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WORKING PAPER

IMPLEMENTING OPEN DATA STRATEGIES FOR CLIMATE ACTION: SUGGESTIONS AND LESSONS LEARNED FOR GOVERNMENT AND CIVIL SOCIETY STAKEHOLDERS

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EXECUTIVE SUMMARY

Highlights

- Shared data and information are fundamental to mainstreaming climate action and promoting a coordinated and coherent response to climate change across government and society.
- Open data—the publication of datasets that can be freely used and redistributed by anyone, anywhere—offers opportunities to improve climate policymaking and implementation while enhancing transparency in line with the Paris Agreement.
- This working paper draws on a literature review, expert consultations, and observations from pilot projects implemented in Chile and Uruguay to provide insights on the specific opportunities and challenges that open data approaches hold for climate action. For each challenge, the paper showcases potential solutions with illustrative examples.
- Benefits include improved data coordination and quality, informed decision-making, novel partnerships, and enhanced monitoring. Common barriers include a lack of awareness of benefits, poor technical capacity, insufficient legal framework, and a lack of political incentives to enable cooperative data sharing.

CONTENTS

Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback, and to influence ongoing debate on emerging issues. Working papers may eventually be published in another form and their content may be revised.

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- Using illustrative examples from a variety of contexts and countries, we provide recommendations to strengthen the results chain from data publication to impact. These include continuous stakeholder engagement, open data initiatives tailored to users' needs and capacities, greater investment in communication, and supportive governance arrangements.

Background

In recent years, the urgency and sheer scale of climate impacts have made clear the need for similarly urgent and ambitious solutions—solutions that will only be feasible with the inclusion of actors across government and society. The cross-cutting nature of the challenge, as well as evolving policy processes at international and national levels, call for action from line ministries to local governments, the private sector, civil society, and academia (IPCC 2018). Improving the availability and accessibility of climate-related data and information across this range of actors, therefore, is necessary to orchestrate a whole-of-society response to climate change.

Often, however, climate-related data is incomplete, fragmented across agencies, or not made available in formats that facilitate its comprehension and reuse, resulting in redundancies and limited value for decision-making (UNECE 2014; U.S. GAO 2015). In this context, open data emerges as a promising approach to improve data accessibility and connect data with the ecosystem of users who need them (World Bank 2014).

Open data is digital data published with the technical and legal characteristics to be "freely used, reused, and redistributed by anyone, anytime, anywhere" (Open Data Charter 2020). This means data that are published in technical formats that allow any software or device to read them, and licensed to permit free redistribution and reuse (World Bank 2014).

Advocating for the adoption and implementation of open data policies falls under a broader struggle for transparency—free access to quality information that is relevant for understanding and participating in decisions that are in the public interest. Transparency has long been a mechanism of environmental regulation (e.g., through environmental impact assessments and disclosure of toxic chemical release). It also features prominently in the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement to facilitate clarity when communicating and reporting progress.

The strengthened attention to climate action transparency sparked by the Paris Agreement, along with governments' efforts to digitalize assets and services, have spurred new opportunities to improve climate data access and use across a broad range of users within and outside of government (Brusa 2020). Yet, governments and domestic stakeholders have received little to no guidance toward implementing these shared goals. In this paper we have developed and piloted a methodology to address this gap, enabling key stakeholders and policymakers to assess and improve the openness of datasets most relevant for climate action in their given country context.

About This Paper

This paper aims to promote greater accessibility of climate-related data by building government officials' and other stakeholders' understanding of the benefits of open data principles and practices, the challenges they may encounter in implementing them, and ways to address these challenges while taking steps to ensure that data publication is impactful, responsible, and sustainable. It primarily addresses national government authorities responsible for climate policymaking and implementation, as well as those responsible for digital government strategies, data management, and knowledge production. Civil society organizations working on climate change action are a secondary audience for this paper and can use the insights provided to better advocate for and support data publication processes.

Research for this paper was conducted in collaboration with the Open Data Charter and the Inter-American Development Bank (IDB). This included the development of a draft guide and typology for opening up climate-related data, which was piloted with government and civil society partners in Chile and Uruguay between August 2019 and August 2020. This publication gathers insights from a literature review, iterative consultations with experts and implementers of open data initiatives, and the pilot projects in these two countries.

Key Findings and Recommendations

Promoting greater accessibility to climate-related data through open data can hold multiple benefits for climate policymaking and action, including:

- **IMPROVED DATA COORDINATION AND QUALITY:** Open data can shed light on heterogeneous use of standards and duplicative investments in data products. It makes the process of data access more efficient and allows users to validate data through practical applications and provide feedback.

  Example: In Chile, the Center for Climate and Resilience Research (Centro de Ciencia del Clima y la Resiliencia; CR2) uses available open data to build nationally-relevant climate models and a platform for easy data access—so easy and reliable, in fact, that even officials from data-producing agencies use it (FIMA 2020).

- **INFORMED DECISION-MAKING:** Open data can help improve the use of data for decision-making by reducing fragmentation, building users' awareness of available data, and facilitating the integration of data from various sources.

  Example: The platform Aclímate Colombia integrates data from several sources, including open government datasets, to help farmers understand and adapt to changing weather patterns (Young and Verhulst 2017). It has enabled research institutes and farmers' associations to make better recommendations regarding planting dates, crop varieties, and other farm practices (Pineda 2017).

- **GREATER COORDINATION AND NOVEL PARTNERSHIPS:** Open data initiatives can be an effective strategy to build trust between actors and foster new collaborations through data applications.

  Example: In the aftermath of the 2016 Aceh earthquake in Indonesia, scientists, local and national government officials, and communities collaborated through the InaSAFE open data platform to identify risks to communities and infrastructure. The shared data and knowledge then equipped disaster managers to better prioritize response and recovery efforts (World Bank 2018).

- **DEMOCRATIZING MODELLING APPROACHES:** Open data can help make climate modelling more transparent, accessible, and context-specific by increasing access to local and national data that can be used to downscale regional or global models.

  Example: In the workshops, Uruguayan government officials reported that generating more observation data on the national ocean territory and making that data accessible in open data format would help calibrate global climate models to the national context.

- **ENHANCED MONITORING OF POLICIES AND PROGRAMS:** By improving accessibility, open data makes it possible for citizens to engage in formal and informal monitoring processes in an evidence-based manner. Open data practices also facilitate the development of indicators to monitor climate actions, while enabling greater accountability of the analysis used to substantiate policy proposals. On national and global stages, these initiatives can further strengthen governments' reporting frameworks under the Paris Agreement by improving mechanisms for knowledge and data sharing across agencies.

  Example: In Spain, the Futuro en Común coalition used multiple open datasets to review the government's progress toward attaining the Sustainable Development Goals (SDGs), including SDG 13 on climate action.

National stakeholders interested in improving the accessibility of climate-related data may encounter various barriers in their efforts to coordinate and implement open data practices. These may include:

- **LACK OF AWARENESS OR MISUNDERSTANDING ABOUT OPEN DATA PRACTICES:** A lack of awareness about what open data means in practice, of the demand for specific types of data, or of the value proposition of open data projects, can lead to a general unwillingness or hesitation to share data. This barrier can be addressed through national agencies with a mandate to work on public information access and digital government. These designated agencies can provide expertise and targeted assistance and follow-up, and assist through collaborative awareness-raising campaigns and events.

  Example: Uruguay's digital government agency provides tailored support to data-producing teams across ministries.

- **TECHNICAL CAPACITY GAPS:** A lack of technological resources and data science skills and capacities may be an important operational challenge facing both data providers and users in some contexts. Even in contexts where such barriers are significant, it is still worthwhile to build awareness of open data practices alongside data management capacities to prepare stakeholders to implement data publication strategies when the time is right. One way to tackle this barrier in the short-term is to foster diverse communities of practice that can encourage

collaboration between actors with complementary capacities. In the long-term, these capacities can be further built through institutionalized training opportunities related to data management and reuse in the context of existing networks or institutional coordination mechanisms, such as national climate change coordination bodies.

Example: The Caribbean Handbook on Risk Management (CHaRIM) fosters regional cooperation to strengthen the collection, management, and sharing of hazard data across the region (CHaRIM 2020; Chrzanowski 2020).

- **LACK OF REGULATORY FRAMEWORKS TO SUPPORT INFORMATION TRANSPARENCY:**
  The lack of access-to-information laws or of clear procedures governing the disclosure of public information can lead to uncertainty and obscure roles and responsibilities in publishing information. Data-holding agencies interested in improving the accessibility of their data can consider establishing an institutional strategy for data publication that clarifies the process, roles, and responsibilities.

  Example: In Sweden, several government bodies jointly developed an Environmental Data Management Strategy to serve as a guiding principle for improving the availability and use of environmental data and information (Swedish EPA 2020a).

- **LACK OF MANDATE OR POLITICAL LEADERSHIP, OR INSUFFICIENT INCENTIVES TO COORDINATE DATA PUBLICATION ACROSS AGENCIES:**
  A lack of clear mandates or sufficient political leadership to bring all relevant stakeholders to the table can also hamper open data processes. Even when technical capacity is available, agencies may not have a culture of data disclosure or may worry that it could reveal performance gaps or data quality issues. It is therefore critical to identify government champions with a relevant role in collecting and managing climate-related data. It may also be helpful to work within existing institutional coordination mechanisms that can legitimize the effort, and to look for opportunities to connect two or more national agendas.

  Example: In Costa Rica, strong support from the Ministry of the Presidency for open data converged with efforts undertaken by the Ministry of Environment to improve the national transparency framework in line with the Paris Agreement. This helped establish institutional arrangements between agencies for continuous data provision and led to the development of the National System of Climate Change Metrics (SINAMECC), an online open data platform for climate-related data (Moya 2019).

Our analysis further identified key factors that can help ensure that open data projects—and data publication efforts more generally—meet users' needs and capacities, serve to strengthen networks and relationships, and are embedded within supportive governance structures for long-term impact and sustainability. These include:

- **CONTINUED ENGAGEMENT AND PARTICIPATION** with data users within and outside of government to build trust and a shared understanding of the value proposition of open data and to enable mutual learning and the continuous improvement of open data initiatives and projects.
- **ASSESSING THE DEMAND** for specific types of data, stakeholders' data-related needs and capacities, and existing delivery platforms to tailor open data efforts.
- **PLANNING FOR AND INVESTING IN COMMUNICATION TECHNIQUES** to promote awareness of the available data and provide new ways for targeted user groups to engage with climate-related data.
- **INSTITUTING SUPPORTIVE GOVERNANCE STRUCTURES** by fostering policy and information coordination across levels of government, encouraging a proactive and entrepreneurial bureaucracy, establishing high-level or cross-sector mandates for data coordination, and ensuring adequate resource allocation for agencies that publish data and those that can support them in doing so.

