is a country that is not making these efforts. Accordingly, the segments represent a relatively homogenous group of countries with likely similar adoption rates for DPI in that sector (Exhibit 6 presents countries based on their digital readiness index). These groupings were used to scale the estimated impact for the entire segment in that sector:

Exhibit 6: Selected LMICs based on their digital readiness criteria



Countries may be grouped in three categories. For example, **Category A** countries have supportive ecosystems for the DPI, indicating a likelihood of fast adoption; however, in many cases, these countries may already have advanced non-DPG solutions that are deeply embedded, limiting the overall potential for growth. On the other hand, **Category B** countries include those that have enabling ecosystems along with a few non-DPG-based sector-specific solutions. These present greater growth opportunities for DPI. However, speed of adoption in these countries could be slower than for those in category A. **Category C** countries present the highest potential for growth of the DPG. However, the adoption here could be slowest due to limitations on the enabling digital ecosystem.

We defined readiness criteria based on composite indexes. **Digital readiness** is based on *ecosystem metrics*, *people and citizen related metrics*, and *business-related metrics*. Similarly, among sector readiness metrics, **financial readiness** included access to and growth in individuals with bank accounts, **climate resilience** included CO_2 emissions (per unit of GDP), state policies on renewable energy, and agricultural productivity, and **justice effectiveness** included access to civil justice, availability of alternative dispute resolution mechanisms outside the state justice system, and effectiveness of criminal adjudication.

STEP III: REFINING ASSUMPTIONS AND TRIANGULATING RESULTS

Finally, to ensure the quality and reliability of the model, the research team has referred to numerous studies, white papers, reports by multilateral and bi-lateral organisations, and over 15 in-depth expert interviews. The research started by **stress-testing pathway logic and framing,** followed by multiple rounds of **refining the assumptions**, ensuring that they are rooted in real-world evidence or are derived from established sources. In cases where no prior evidence exists, the research team considered a reasonable proxy and ensured that the assumptions were verified by subject-matter experts. Finally, we **triangulated the overall estimates** by sense-checking the values using (i) findings from independent studies and (ii) inputs from sectoral experts. These steps have allowed the research team to establish the impact of DPI/DPGs across the listed anchor pathways with a high degree of confidence.

Key Points

The research quantified the benefits of developing and adopting DPI along eight separate pathways across three sectors for 70 LMICs, as compared to baselines defined by their current trajectories. This analysis and methodology allowed for reporting on the incremental impact of DPI in 2030 across a series of impact metrics that begin with the more efficient and effective delivery of public services, and amount to the reduction of undernourishment and carbon emissions while growing the economies of LMICs. The results estimate meaningful improvements in the lived experiences of some of the poorest and most vulnerable cohorts of society, and the tangible benefits of cooperation and collaboration across countries and communities in advancing DPI.

The reported results are conservative. As mentioned above, the methodology used errs on the side of caution, preferring to make evidence-backed assumptions instead of expanding the scope and number of impact pathways quantified. It was, therefore, ensured that impact statements are specific to the analysed pathways and limit the degree of aggregation across sectors and countries. Nonetheless, the pathways modelled likely represent the largest proportion of the total potential impact DPI can have in these three sectors as known today. It is not reasonably predicting how these sectors will structurally change with the adoption of foundational DPI. These solutions may spur rapid innovation or unexpected outcomes that differ significantly from the historical trajectories we have used to inform our forecasts.

This report looks to pave the path for informed deliberation and further analysis of DPIs and the changing features of public governance across sectors. It is not, however, an academic estimate of the impact DPIs can have and is instead a rigorously grounded real-world estimate of their potential. Our analysis suggests that there is more upside to investment in DPIs than there are risks. In 2030, investment in the three prioritized pathways of open credit, digital retail payments, and penetration of G2P systems can grow LMICs' economies by 1-2 percent of GDP. Investment in digital public infrastructures in justice will expand access to formal judicial channels to up to 43 million more people in 2030 alone. At the same time, digital public infrastructure can reduce carbon emissions at minimum 1 GtCo2e over the next eight years. Implemented with design principles that ensure inclusivity and keep human rights at the centre, DPI will help be integral to successfully transitioning our commercial, social, and civic lives online.

Annex: Bibliography and list of experts

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B. List of experts

#	Expert	Organization	Designation
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2	Alexandra Soezer	UNDP	Global Carbon Technical Advisor – Energy, Sustainable Energy Hub
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4	Chris Decker	MIZAN	Project Manager
5	Amanda BenDor	Digital Square, Path	Deputy Director
6	Catherine Diam, Omar Zamrag	UNDP	Climate Specialists
7	Tanuj Bojwani	Ispirit	Volunteer
8	Yvonne Nyokabi, Sharon Wekesa, Leticia Guimaraes	UNDP	Climate Specialists

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10	Leanne Mckay, Dany Wazen, Sarah Mccoubrey	UNDP	Justice Advisors
11	Fred Stolle	World Resources Institute	Deputy Director, Forests