GLOSSARY OF TERMS

Open data	Digital data published with the technical and legal characteristics to be "freely used, reused, and redistributed by anyone, anytime, anywhere" (Open Data Charter 2020). This means data that are published in technical formats that allow any software or device to read them, and licensed to permit free redistribution and reuse (World Bank 2014).
Climate-related data	Environmental, social, and economic data on the human causes of climate change, the impacts of climate change on human and natural systems, and efforts to mitigate climate change or adapt to its consequences (UNECE 2014).
Data provider	An agency or organization that publishes or otherwise shares data assets it owns.
Data user	An individual or organization that makes use of a dataset.
Data reuse/ reutilization	The application of a dataset for a particular use, like research and analysis, creation of a tool or software, creation of visualizations, etc., other than that for which it was originally intended.
Open data readiness	Capacity to evaluate, design, and implement an open data initiative (World Bank 2019), or to understand and make use of open data.
Proactive disclosure	Instance when a public body purposefully and preemptively releases information, without a request being filed (Excell and Moses 2017).

INTRODUCTION

Tackling the climate crisis poses a singular challenge to governments and societies worldwide—a challenge that is both profoundly urgent and cross-cutting in its impacts and solutions. Heat waves, changing rainfall patterns, rising sea levels, more frequent extreme weather events, and other potentially calamitous climate change impacts affect all social and economic sectors. What's more, planning decisions made in one sector can reduce adaptive capacity or increase risk in another, for instance, by increasing upstream water use in a context of increasing water scarcity (Scobie 2016). Meeting the global goal to keep temperature rise to well below 2°C, and achieving countries' nationally determined contributions toward that goal, are not the sole remit of Ministries of Environment, but call instead for a coherent and coordinated response across government institutions. Additionally, while national governments must play a lead role in setting ambition and taking action, the Paris Agreement clearly establishes that contributions from subnational governments, the private sector, and civil society are crucial for success. The vast transformations needed to mitigate climate change and adapt social and economic systems to its inevitable impacts require autonomous and concerted action across government and society, from parliaments creating legal frameworks to assign roles and responsibilities, to farmers making field-level decisions for the short- and long-term.

The intersections of these problems and solutions makes data sharing and collaboration imperative. Improving the availability and accessibility of climate-related data and information across this range of actors is necessary to build a shared understanding of risks and opportunities. This applies to data types well beyond greenhouse gas (GHG) emissions levels. As the examples throughout this paper illustrate, data needed to make analyses and decisions relevant to tackling the climate crisis span nearly all sectors (see Appendix A for an illustrative, non-exhaustive list). There is a growing body of evidence, drawn from case studies around the world, that open data policies can make government more accountable and efficient, empower citizens to mobilize and participate more effectively, create new economic opportunities, and help lead to solutions for large-scale, difficult public problems (Verhulst and Young 2016). Climate change is one such problem, and open data can support coordinated responses across government and society.

Box 1 | **Defining Climate-Related Data**

In this paper, we use the Conference of European Statisticians' definition referring to climate-related data as "[e]nvironmental, social and economic data that measure the human causes of climate change, the impacts of climate change on human and natural systems, the efforts of humans to avoid the consequences as well as their efforts to adapt to the consequences."

Source: UNECE 2014.

Often, even when climate-related data exists, it is incomplete, fragmented across agencies, or not made available in formats that facilitate its comprehension and reuse (UNECE 2014; U.S. GAO 2015). Improving data accessibility—and ultimately its utilization—beckons to consider new approaches and techniques for data dissemination and access. In this context, open data emerges as a promising approach to streamline data publication and enhance its reach.

Box 2 | **Defining Open Data**

Open data is digital data published with the technical and legal characteristics to be "freely used, reused, and redistributed by anyone, anytime, anywhere."[a] This means data that are published in technical formats that allow any software or device to read them, and licensed to permit free redistribution and reuse.[b]

Notes:

[a] Open Data Charter 2020.

[b] World Bank 2014.

Situating Open Data within Broader Transparency Frameworks

At the global level, the United Nations Framework Convention on Climate Change (UNFCCC) and Paris Agreement laid the foundation for greater transparency of countries' efforts to address climate change. In particular, the Paris Agreement's "enhanced transparency framework" established a common reporting framework for all parties to the Convention as an essential element to track progress toward collective goals, identify support needs, and enable countries to iteratively design more ambitious climate actions (Dagnet et al. 2019a). Reporting under the Paris Agreement spans information and data related to countries' mitigation and adaptation efforts, as well as capacity-building, technology transfer, and financial support provided or received (Dagnet et al. 2019b). The data needs underlying these reporting requirements intersect with those of related international agendas, like the Sendai Framework for Disaster Risk Reduction, the 2030 Agenda for Sustainable Development, and the New York Declaration on Forests.

In this context, open data practices offer an approach to help streamline governments' efforts to fulfill reporting requirements across these global agendas and related national strategies like green growth or coastal resilience. Open data can reduce redundancy in reporting efforts by making data more easily accessible to a wider range of users across government (Badiee et. al 2019). It can also support cross-sector dialogue and information sharing, in support of the consultation processes necessary to design climate policy instruments like Nationally Determined Contributions (NDCs). Just as significantly, open data strategies can help achieve multilateral goals related to public awareness, public access to information, and education put forth in these agreements (notably Article 6 of the UNFCCC and Article 12 of the Paris Agreement). Given the wide-ranging implications of climate change and climate action for social equity, achieving these goals will be critical to ensuring procedural and distributive justice in the collective response to climate change.

Current Challenges and Opportunities

The UNFCCC Secretariat's reports on the implementation of capacity-building in developing countries note several gaps related to the collection, management, and use of data and information for climate action (Dagnet et al. 2019a; UNFCCC 2017; UNFCCC 2018). Country reports highlight challenges in first generating the data necessary to calculate GHG emissions and elaborate GHG inventories, to conduct context-specific vulnerability assessments and develop responsive adaptation measures, to track climate finance, and to develop indicators for mainstreaming gender perspectives in climate action (UNFCCC 2017; UNFCCC 2018). The reports also highlight challenges in effectively managing and sharing data across sectors and institutions. In many cases, existing institutional arrangements do not allow for the timely and efficient flow of information due to, among other factors, lack of mandates to share data across agencies and reliance on informal data sharing mechanisms (Dagnet et al. 2019a). This results in missed opportunities to make use of existing information products across sectors and levels of government, encourage strong linkages between science and policymaking, and raise awareness of the impacts of climate change at both the local and policy levels (UNFCCC 2017; UNFCCC 2018).

In this context, three factors have spurred a growing push to apply the practices and principles of open data in the climate space. First, in post-Paris international climate governance structures, the enhanced transparency framework and greater awareness of the importance of subnational and non-state actors' contributions have highlighted the importance of transparent information to build clarity and trust (Jordan et al. 2018). Second, in the past 15 years, a global movement has coalesced around open data's potential to support innovation, enable public oversight, and advance collaboration between government, the private sector, and civil society tackling key social challenges (World Bank 2014). Efforts to bridge the experience, knowledge, and communities found in these two movements can be seen in the growing number of stakeholder-driven commitments related to open climate data through the Open Government Partnership (OGP), and in the emergence of open-source platforms aiming to facilitate climate action accountability, like Climate Watch,[1] Partnership for Resilience and Preparedness (PREP),[2] and Open Climate.[3] Finally, governments' push to modernize and digitize government data assets is opening up tactical opportunities to ensure these investments enable greater climate data access across a broad range of potential users, both within and outside of government (Brusa 2020).

Ultimately, open data efforts are about developing the capacity and incentives to shift bureaucratic culture toward one of transparency and collaboration. Beyond the value derived from the specific datasets that are made open, an increased familiarity with open data principles and practices can have effects that ripple through an agency's approach to data management and use of information for policymaking (Carranza 2019). An understanding of the value of data sharing can foster knowledge integration and collaborative approaches to data-driven climate action. For this reason, while open data initiatives may seem most immediately relevant in contexts with moderate- or high-data availability, it is just as important to build awareness of and technical capacities for this approach in environments with low-data availability, as it can shape the design of new data collection efforts and structures (GFDRR 2018; World Bank 2016).

Scope and Objectives of This Paper

This paper is intended to serve as a resource for civil servants, policymakers, and other stakeholders to develop a collaborative process to identify priority climate-related data and establish the structures and practices required to make these data open. It provides guidance on how to conduct a bottom-up assessment of priority climate-related data needs and availability, as well as insights for making effective plans to improve data accessibility. In doing so, this paper seeks to build government officials' and other stakeholders' understanding of the benefits of open data principles and practices, the challenges they may encounter in implementing them, and ways to address these challenges while taking steps to ensure that data publication is impactful and sustainable. It draws from the experiences of piloting a typology for mapping existing datasets and their degree of openness developed by World Resources Institute (WRI) and implemented in partnership with the Open Data Charter and national civil society organizations in Uruguay and Chile in 2019 and 2020.[4]

The findings and recommendations are primarily relevant for national government authorities responsible for climate policymaking and implementation, as well as those responsible for digital government strategies, data management, or knowledge production. This paper provides insights for governments with different levels of capacity, from those with mature data collection and publication protocols to those investing in new data generation processes. Civil society organizations working on climate change action, as representatives of data user groups, are also important stakeholders and a secondary audience for this paper. Insights provided here aim to empower them to better advocate for and support data publication processes with new insights and perspectives.

Our focus is on examining how open data practices, as a tool for transparency, can enable greater data accessibility, and its implications for collaborative, data-driven climate action. As such, throughout the paper we focus primarily on data publication and dissemination activities. These are discrete steps in the data value chain, which itself extends from data collection to impact. Conceived initially as a response to emerging efforts to apply open data practices to climate-related data observed in the OGP, and refined through discussions with issue area experts, this paper focuses on data produced by governments, and in particular national governments. This narrowed scope reflects that this project was a small-scale pilot, but the methodology could be adapted to subnational governments as well. Several of the benefits, barriers, and suggestions discussed, however, are also applicable to other data producers, such as subnational government entities, academic and research institutions, businesses, and international organizations. This is particularly important in the case of climate change analysis and policymaking, as the data involved span a wide range of producers, sectors, and spatial and temporal scales, and because climate-related data is sometimes highly privatized (e.g., in the case of data reported through voluntary reporting platforms).

Other crucial steps in the data value chain include data collection, processing, verification, curation, and analysis. As noted above, there are critical gaps in the generation of accurate, reliable, and high-quality data for climate analysis and decision-making. While issues regarding data generation are extremely important, they fall outside the direct scope of this paper.[5] Instead, we focus on how to develop a collaborative approach—involving data producers and users within and outside of government—to implementing open data practices for climate-related data.

METHODOLOGY

This publication combines insights from a literature review, iterative consultations with experts and implementers of open data approaches for climate-related data, and pilot projects to guide stakeholder-driven data publication processes in Chile and Uruguay (see Appendix A for a description of the project activities in both countries).

The literature review explored the benefits of and barriers to implementing open data approaches for climate-related data, as well as the ways in which governments are developing mechanisms to enable data sharing and use in support of climate objectives. It encompassed English- and Spanish-language peer-reviewed articles, institutional reports, and project notes focused on climate governance and transparency, climate-related data generation, dissemination, and use, and open data implementation.

Between February 2018 and July 2019, the authors worked closely with 20 WRI experts with experience in data governance and applications in various sectors. These consultations helped refine the analytical approach and develop a non-exhaustive list of climate-related data types (see Appendix A), which was used as input for the pilot projects in Chile and Uruguay, as described below. Through a side event at the International Open Data Conference in Buenos Aires in September 2018, we gathered further feedback and insight from 20 government representatives and civil society practitioners from various countries. A questionnaire circulated through the OGP and informal interviews with five practitioners identified through both this questionnaire and the pilot projects provided further examples and insight into the opportunities and challenges associated with open data practices for climate-related data management.

This paper also draws from activities implemented in Chile and Uruguay by the project partners to pilot a draft guide for opening up climate-related data. The selection of these two countries was determined by the geographical focus of the funder (the Inter-American Development Bank, IDB) and by the presence of government interest and opportunity to work with both the environment ministries and digital government agencies. These activities tested a process for evaluating the current degree of accessibility, or openness, of various climate-related datasets and fostering dialogue between key stakeholders to identify opportunities for improving their openness in the short- and long-term. The discussions provided

deeper perspectives on the governance of climate-related information in these countries, how relevant stakeholders view the opportunity of open data approaches, and the factors facilitating or impeding implementation of these approaches. By engaging with various data producers and potential users, the pilots sought to answer questions like: Who generates which types of climate-relevant data? How are these accessed and disseminated? What are current gaps in the generation and/or sharing of different data types? What are the most important climate risks and associated socio-economic impacts at regional, national, and local levels, and which types of information are needed to address them? Table 1 summarizes the major questions and action points that shaped these discussions, as well as the organizations that participated in the activities.[6]

We recognize that the results of the pilot activities in these two countries are not generalizable on a global scale. The insights from these activities, as well as country-specific perspectives gathered through the informal interviews and questionnaire, are used to illustrate broader points emerging from the literature review. To the extent possible, we sought to identify additional examples and insights from literature based on experiences in other parts of the world. Nevertheless, future research could seek to explore these same questions with an explicit geographical focus in other regions.

Table 1 | **Summary of Workshop Participants and Major Discussion Questions**

	CHILE	URUGUAY
Organizations involved in the workshop (and interviews, in case of Chile)	**Government**: National Forestry Commission (Corporación Nacional Forestal, CONAF); COP 25; Ministry of Environment; National Statistics Institute; Ministry of Energy; General Directorate of Civil Aeronautics; Directorate of Meteorology; Ministry of Science; Ministry of Health; Ministry of Housing and Urbanism; Superintendence of Sanitary Services; Ministry of Transport and Telecommunications; Digital Government Division **Civil society and private sector**: University Student Congress for Sustainability; Center for Climate and Resilience Research; Food and Agriculture Organization; Fiscalía del Medio Ambiente (FIMA); National Agriculture Society; Wildlife Conservation Society; WWF; Greenpeace; Asociación Interamericana para la Defensa del Ambiente (AIDA)	**Government**: Ministry of Housing, Land Use Planning, and Environment; National System of Emergency; Ministry of Energy, Industry, and Mining; Office of Planning and Budget; Uruguayan Institute of Meteorology; National Secretariat for Environment, Water, and Climate Change; Agency for Electronic Government and Information and Knowledge Society; Ministry of Livestock, Agriculture, and Fisheries; Ministry of Tourism and Sports **Civil society and private sector**: SARAS Institute; Union of Exporters of Uruguay; DATA Uruguay; Adagio Consulting; Jugando en la Naturaleza (JULANA); National Commission for Rural Development
Key questions shaping the discussions	▪ What role can greater data accessibility play in improving public policy design and monitoring? ▪ How can the private sector and academia be better engaged in discussions around data accessibility? ▪ How can open data help address issues of interconnectivity and interoperability across data sources? ▪ What are the capacity-building needs among data producers and users in order to ensure that high-quality data is published consistently and used in accordance with its limitations? ▪ How could a common regulatory framework support data generation and publication processes across sectors? ▪ What are the possible risks of data publication and how can these be reduced? ▪ How can data be more accessible to citizens for decision-making on climate and environmental issues in their territories and communities?	▪ What types of data should be considered priority for publication, given national priorities, expected climate impacts, and potential for reuse? ▪ How can greater data accessibility strengthen policy design and project results and contribute to transparency efforts in relation to climate change? ▪ How can publication of data in open formats be aligned with and contribute to the development of the public measurement, reporting, and verification (MRV) system for the Nationally Determined Contribution? ▪ How can efforts to open data help improve the frequency of data updates? ▪ How can open data help address issues of interoperability and redundancy across data sources? ▪ What regulatory measures are required in order to update or revise data classification and access policies?

Table 1 | **Summary of Workshop Participants and Major Discussion Questions (Cont'd)**

	CHILE	URUGUAY
Policy frameworks mentioned in relation to data publication	Transparency and Access to Public Information Law (20.285), Lobby Law (20.730), Proposed Climate Change Bill (in Senate)	National Climate Change Policy (Executive Decree 310/017), Escazú Agreement (Regional Agreement on Access to Information, Public Participation, and Justice in Environmental Matters, ratified by Uruguay in September 2019)
Key changes identified to improve data openness	▪ Improve interministerial coordination with regards to data management—for example, through the Interministerial Technical Team on Climate Change ▪ Reinforce a regulatory framework to guide the coordination of data across sectors ▪ Invest in building human and technological resources ▪ Reinforce feedback loops between data users and producers, as well as quality assurance processes ▪ Continue to hold opportunities for discussion and collaboration, including with a broader range of stakeholders, to build deeper awareness of issues related to data openness and pave the way for more tangible progress	▪ Improve interministerial coordination, including initiatives to promote better awareness of the standards and methodologies for data collection across sources ▪ Invest in building human and technological resources ▪ Generate or strengthen channels for communication and public participation, to promote citizens' appropriation of data and climate issues more broadly ▪ Continue to hold opportunities for discussion and collaboration, including with a broader range of stakeholders, to build deeper awareness of issues related to data openness and pave the way for more tangible progress

Source: WRI authors.

The following sections gather insights from these various sources to summarize the principal benefits of open data for climate action (Section 3), the main types of barriers encountered in efforts to open climate-related data and suggestions to address them (Section 4), and suggestions for setting up open data initiatives with the governance structures to enable sustainable impact (Section 5).

BENEFITS OF OPEN DATA STRATEGIES FOR CLIMATE ACTION

Promoting greater accessibility to climate-related data through open data techniques and practices can hold multiple benefits for climate policymaking and action across sectors and at national and subnational levels. This section summarizes these benefits in broad categories, providing examples reported in the literature or collected through consultations with national stakeholders.

Improved Data Coordination and Quality

Opening up datasets can improve quality control by enabling a wider variety of users—some of whom may be subject area experts—to scrutinize data quality and consistency. Indeed, the users of open datasets can validate the data through practical applications or provide concrete feedback on how dataset quality or relevance may be improved (GovLab 2018; Verhulst and Young 2016). For instance, users can point out where there is inconsistent use of common formats across datasets or when the periodicity of data updates is inadequate for specific applications, like climate risk modelling (GovLab 2018). Additionally, both the publication of data and stakeholder engagement centered on data access can shed light on heterogeneous standards and costly duplication of investments in data information products, sometimes within the same institution (Venkateswaran et al. 2018; Chrzanowski et al. 2020). Given that many datasets used in climate change analysis are geospatial, standardized geocodes and spatial scaling are particularly important to allow comparison across datasets and processing with various software. Pointing out areas for improvement in data comparability and in the efficiency of data collection were seen as very valuable outcomes of data publication efforts during the workshops organized in Chile and Uruguay in the context of this project.

In addition to helping improve the quality of the data itself, publication in open formats can help make the process of data access more efficient, improving users' experience. Data is proactively disclosed (i.e., not requiring the user to submit a request form) and available in formats readily used in analysis, visualizations, and more. This is especially significant when it helps make the data

accessible to users who do not have the time or resources to go through lengthy bureaucratic information request processes (FIMA 2020; Lizbona Cohen 2019; Pastorino 2019). Civil society stakeholders in Chile, for example, cited instances of searching through statements and presentations given by government officials to track down the most recent water data. They also identified complex data access processes as a reason behind the lack of appropriation and use of climate information by groups facing climate risks at the local level (FIMA 2020).[7] On the other hand, the availability of open data has enabled the research institute CR2 to build nationally-relevant climate models and create a platform for easy data access, used even by government officials from data-producing agencies (FIMA 2020). By streamlining data coordination and publication processes, open data platforms like CR2's can help maintain the accessibility of datasets when frequent changes in bureaucracy could otherwise delay data access (Venkateswaran et al. 2018).

The process of developing projects with an open data component can also improve the quality of internal data management and use by data collecting agencies (Carranza 2019). This is often due to the open data initiative alerting different departments within an agency of the existence of the data, or of the elimination of bureaucratic data request processes (Carranza 2019). For instance, the development of the Forest Ecosystem Management System decision support tool by the United Nations Development Programme (UNDP) and the General Directorate of Forestry in Turkey helped the contributing agencies improve the quality and coordination of the shared datasets (Ozbagdatli 2019).

Informed Decision-Making

Open data efforts can also help improve the use of data for decision-making by reducing fragmentation, building users' awareness of available data, and facilitating the integration of data from various sources.

Organized and systematic data publication can reduce data fragmentation by centralizing access, and therefore contribute to building users' awareness of available data. This is very significant because a frequently reported challenge in incorporating climate-related data in decision-making and analysis is knowing what data are available, in what formats, and where or how to access them (Lizbona Cohen 2019; Morales 2018; Ryan and Bustos 2019; Shakya et al. 2018). This was mentioned by stakeholders in Chile and Uruguay and was noted by the Conference of European Statisticians in calling for the need to promote better awareness of existing statistics to improve their use in climate change policy and analysis (UNECE 2014). A civil society stakeholder in Chile, for instance, noted that much of the information useful for climate change research and programs is sectoral and not tagged as "climate change related" information; therefore, intuitive systems for data discovery and access are very important (FIMA 2020). Similarly, the workshop discussions in Uruguay highlighted the example of territorial ocean data, which would be critical for downscaling global climate models but are not currently used for this purpose because they are scattered and not easily accessible.

Strengthening the availability and accessibility of relevant and timely climate-related data is not only important for informing climate policymaking, but is also key to mainstreaming climate risk and climate targets in sectoral planning, a process that is essential to tackling the climate crisis on the scale and at the pace required. Experiences around the world show that access to credible information is integral for successfully mainstreaming climate adaptation (Mogelgaard et al. 2018; Tye et al. 2020). For this reason, Action on Climate Today's work on water management in South Asia has focused heavily on obtaining and communicating data while strengthening institutional systems to encourage the delivery and use of timely evidence (Venkateswaran et al. 2018). Similarly, the Global Commission on Adaptation points to the need to make credible data and modeling technologies available to cities in order to incorporate climate risk information in the planning and delivery of urban services (Global Commission on Adaptation 2019).

The ability to integrate data from various sources is necessary not only to mainstream climate action across sectors, but also to proactively address its equity dimensions. This requires identifying groups who may be affected negatively (or positively) by specific climate impacts and by proposed adaptation measures (Bouyé et al. forthcoming). Depending on the context and policies in question, it may also require socially-disaggregated vulnerability and climate risk assessments, ex ante analyses of the socioeconomic and distributive impacts of climate policies, and/or ex post evaluations of effects on specific groups' vulnerability (Bouyé et al. forthcoming). All these analyses would benefit from the integration of data and knowledge across sectors and disciplines.

Box 3 | **Integrating Climate and Social Vulnerability Analyses with the Help of Open Data**

Climate Just is a tool that integrates open datasets from various sectors to support the delivery of equitable responses to climate change at the local level in the United Kingdom.[a] Its main objective is to assist in the development of socially just responses to the impacts of extreme events like flooding and heatwaves.[b] The tool combines open government and academic data with various communications approaches and case studies to allow users—especially public service providers—to explore how social vulnerability may interact with climate impacts and develop ideas for socially just adaptation strategies.[c] For instance, data from Climate Just was uploaded by the Greater Manchester Combined Authority into its own interactive mapping system and used to invite residents and developers to identify sites potentially suitable for development. Datasets from Climate Just and other sources, including local data, were then used to analyze the sustainability and vulnerability of the proposed sites.[d] Data from the platform was also used by the city's Fire and Rescue Service to quantify exposure and vulnerability to flooding in two boroughs, enriching its analysis with social factors affecting households' vulnerability and ability to prepare.[e]

Notes:

[a] Lindley et al. 2014.

[b] Lindley et al. 2014.

[c] Lindley et al. 2014.

[d] Climate Just 2020a.

[e] Climate Just 2020b.

On the other hand, a lack of adequate data sharing and dissemination mechanisms can hamper the uptake of knowledge and information products for decision-making, and thus pose an obstacle to the mainstreaming of climate policy across sectors (Ryan and Bustos 2019; Venkateswaran et al. 2018). For example, a diagnostic on the use of knowledge for adaptation planning in Costa Rica found gaps in the transfer of information and a lack of cooperation between the public sector, academia, and private sector in producing data and knowledge for climate adaptation. Many of the recommendations proposed by the survey respondents who contributed to the diagnostic focused on improving information sharing to enhance adaptation planning (Morales 2018). Similarly, the Conference of European Statisticians recommended improving the accessibility and awareness of existing statistics as a way to address the disconnect between climate-related statistics across agencies (UNECE 2014).

The above is true not only for decision-making in the public sector, but also among citizens and the private sector. Informing citizens to enable their effective participation in decision-making was indeed identified as one of the primary expected benefits of open data by participants in the workshop organized in Chile. Open data can help citizens be better prepared for formal public participation processes, making these processes more effective. Improving the accessibility of reliable data can also inform citizen and civil society engagement around climate change outside of formal consultation processes, improving the quality of public debate (Shakya et al. 2018). Accessible and reliable data can additionally help build local organizations' ability to produce trusted information from the raw data (Shakya et al. 2018). Both government and civil society stakeholders in Chile expressed the importance of linking the data—whether it is through how it is collected or how it is communicated—to the problems communities face at the local level, like water scarcity, so they will be better able to use the information to advocate on climate issues (FIMA 2020).

Greater accessibility of reliable data can also reduce uncertainty about projected climate impacts as well as climate policies and programs, enabling citizens and the private sector to make better political and economic decisions (FIMA 2020). Accessible and consistent information regarding climate policies and their enforcement mechanisms can provide the long-term regulatory certainty that the private sector needs to implement ambitious climate actions (Metzger et al. 2018). As with public sector actors, having access to relevant data also helps the private sector mainstream considerations of climate risk in their operations. For instance, the International Center for Tropical Agriculture (CIAT) developed the platform Aclímate Colombia by integrating data from several sources—including open government datasets—to help farmers understand and adapt to changing weather patterns (Young and Verhulst 2017). CIAT has used the platform to train farmers from two national associations on the use of climate forecasts for farm-level decision-making. The data and related information products, accessible on the platform, enable CIAT and the farmer associations to make better recommendations regarding planting dates, crop varieties, and other farm practices (Pineda 2017). As another example, Mars, among other companies, uses the open data platforms Aqueduct[8] and Global Forest Watch (GFW)[9] to set science-based corporate sustainability targets and track progress metrics. The company uses Aqueduct and GFW data to evaluate water and deforestation risks in its supply chain and set context-specific targets to reduce water consumption and deforestation (Amaral and Steer 2017; WRI 2020).

Enabling Collaboration and Novel Partnerships

Open data efforts can be an effective strategy to promote greater coordination and collaboration between actors. This is particularly important in the context of climate action, given the interdisciplinary nature of solutions and the vast range of actors who have a role to play in implementing them. Open data can achieve this by promoting the function of effective and timely information flows in building a collective understanding of risks and priorities, which in turn sustains networks and coalitions for climate action (Shakya et al. 2018). For instance, InaSAFE is a free software that combines open hazard exposure data from the Indonesian government, academia, and disaster management organizations with crowdsourced data to assess the possible impact of disaster events on a community, its assets, and local infrastructure. When the Aceh earthquake hit Indonesia in 2016, the sharing of data and analysis by scientists, local and national governments, and communities through the InaSAFE platform improved the ability of disaster managers to prioritize response and recovery efforts (World Bank 2018).

Furthermore, the process of developing open data projects can spark coordination and build trust by engaging stakeholders in new conversations around data use and availability, such as workshops or other participatory activities to assess data demand. In this way, the relationships established through the development and maintenance of open data initiatives could hold a significant benefit for climate policy development processes, like NDC enhancement and long-term strategy formulation, for which compiling the necessary datasets requires high degrees of trust and coordination between agencies.[10] In Uruguay, the publication of climate-related datasets in the context of the country's monitoring, reporting, and verification (MRV) program and activities undertaken for this project generated the opportunity to collaborate with a fiscal transparency initiative under the Ministry of Finance. The Ministries of Environment and Finance, along with the national digital government agency (Agencia de Gobierno Electrónico y Sociedad de la Información y del Conocimiento, AGESIC) and IDB, co-hosted a hackathon to promote data reutilizations related to climate change, including climate finance data. (See Box 4 for more information on Uruguay's MRV Program.)

Once data is published, it can help sustain novel partnerships and innovative data uses (GFDRR 2018; World Bank 2016). This is crucial considering that climate change analyses—like downscaling global climate models, assessing climate risks in diverse systems, and estimating the possible effects of specific mitigation and adaptation actions—can require complex techniques and specialized knowledge. As national and local governments currently face a shortage of this technical expertise, collaboration with academia and the private sector, founded on the exchange of comparable and interoperable data, is crucial (UNFCCC 2017). Illustrating this point, the Climate Risk Atlas in Chile is an initiative led by academia but coordinated by the Interministerial Technical Team on Climate Change. At a global scale, the Open Climate Project leverages existing databases and the collective intelligence of a multitudinous range of collaborators around the world to explore blockchain technology applications for climate accounting (Open Climate Collabathon 2020).

New collaborations within government can also bring specific technical expertise to climate analysis. Experiences shared through multilateral spaces like the Expert Group on Environment Statistics (EGES) point to the importance of enhancing collaboration with national statistical organizations (NSOs) who can provide not only data but also expertise and resources to enhance the accuracy and usability of information generated for reporting (EGES 2018). NSOs, for instance, can provide critically needed expertise for compiling GHG inventories and generating projections of GHG emissions and removals under different policy scenarios. Data publication strategies can provide one avenue for strengthening these collaborations.

Further, open data initiatives can play a very significant role in enabling collaborations between actors with specific data analysis expertise and actors who represent the needs of affected communities. This is particularly crucial for the design and implementation of climate change adaptation measures. Given that climate change impacts and communities' adaptation needs can be highly specific to each location, responses must integrate both local knowledge and complex information tools, like climate risk assessments and climate impact scenarios. Partnerships are then needed to make the information actionable for affected communities. For example, in Malabon City in the Philippines, Partners for Resilience (PfR), a coalition of international NGOs and civil society organizations from the Global South, leveraged information from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA) to build residents' awareness of flood risks (Tye et al. 2020). PfR printed flood risk maps on large tarpaulins posted at strategic locations in the city. It also trained local officials on community-based

disaster risk management and worked with the local government to adapt the warning information provided by PAGASA to the local context (Arcilla 2015).

Finally, the nature of climate change impacts makes facilitating collaboration across jurisdictional boundaries another important potential benefit of open data. The UNFCCC's Subsidiary Body for Implementation notes that "[forming] and using regional and international networks for information sharing and cooperation can help better tackle climate change related issues that are often transboundary, including the adaptation and management of water systems and marine areas, climate resilience, and integrated risk assessment" (UNFCCC 2018). In the example of flood risk management in Malabon City mentioned above, the fact that ecosystems and river basins cut across city boundaries has hampered the implementation of ecosystem-based risk management approaches, such as mangrove restoration (Tye et al. 2020; Arcilla 2015). Stronger collaboration necessitates a shared understanding of ecosystem- and watershed-level risks. In this context, project implementers note the positive effect of PAGASA's river basin approach to flood mitigation (Arcilla 2015).

Democratizing Modelling Approaches

An additional advantage of open data that is particularly relevant for climate policymaking is its contribution to improved, accessible, and accountable modelling. Modelling exercises are crucial for climate change analysis and decision-making, from creating scenarios of future climatic conditions to estimating risks of particular climate-related hazards (such as flooding and drought) and generating credible projections of future GHG emissions. Data availability and transparency is critical to building context-specific models that are trusted and reliable and can be effectively used in national, sectoral, and local planning. Open data can enable greater scrutiny and comparison of model results, in turn allowing for greater accountability of the decisions made using modelled data (UNDRR 2019).

The recent availability of satellite data made openly accessible by the United States Geological Survey/NASA and the European Space Agency through the Landsat and Copernicus programs has enabled a boom in scientific research and aided the generation of models in parts of the world where local data are scarce (UNDRR 2019). For example, NASA collaborated with the Rwanda Environment Management Authority to forecast land-use changes up to 2030 and pinpoint critical areas for enhanced wetland protection (NASA DEVELOP 2017).

Open data is also critical to democratizing modelling and catalyzing new projects, which can help bridge the usability gap of larger-scale models (UNDRR 2019; GFDRR 2018). Ensuring access to national- and local-level data enables national and local modelers to downscale larger-scale climate models. In this way, open data provides the incentives and means for various stakeholders—from public and private sectors, academia, and civil society—to build context-specific models to fit particular decision-making needs (UNDRR 2019). For example, government stakeholders who participated in the Uruguay workshop noted that generating more observational data on the national ocean territory and making it accessible in open data format would help calibrate global climate models to the national context. In Chile, the research institute CR2 has created climate simulations at the national and regional level using, in part, publicly accessible global and national datasets. These models, as well as other data made available through CR2's platform, are widely used by Chilean stakeholders from all sectors, including government. Finally, open data promotes collaborative and transparent risk management by enabling other technological approaches, such as open source risk modelling tools and machine learning applications for disaster risk management (GFDRR 2018; UNDRR 2019).

Given the systemic, multidimensional impacts of climate change and potentially of policy responses, the models used to facilitate decision-making should be based on trusted, accurate, and reliable data (GAR 2019). Open data can contribute to strengthening the accountability of modeling exercises by allowing scrutiny of the underlying datasets' provenance and processing (GAR 2019).

Enhanced Monitoring of Policies and Programs

Open data initiatives can play an important role in enhancing the monitoring of climate policies and programs. By improving the accessibility of relevant data and information, open data initiatives make it possible for citizens and civil society groups to engage in formal and informal monitoring processes in an evidence-based manner. For instance, in Bangladesh, the availability of a public climate change budget[11] allowed a coalition of civil society organizations and journalists to come together to review the budget allocations and propose recommendations (Shakya et al. 2018). Their recommendations were subsequently discussed in a dialogue hosted by the Secretary of Finance and Secretary of Environment, and plans were put in place to adopt some of the recommendations, including the establishment of a monitoring task force (Allan et al. 2019). In Spain, a coalition of civil society organizations used multiple open datasets to review progress made by the government toward the attainment of the Sustainable Development Goals (SDGs), including SDG 13 on climate action. The review was undertaken as a complement to the official reporting process and comments on the government's performance on matters related to CO_2 emissions reductions, energy transition, and natural resource conservation (Futuro en Común 2018). The data used included open national and regional datasets related to waste management, CO_2 emissions, energy poverty, renewable energy consumption, water use, air quality health impacts, and more (Futuro en Común 2018).

Open data initiatives can also contribute to strengthening governments' monitoring and reporting frameworks under the Paris Agreement by improving mechanisms for knowledge and data sharing across agencies and levels of government (Comstock 2018; Dagnet et al. 2019a; Scobie 2016). In Costa Rica, the Climate Change Directorate expects that the strengthened relationships and institutional arrangements that resulted from development of the National System of Climate Change Metrics (Sistema Nacional de Métricas de Cambio Climático, SINAMECC) open data platform will facilitate the country's transition to new reporting procedures under the Enhanced Transparency Framework (Moya 2019).

Box 4 | Developing an MRV Program for the National Climate Change Policy and NDC in Uruguay

In Uruguay, the National Climate Change Policy adopted in 2017 calls for all plans, programs, and projects for climate change mitigation and adaptation to be subject to an "annual, reliable, transparent, timely, and comparable" monitoring system.[a] On the basis of this policy, the National System for Response to Climate Change (Sistema Nacional de Respuesta al Cambio Climático, SNRCC) is preparing an MRV program to track progress of the measures implemented to attain the country's NDC. The system will also enable users to track each measure's gender impact, contribution to other SDGs, and a mapping of all actors involved in its implementation and monitoring.[b] In developing this program, the Ministry of Environment is working with open data approaches and collaborating with AGESIC, the agency responsible for supporting the government's transparency policy and open data portal. The program is seen as contributing to the transparency of climate action and the fulfillment of the country's commitments under the Paris Agreement.

Notes:

[a] Ministerio de Ambiente 2017.

[b] SNRCC Uruguay 2020.

Similarly, open data initiatives can make data available to facilitate the development of indicators to monitor adaptation actions, which are necessary to refine existing adaptation programs, make the case for investing in adaptation, and allocate resources most effectively. For instance, the development of indicators to track the National Adaptation Plan for Cities in Uruguay relied on open and available data whenever possible (e.g., on urban land use and water infrastructure), which was easier to acquire and use in the analyses than data that had to be requested (Pastorino 2019).

Another important area of monitoring that open data can facilitate is the monitoring and evaluation of climate funds. Given the scale of finance needed to meet global mitigation and adaptation objectives, there is a need for mechanisms to track the flow and use of climate funds (UNFCCC 2017). In Colombia, the government has established an open data platform to track public and private climate finance flows at the project level, allowing

government officials, citizens, and other stakeholders to better understand how climate funds are being invested (Dagnet et al. 2019a). Similarly, open data practices can enable the accountability of analyses and research products used to substantiate policy proposals (De Pinto et al. 2017; Jairaj et al. 2016). The publication of data used to elaborate energy efficiency standards, for instance, enables third-party verification and ultimately greater public confidence in the standards and labels (Jairaj et al. 2016). On the other hand, a lack of publicly available data prevents awareness of the analyses underlying policies and programs. This concern was highlighted by stakeholders in Chile, who noted that a lack of data transparency can make it difficult to trace the analyses and information products generated by consultants.

Beyond the benefits resulting from improved accessibility to specific datasets, an important contribution of open data efforts is building the awareness and capacity of actors across the data value chain to manage data differently (Carranza 2019). An increased familiarity with open data principles and practices can have effects that ripple through an agency's approach to data management and use of information for policymaking. Therefore, while data publication efforts may be most immediately relevant in contexts with moderate- or high-data availability, it is just as important to use open data principles for awareness and capacity-building in environments with low-data availability, as it can shape the design of new data collection efforts and structures (GFDRR 2018; World Bank 2016). For instance, in Togo, the FUNES tool was developed by the Red Cross to enable better flood risk forecasting and community preparation. While the development of the tool required extensive data collection and crowdsourcing efforts given low initial data availability, it sparked new reflections in the national disaster risk reduction platform on how data validation and sharing could benefit other ministries (World Bank 2018).

In Sierra Leone, multistakeholder efforts were credited with enabling improved mapping and sharing of health care data during the 2014 Ebola outbreak (World Bank 2015). A few years later, with the support of international partners, the government of Sierra Leone mapped over 28,000 water points across the country to assess functionality and gather feedback from users, then established a mechanism to update these data, making it downloadable and reusable (Government of Sierra Leone 2020). These measures took place even as the government was developing the technical capacity to collect, interpret, and standardize data.

OVERCOMING BARRIERS TO OPENING UP CLIMATE-RELATED DATA

National stakeholders interested in improving the accessibility of climate-related data may encounter various barriers in their efforts to coordinate and implement open data practices. This section describes the broad types of barriers identified in our research and provides examples of the ways in which projects around the world have sought to address them.

Lack of Awareness or Misunderstanding about Open Data Practices

One of the most common barriers encountered by open data initiatives, and data sharing efforts more broadly, is resistance or hesitation from data producers engendered by a lack of awareness of open data principles, of the demand for specific types of data, or of the value proposition of open data projects (GovLab 2018; Morales 2018; Scobie 2016). This challenge was frequently referenced in the workshops organized in both Chile and Uruguay. Additionally, data producers may be unwilling to publish data for fear of exposing flaws in the datasets or to avoid negative scrutiny (GovLab 2018; Venkateswaran et al. 2018). They may also be concerned that data will be misinterpreted or misused. For instance, Action on Climate noted that in its climate-resilient water management program in India, some departments were hesitant to share their data as they feared they would be asked to help clean gaps (Venkateswaran et al. 2018).

Strategies to address this barrier

Where there are national agencies with a mandate and expertise to work on public information access and digital government, they can provide tailored advice and support to data-producing departments to build their awareness of the steps involved in data publication and their capacity to prepare datasets for publication. While this strategy can be labor-intensive, it builds trust and capacity in the long-term, which are essential to ensure that open data initiatives create sustainable impact. These supporting agencies can also be a crucial partner in data coordination activities implemented through inter-institutional coordination mechanisms, like mapping metrics for NDCs. For instance, AGESIC, the agency responsible for overseeing Uruguay's digital government and information transparency policies, provides this kind of tailored support to data-producing teams across ministries and to the Climate Change Directorate in the context of the MRV program.

More collaborative, group-focused awareness-raising events can also help address this barrier, while requiring less time and human resources. They have the additional benefit of surfacing the common challenges that diverse stakeholders face in accessing and/or publishing data (GovLab 2018). Both workshops organized in the context of this project, which gathered stakeholders from a wide range of government agencies and prioritized discussions in interdisciplinary groups, had this effect. Another example comes from the Open Data for Resilience Initiative (OpenDRI), which has used experiential learning games to engage diverse stakeholders in the city of La Plata, Argentina, around collaborative urban flood risk management (World Bank 2018). Through simulations of flood scenario responses, the game familiarized participants with the use of disaster risk management tools, highlighting the importance of free and open source software and the need for open data to drive shared analysis and negotiation (World Bank 2018).

Another way to tackle lack of awareness is to engage data providers at all stages of open data projects and data reutilizations to build trust and greater understanding of the value of data publication (Venkateswaran et al. 2018; World Bank 2018). Allowing data providers to play a role in the development of projects that use their open data builds greater buy-in for those particular applications and a greater understanding of the value proposition of data publication that can carry over to their approach to data management in general. For example, in developing the Mahanadi Flood Forecasting Model in Odisha, India, the Action on Climate Today team engaged the state's Water Resources Department very early on to establish project ownership. It also engaged the various agencies whose data were needed for the model in multiple iterations, including technical steps like data recalibration and continuous collection, correction, sanitization, and recollection. Finally, it held multiple rounds of discussions to build confidence in the proposed methodology and effectiveness of the modelling, even before starting to work on the model itself. The model was subsequently approved by the principal secretary of the Water Resources Department and the chief minister of Odisha, and it is currently being implemented and improved upon by the department (Venkateswaran et al. 2018).

In Costa Rica, a new project to create a tool to prioritize nature-based approaches for biodiversity conservation and sustainable development, led by the Ministry of Environment and UNDP, kicked off with a gathering of data producers and managers from numerous agencies. This project has not only helped identify potential data sources and build greater buy-in for the project, but has also facilitated discussions about the challenges that data producers face in managing and sharing data (Monge 2019).

In engaging with data providers, it could also be helpful to frame open data projects as a constructive opportunity to support the data-providing agencies in cleaning datasets, ultimately making data more valuable for both internal and external users. In the process, it is crucial to engage data providers around the importance of proper documentation of metadata as a way to mitigate risk of misinterpretation or misuse of the data (World Bank 2014).

Technical Capacity Gaps among Data Producers and/or Users

A lack of technological resources and of data science skills and capacities may be an important operational challenge facing both data providers and users in some contexts (GovLab 2018; Morales 2018). This deficiency, mentioned by stakeholders in both Chile and Uruguay, could include a lack of hardware or software platforms, technical literacy, and capacity to use common standards or to clean datasets. While it may not necessarily result in the failure of open data projects, it could delay their development and limit their ultimate impact (Verhulst and Young 2016). Even in contexts where such barriers are significant, it is still worthwhile to build awareness of open data practices alongside data management capacities to prepare stakeholders to implement data publication strategies when the time is right.

Strategies to address this barrier

One strategy to address this barrier, with benefits beyond capacity-building, is to foster diverse communities of practice by encouraging collaborations between actors with complementary skills and capacities (GFDRR 2018; GovLab 2018; World Bank 2018). Such communities of practice can include both data providers and users across public, private, and civil society sectors. For instance, in OpenDRI projects, fostering communities of practice and networks of local stakeholders around the crowdsourcing of data for disaster risk management (DRM) has helped build stakeholders' capacity to apply open data for DRM applications (GFDRR 2018; World Bank 2018).

Because they bring substantial data management expertise, NSOs can have a big role to play in such communities of practice. Moreover, NSOs are well-placed to facilitate dialogue on data quality and interoperability and contrib-

ute to strengthening foundational factors like data literacy and data protection, all of which can help ensure that data from various sources can be integrated in knowledge creation (Fritz et al. 2019; MacFeely 2019).

The transboundary nature of climate change also presents the opportunity to work regionally to build data management capacities, especially with regards to data of common interest, like natural hazard risk data in the Caribbean and Amazonian land-use data in South America. The Caribbean Handbook on Risk Management (CHaRIM), for instance, has fostered regional cooperation to strengthen the collection, management, and sharing of spatial data related to landslide and flood hazards (CHaRIM 2020; Chrzanowski 2020). The Latin American and Caribbean Initiative for Sustainable Development (ILAC) Working Group on Environmental Indicators also supports cooperation and capacity-building to increase the availability of and access to environmental data and information (Forum of Ministers of Environment of Latin America and the Caribbean 2018). Exchanges between technical staff facilitated by the Latin American Network of GHG Inventories (RedINGEI) and the Global Support Programme have also been noted to help develop a common approach to managing data of regional significance in Latin America (FIMA 2020).

To promote effective uptake and reuse of open datasets, it is also critical for data providers to meet users where they are. Implementers of open data projects should assess stakeholders' open data readiness (i.e., their capacity to understand and use open data) and link data publication processes with appropriate collaboration and communication techniques (Verhulst and Young 2018). Such techniques may include data visualizations, web platforms, social media communication channels, or applications (World Bank 2018).

Beyond navigating capacity-gaps in the short-term, it is important to take steps to build long-term capacity to design and make use of open data projects. Proactive steps should be taken to identify capacity gaps, whether related to human resources, knowledge, or data infrastructure, and to make the case for resource allocation. It may also be useful to institutionalize training opportunities related to data management and reuse in the context of existing networks or institutional coordination mechanisms, like national climate change coordination bodies. Integrating such efforts in the activities of existing coordination mechanisms may ensure the continuity of capacity-building and awareness-raising efforts, while reinforcing relationships between actors. Stakeholders in Chile, for instance, saw an opportunity to deepen actors' awareness and knowledge of open data practices through the existing climate change coordination mechanism.

Lack of Regulatory Frameworks to Support Information Transparency

While the majority of countries[12] have enacted legal frameworks that establish rights and rules for accessing information held by public authorities (commonly referred to as "Right to Information" laws), some may have been developed prior to the open data movement or otherwise lack clear statements on how data should be shared or disclosed. Additionally, early access to information laws primarily established rights for information disclosure by request while the movement towards "open by default" or proactive disclosure has come about more recently (Excell and Moses 2017). Whether through new laws or amendments to existing laws, a clear legal framework can guide and support data sharing while kickstarting capacity building by, for instance, requiring agencies to designate an open data focal point to oversee implementation, coordinate with other agencies, and respond to requests. Updated legal provisions can establish open licensing requirements while ensuring that no personally confidential information is released and that data is subject to the same exemptions governing information requests (Open Data Barometer 2017). For instance, the United States' Open Government Data Act (2019) requires all federal agencies to publish their information in standardized, machine-readable formats with accompanying metadata, and also establishes an "online repository of tools, best practices, and schema standards" to promote open data practices across government (Kim 2019).

When there is uncertainty regarding roles and responsibilities, agencies may act protectively to restrict data access, resulting in disparate data publication across agencies. At the workshops organized in Chile and Uruguay, stakeholders expressed that the countries' respective information transparency laws provide a supportive framework for open data. In Chile, however, stakeholders also felt that the lack of a comprehensive regulatory framework specifically governing data publication led to differences in how agencies manage their data and posed a challenge to linking data across sources and sectors. This was echoed by a Climate Change Directorate representative in Costa Rica, who noted that the process of developing the SINAMECC platform highlighted that common rules are integral to facilitate data sharing (Moya 2019). Chilean stakehold-

ers also linked the robustness of regulatory frameworks supporting data publication to the availability of private sector data for decision-making.

Strategies to address this barrier

Policymakers can review administrative laws that assign access to information rights to ensure that they include or are consistent with open data policies. Open licensing rules can help ensure government data is open by default unless there are privacy concerns. Data-holding agencies interested in improving the accessibility of their data can consider establishing an institutional strategy for data publication clarifying the process, roles, and responsibilities. Developing such a strategy within an institution can also open the opportunity to collaborate with other ministries or agencies that produce related information, to ensure a coherent approach. For instance, in Sweden, the Environmental Protection Agency, the Marine and Water Authority, and the County Administrative Boards jointly developed an Environmental Data Management Strategy to serve as a guiding principle for improving the availability and use of environmental data and information. It aims to make environmental data "easily accessible, easy to use, and efficiently managed" and contains 10 guidelines and 28 specific recommendations for data managers (Swedish EPA 2020a). The Strategy has since been signed by 40 government entities. It is accompanied by a "general process for making datasets available" that guides data managers through the steps of data publication with metadata guidelines that are specific to the Environmental Protection Agency (Swedish EPA 2020b).

Where the lack of a regulatory framework guiding data publication results in uneven accessibility of datasets across sources, interested stakeholders can implement a collaborative approach to map the "state of openness" of relevant datasets. This could help shed light on the need for such a regulatory framework or guidelines, and to engage with data producers and users in drawing a plan of action to improve the state of openness of the datasets (see Appendix A for a summary of how this approach was applied in Chile and Uruguay).

Lack of Mandate or Political Leadership to Coordinate Data Publication across Agencies

Efforts to open climate-related data may also be hampered by the lack of a clear mandate or sufficient political leadership to bring all relevant stakeholders to the table and coordinate data sharing processes. For instance, regional stakeholders have pointed out that a general unwillingness of state and non-state actors to share information has limited the success of the Caribbean Community Climate Change Centre's information sharing platform (Scobie 2016). Data-holding agencies may not see their incentives as aligned with disclosing data at all, or with disclosing data in open formats. Agency leadership or staff may worry that data, once disclosed, could demonstrate inconsistencies or be interpreted as showing poor performance and lead to budget cuts or reassignment of roles and responsibilities across government. Sharing data and information across departments in a bureaucracy does not often occur naturally without the steering and guidance of legal mandates, coordination structures, and bureaucratic incentives like budgetary appropriations for additional responsibilities and performance evaluations. Legal mandates alone may not resolve this if agencies do not foresee major consequences—budgetary or otherwise—for failure to proactively disclose data or to comply consistently.[13]

Strategies to address this barrier

Where possible, stakeholders interested in improving the accessibility of climate-related data should find government champions who have a relevant role in collecting and managing climate-related data, even if they do not have the primary responsibility for climate change policy (Shakya et al. 2018). For instance, in its efforts to improve the availability of accurate and relevant evidence on climate change risks for policymaking in Nepal, Action on Climate Today shifted away from working with the Climate Change Knowledge Management Centre, where there was little political traction, and instead supported the Central Bureau of Statistics to integrate climate issues into its surveys and conduct Nepal's first national climate change survey (Shakya et al. 2018).

Drawing from the literature on fiscal and budgetary transparency, Carolan notes that competitive dynamics can shift political positions (Carolan 2016, citing Khagram et al. 2013). For instance, corruption scandals may cause new administrations to prioritize transparency and accountability.[14] Political parties may see strategic use of transparency as supporting their election hopes, particularly if there are growing domestic constituencies supporting transparency (Carolan 2016). In some cases, political elites may be sensitive to the perceptions of outside actors, such as donors and multilateral networks like the OGP, particularly if there are political incentives to improve their international image or influence.

Since coordination is inherent to many governance issues, it may be sensible to integrate data sharing norms, structures, and capacity-building into larger efforts to improve coordination across government, such as facilitating NDC implementation or ensuring the alignment of climate actions with the Sustainable Development Agenda. Working within existing institutional coordination mechanisms, like interministerial climate bodies, can legitimize open data initiatives. For instance, in Uruguay, efforts to promote greater data accessibility are being pursued in the context of establishing the MRV program for the NDC, led by the National System for Climate Change Response. In Mexico, a survey to map the availability of climate change related statistics and indicators was completed through the Inter-Agency Climate Change Committee (EGES 2018).

Where such interinstitutional mechanisms do not exist or do not have a mandate to coordinate data-sharing, creating cross-sector working groups focused on collaboration for a specific data project can create an opportunity for awareness-raising, capacity-building, and developing a joint data publication strategy. For instance, the Malawi Spatial Data Portal Working Group, which gathers key stakeholders involved in producing or using risk data, has served to share communications, conduct trainings, and develop a policy framework for sharing geospatial and other relevant data among all stakeholders (World Bank 2016).

Another important strategy is the incorporation of specific open data mechanisms or goals in climate policy instruments, such as NDCs, National Adaptation Plans, and Nationally Appropriate Mitigation Actions. This is especially relevant for components related to capacity-building, education, public awareness, and public access to information (articles 11 and 12 of the Paris Agreement).

Stakeholders seeking to establish greater incentives for opening up climate-related data may also identify opportunities to connect two or more national agendas—including through global initiatives—to lend greater political weight to the project (World Bank 2016). For example, in Costa Rica, interest from the Ministry of the Presidency in promoting data openness through the OGP converged with efforts undertaken by the Climate Change Directorate to improve Costa Rica's transparency framework in line with the Paris Agreement (Moya 2019). Backing from the presidency helped establish institutional arrangements for continuous data provision between agencies, supporting the development of the SINAMECC, an online open data platform for climate-related data (Moya 2019).

STRATEGIES TO STRENGTHEN AND SUSTAIN OPEN DATA INITIATIVES FOR CLIMATE ACTION

This section provides lessons on factors that enable successful open data initiatives over time, including meeting users' needs and capacities, strengthening networks and relationships, and fostering supportive governance structures for long-term impact and sustainability. These suggestions summarize insights gathered from the literature review and in consultations with stakeholders (data providers and users) of climate-related data publication initiatives. They could be implemented alongside a process to map the availability and openness of existing climate-related data, as was carried out in Chile and Uruguay in the context of this project (see Appendix A). In so doing, national stakeholders could adapt the list of data types to their country context (for instance, by cross-referencing with NDC measures and metrics) and convene a broad group of stakeholders to undertake an iterative data mapping process.

Prioritize Continued Engagement and Participation

The literature and stakeholders' perceptions of lessons learned from the implementation of open data projects highlight the chief importance of ensuring that stakeholder engagement and participation activities are consistent and continued throughout the lifetime of a project. This is crucial for building trust among the stakeholders involved and a shared understanding of the value proposition of open data (Venkateswaran et al. 2018; World Bank 2016). For instance, during the development of the SINAMECC open data platform in Costa Rica, the co-development of processes and rules, as through the testing of functions to transfer or publish data, helped build trust among data providers (Moya 2019).

Continued engagement is also important for gradually building an ecosystem of data providers and users with the capacity and partnerships to generate impactful data uses that create more value from investments in data generation and publication (Carranza 2019; World Bank 2016; World Bank 2018). Reflecting on lessons learned from open data projects in three previous OGP Action Plans, AGESIC is now prioritizing the facilitation of ecosystems of actors and inscribing the activities undertaken for this project within a longer-term collaboration with the Climate Change Directorate.

Seeking continued engagement and participation of diverse stakeholders is also necessary to enable mutual learning and the continuous improvement of open data initiatives and projects (GovLab 2018; Venkateswaran et al. 2018; World Bank 2016). As highlighted by the activities implemented in Chile and Uruguay, as well as lessons learned from the implementation of other open data projects, identifying and prioritizing data needs requires iterative dialogue (Verhulst and Young 2016). Similarly, mutual learning, enabled through continued engagement between data providers and users, can help ensure that data publication efforts stay attuned to users' needs, while simultaneously setting expectations for how to use the data in decision-making processes (Venkateswaran et al. 2018). Sustained engagement and participation channels also present an opportunity to use crowdsourced data and local knowledge to validate and interpret top-down data (Shakya et al. 2018). These points were echoed by participants in the workshop organized in Chile, who expected that as communication between data providers and users increased, the quality of the data published would improve, as would user comprehension.

Stakeholders interested in promoting open data initiatives for climate-related data do not necessarily have to create all new spaces and opportunities for engagement, but should instead take advantage of and reinforce existing processes for participation, such as consultations held in the context of interministerial climate change coordination bodies or for climate policy instruments (World Bank 2018). This would not only reduce duplication of efforts and make more efficient use of resources, but could also help build the legitimacy of the efforts.

Finally, promoting continued engagement and relationships between stakeholders can contribute to building a new awareness of and capacity to manage data differently, promoting the sustainability of open data principles beyond the scope of a particular open data project (Carranza 2019; World Bank 2018).

Tailor Open Data Initiatives to Meet Users' Needs and Capacities

Mapping potential users, assessing the demand for specific datasets or types of data, and evaluating actors' readiness to use the data in climate-related applications is an important first step when setting up an open data project.[15] It is critical for tailoring open data initiatives to stakeholders' needs, and ultimately ensuring that data publication will have the expected impact (GovLab 2018; World Bank 2016). In contexts where some data is already publicly available but not widely known or significantly utilized, this may also involve assessing the delivery platforms to determine whether users' access needs are being met. For instance, data may be publicly available but dispersed across platforms.

For climate action perhaps more than in other policy areas, it is necessary to identify and engage not only the users of data, but also the intended beneficiaries of the data applications or information products. Given the complexity associated with climate change analysis and tools, data will often be used primarily by specialized users, like government agencies, universities, the private sector, and research organizations. The information products, analyses, and policy recommendations built on that data, however, must ultimately serve the mitigation and/or adaptation needs of specific communities. Understanding these needs should therefore inform data publication strategies. It could also facilitate beneficiaries' appropriation of the resulting information, enabling them to better advocate for the policies they need and providing an important accountability mechanism.

Investing in these steps from the outset can help address or avoid a "usability gap," whereby data providers fail to consider users' decision-making needs while users do not know or have unrealistic expectations for how climate information fits into their decision-making process (Morales 2018; Venkateswaran et al. 2018).

Plan for and Invest in Communication and Collaboration Techniques

Experience from open data projects around the world shows that adequately planning for communication and collaboration techniques is necessary to promote the effective use of data in decision-making (World Bank 2018). This was echoed by stakeholders in the workshops organized in Chile and Uruguay, who emphasized the need to promote communication and participation channels to facilitate users' appropriation of climate-related data. Communication activities may include disseminating visualizations of the data, like maps and graphs, and promoting awareness of the data available through channels like social, broadcast, digital, or print media, mobile applications, and web platforms. The communication techniques most appropriate for a particular project or types of data should be selected based on an assessment of users' needs and capacities. Opportunities to coordinate such efforts with other data-producing agencies can help reduce costs.

Innovative communication techniques not only contribute to promoting awareness of the available data, but can also provide new ways for targeted user groups to engage with climate-related data (World Bank 2016). For instance, the Disaster Risk Financing team of the World Bank developed communication tools to convey risk data in a way that is relevant to Ministries of Finance (World Bank 2016). Improved communication can also help to make climate information less technocratic and bring it closer to citizens' concerns. Chilean stakeholders pointed out that this may be very important for climate-related data in particular, given citizen movements' role in advocating for climate action around the world, and to promote citizens' engagement in local issues that they may not realize are connected to climate change, such as air pollution and water quality (FIMA 2020).

In this respect, engaging data intermediaries from civil society can be a very useful communication strategy to translate climate-related data and information for a broader audience, especially groups most directly affected by climate change.

Design Supportive Governance Arrangements

Experiences highlighted in the literature and in consultations with stakeholders of climate-related open data projects point to several elements of the data governance structure that can support open data efforts.

The implementation and monitoring of mitigation and adaptation actions require the integration of efforts and information across scales of governance, from local to national and even international levels. Aligning incentives to work across scales and sectors is therefore crucial to enable data sharing for climate action design, tracking, and adjustment (GovLab 2018; Scobie 2016; Venkateswaran et al. 2018). For instance, the development of climate-resilient flood management plans in four cities in Assam, India, necessitated the integration of data spread across sources from different levels of government and the private sector, which was further complicated by these actors' varying levels of willingness to share data and different ways of collecting and reporting that data (Venkateswaran et al. 2018). In Uruguay, the development of indicators to track the Cities National Adaptation Plan highlighted areas where collaboration across different scales—national, regional, departmental, and municipal—could complement data gaps at the city-level (Pastorino 2019).

Another important element of supportive governance structures for data sharing and publication is encouraging a proactive and entrepreneurial bureaucracy, with space for adaptive learning and reflexivity (Shakya et al. 2018; Verhulst and Young 2016; World Bank 2018). It is important that data producers involved in open data projects have the space to innovate and try new approaches, while being responsive to feedback and adjusting data publication efforts as needs and priorities evolve (Verhulst and Young 2016). This could involve systems of evaluation and metrics for data publication efforts co-created with relevant stakeholders (Verhulst and Young 2016). It could also include mechanisms to revise and validate the output of data mapping processes, such as the one described in Appendix A (Pino Zúñiga et al. 2020).

Additionally, high-level or cross-sector mandates for data coordination can build a solid foundation on which to develop data publication projects. In Uruguay, the National Climate Change Policy—the document governing climate policymaking and action in the country—calls for all climate programs and projects to be subjected to an annual monitoring system that is reliable, transparent, and comparable (Ministerio de Ambiente 2017). This mandate is a significant factor supporting the development of an MRV program with open data components. Similarly, INDAGEA,[16] a governmental initiative launched in 2017 to improve the interoperability and sharing of environmental data between ministries, is managed by a secretariat housed in the presidency, lending it the necessary mandate and political weight to bring all relevant actors to the table (AGESIC 2017). Additionally, legal frameworks on environmental rights, such as the Aarhus Convention in Europe and the Escazú Agreement in Latin America and the Caribbean, can serve as a reference for the management of climate-related data.

The sustained impact of open data initiatives also requires adequate resource allocation, both for the agencies that wish to implement open data projects and for those that can support them (e.g., digital government offices). While some open data projects can be started inexpensively, building the technical capacities and skills of all actors in the ecosystem and sustaining engagement in the long-term require committed funding (Verhulst and Young 2016). For this reason, the GovLab recommends approaching data as a form of public infrastructure (Verhulst and Young 2016). In some contexts, it may be just as important to resource the improvement of datasets as the publication of new ones (Carranza 2019).

CONCLUSION

This publication shows how open data practices can be a crucial tool to advance an evidence-based response to climate change across government and society. The cross-cutting nature of both climate change impacts and the actions needed to address them underscores the importance of coordinated and coherent action. The Paris Agreement's enhanced transparency framework sets a foundation on which governments can build to ensure that their investments in data collection not only fulfill external reporting requirements, but also provide a useful resource for national stakeholders within and outside of government. This paper has pointed to the experience of several countries where the enhanced transparency framework has encouraged or reinforced a new approach to data management that seeks to make climate-related data accessible to a broad range of local and national actors.

Agencies spearheading efforts to apply open data practices and publish data can face several internal or external challenges, like lack of technical capacity within user or producer groups or lack of mandate or regulatory frameworks providing clear processes for data sharing and publication. Still, these barriers can be overcome in context-specific ways, as we have addressed with a variety of examples.

The potential benefits of improving climate-related data accessibility through open data practices are significant. Experiences from various countries and applications—like disaster risk management, urban resilience, waste reduction, agricultural adaptation, and water management—show how open data can help improve the quality of data for decision-making, spark novel partnerships and innovative data uses, and enhance the monitoring of climate policies. Beyond these benefits derived from greater access to specific datasets, an important contribution of open data principles is building the awareness and capacity of actors across the data value chain to manage data differently, with effects on the transparency of existing and future data. This paper has further provided insights and suggestions to help ensure that data publication efforts have a real and sustainable impact on climate action and planning.

APPENDIX A

This project was funded by the Inter-American Development Bank (IDB) through the Open Data Charter (ODC). In addition to this publication, other project activities included the development of a draft practical guide for opening up climate-related data and its piloting in Chile and Uruguay following a methodology used by ODC for sectoral "open up guides" (e.g., on anti-corruption and agriculture).

The draft guide leveraged the expertise of WRI's centers and programs—including the Climate Program; Food, Forests, and Water Program; Ross Center for Sustainable Cities; Finance Center; and Economics Center—to present a non-exhaustive list of climate-related data types, existing associated standards, and known examples of existing databases (see tables below). This identification was enriched by previous work, including surveys and workshops carried out for the Global Platform for Sustainable Development Data (GPSDD) in Tanzania and Sierra Leone in 2017 (summarized in Worker and Excell 2018) and workshops led by the Center for Open Data Enterprise in 2015 and 2016. The list was further shaped by a review of existing climate-related open data portals and relevant guidance, including, for example, from the Intergovernmental Panel on Climate Change's Data Distribution Centre and the United Nations Economic Commission for Europe's review of climate-related statistics. Open data and climate practitioners consulted through the OGP and at the International Open Data Conference also contributed to this list and provided feedback on the overall approach of the guide (see Appendix B for a questionnaire circulated to OGP stakeholders). This list is not intended to be exhaustive nor to represent datasets that are critical for publication in all contexts. Instead, it is intended to present a starting point for national stakeholders to begin mapping existing datasets and exploring their degree of openness, with a view to initiating dialogues to improve data accessibility. Indeed, in both Chile and Uruguay, project partners identified additional data types relevant in their country contexts. In Uruguay, these included national ocean territory data for downscaling global climate models and georeferenced data on households relocated as a result of natural hazards; in Chile, additional data types included biodiversity and air quality indicators.

To pilot this draft guide in Chile and Uruguay, ODC and WRI partnered with the climate change directorate/office, digital government office, and a civil society partner in each country, as well as with Cívica Digital, an NGO that provided open data technical expertise. This collaboration enabled a mapping of the state of openness of climate-related datasets, using the list of data types provided in the guide as a starting point (partners could propose additional data types to be inventoried, or skip any that were deemed of little relevance in the country context). This mapping exercise was performed from the perspective of a non-specialized user. For each dataset inventoried, a rating was given based on 15 evaluation criteria: dataset is published in an official online data portal; dataset is

accessible to user; dataset is machine-readable; dataset is downloadable; API is available; dataset has an open license; dataset is updated; ease of discovery (few clicks required); dataset is linked to related datasets; backups are available; metadata are available; data dictionary is available; documentation on dataset quality and generation methodology are available; vertical evaluation (level of disaggregation); horizontal evaluation (dataset cleanliness, computational legibility). The exercise also included concrete recommendations for each dataset to improve its score and state of openness. The resulting data inventories are living documents intended to serve as inputs for participatory processes to prioritize data publication efforts.

A workshop was then organized by the partners in each country, bringing together data producers and users across various government agencies and some civil society organizations. The inventories were one of the inputs used to jumpstart conversations around the value of open data, opportunities to improve data access, and challenges faced in sharing, accessing, and publishing data. The insights gathered in these interdisciplinary discussions around data access—which multiple participants agreed should be continued and iterative—were used by the in-country project partners to formulate a data publication plan for the short-, medium-, and long-term.

Data Types Used for the Data Inventories

Table A1 | **Emissions Related Data**

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
GHG emissions disaggregated by sector, as reported to UNFCCC	National	Annual	Monitoring, reporting, and verification of emissions and mitigation actions	GHG Inventory Open Data Portal (Argentina) National Inventory Reports submitted to UNFCCC
Projected future emissions and emissions avoided under current policy frameworks	National (for projected future emissions) Policy or program level (for emissions avoided)	Every two years, if possible[a]	Informing mitigation actions	No data (ND)
Historical GHG inventories	National	N/A	Understanding emissions trajectories and evaluating the impacts of past actions and policies	National Inventory Reports submitted to UNFCCC

Notes: Open access to national greenhouse gas (GHG) inventories and their underlying data enables non-state actors to identify actions and investments to lower emissions. It also allows the identification of priority sectors for focused and coordinated action.

[a] Elliott, C., K. Levin, J. Thwaites, K. Mogelgaard, and Y. Dagnet. 2017. "Designing the Enhanced Transparency Framework: Reporting under the Paris Agreement." Working Paper. Washington, DC: Project for Advancing Climate Action Transparency (PACT). Available online at http://www.wri. org/publication/pact-reporting-under-paris-agreement.

Source: WRI authors.

Table A2 | Agricultural Data

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Acreage by agricultural land use	National	Annual	Understanding emissions from the agricultural sector and changes in ecosystems that might have a bearing on climate impacts	FAOSTAT
Water consumption per commodity	*No standard identified*	*No standard identified*	Informing selection of drought-resistant and resilient crop varieties Informing water modeling studies to understand consumption and availability for other uses	ND
Groundwater levels	Per well	Weekly	Key component of water stress assessment	ND
Carbon stock in soil	20 km[a]	5-10 years[b]	Assessing soil carbon sequestration and soil quality for agricultural production	ND
Emission intensity of agricultural commodities	National	Annual	Understanding emissions from the agricultural sector	ND
Crop production and crop variety data	National	Annual	Understanding potential impacts of climate change on crop production	ND
Livestock inventories	National	Annual	Estimating the contribution of livestock production to climate change and the vulnerability of herding livelihoods	FAOSTAT, USDA (United States)

Notes: Agricultural data enables non-state actors to assess vulnerabilities in this sector and to more effectively support local adaptation, water use, crop selection, and food security strategies.

[a] World Meteorological Organization. 2016. *The Global Observing System for Climate: Implementation Needs*. https://library.wmo.int/index.php?lvl=notice_display&id=19838#.W5rnN-hKiUl

[b] World Meteorological Organization. 2016. *The Global Observing System for Climate: Implementation Needs.* https://library.wmo.int/index.php?lvl=notice_display&id=19838#.W5rnN-hKiUl

Source: WRI Authors.

Table A3 | **Land Use Land Use Change and Forestry (LULUCF) Data**

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Current carbon stocks by type of land use and location	*No standard identified*	*No standard identified*	Assessing carbon storage and estimating avoided emissions through actions in LULUCF sector	ND
Methodology used to estimate all LULUCF-related emissions and removals	*No standard identified*	Annual, or as often as GHG emissions inventories are calculated	Transparent monitoring and reporting on emissions from LULUCF	ND
Geospatial data on concessions agreements	Concession-level	*No standard identified*	Strengthening transparency in monitoring forest governance enforcement and compliance	ND
Location of forest plantations	Plantation-level	*No standard identified*	Understanding and monitoring the impacts of forestry activities on greenhouse gas emissions and climate resilience	ND
Geo-referenced data on land use/land cover conversion rates by type	10-1000m (depending on temporal resolution)[b]	1-10 years[c]	Understanding changes in ecosystems that might have a bearing on GHG emissions and climate impacts	Global Forest Watch
Geo-referenced data relative to protected areas	250 m[d]	Annual	Assessing carbon storage and estimating avoided emissions through actions in LULUCF sector	Open.canada.ca, Protected Areas Indicators World Database on Protected Areas
Geospatial data on locations and types of disturbance (fire, deforestation, timber harvesting, and forest management activities such as thinning) that impact ecosystem carbon cycling	Disturbance-level	Annual	Estimating emissions from forest disturbances	Global Forest Watch Fires

Notes: LULUCF activities have a key role to play in mitigation. Formalizing channels of communication and improving data integration support institutional coordination in land-use decision-making, in support of national mitigation policies.[a] Additionally, increased access to LULUCF data strengthens the accountability of mitigation actions in the sector and allows more informed forest management by communities and the private sector.

[a] Cheung, L., K. Austin, A. Utami, J. Bangoura, and F. Stolle. 2014. "Building National Forest and Land-Use Information Systems: Lessons from Cameroon, Indonesia, and Peru." Working paper. Washington, DC: World Resources Institute. http://www.wri.org/sites/default/files/land-use-infomation-systems_working_paper.pdf.

[b] World Meteorological Organization. 2016. ***The Global Observing System for Climate: Implementation Needs***. https://library.wmo.int/index.php?lvl=notice_display&id=19838#.W5rnN-hKiUl

[c] World Meteorological Organization. 2016. ***The Global Observing System for Climate: Implementation Needs***. https://library.wmo.int/index.php?lvl=notice_display&id=19838#.W5rnN-hKiUl

[d] World Meteorological Organization. 2016. ***The Global Observing System for Climate: Implementation Needs***. https://library.wmo.int/index.php?lvl=notice_display&id=19838#.W5rnN-hKiUl

Source: WRI Authors.

Table A4 | Electricity Data

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Electricity production by fuel source	National or regional	Daily or annual	Understanding trajectories and emissions from electricity generation over time	IEA IDB Energy Database
Power plant characteristics (age, name, capacity, geolocation, and fuel type)	Power plant-level	Latest information available	Understanding potential climate impacts on power plants	Global Power Plant Database
Power plant generation (MWh)	Power plant-level	Annual	Understanding electricity generation from individual units allows for better modeling and planning for energy transitions	EIA (US only)
Power plant ownership structure	Power plant-level	Daily or annual	Assessing governance of electricity sector and corporate compliance with climate goals	EIA (US only)
CO_2 emissions	Power plant-level	Daily or annual	Assessing the role of specific power plants in meeting climate and energy goals and aiding with implementation of carbon accounting policies	EPA (US only), CEA (India only)
Air Pollutant Releases (PM, SO_2, NO_2)	Power plant-level	Daily or annual	Understanding contribution of power sector to local air pollution, cost of AQ control	EIA (US) E-PRTR (Europe, 33 countries)
Water consumption for electricity generation (thousand cubic meters/MWh)	Power plant-level	Daily or annual	Understanding climate risks and vulnerabilities in the power sector from climate-induced water shortages	EIA (US)
Power outages and reason	National and power plant-level	Daily or annual	Understanding climate risks and vulnerabilities in the power sector	CEA (India only)
Grid average emission factors	National or regional	Latest data	Evaluating/estimating emissions from electricity generation	EPA (US only)

Notes: The power sector alone contributes up to 41% of global CO_2 emissions and 18% of freshwater withdrawals.[a] Meanwhile, energy access remains a salient development challenge, attracting a significant amount of private sector and civil society action and investment. Open access to electricity sector data is therefore crucial to coordinate mitigation and adaptation planning and to inform energy access efforts.

[a] Friedrich, J., and A. Kressig. 2017. "Open Power Sector Data: Open Government Data to Understand 21st Century Energy Challenges." Powerpoint Presentation. Washington, DC: World Resources Institute.

Source: WRI Authors.

Table A5 | **Stationary Energy Data**

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Fuel (liquid/gas/biomass) consumption and sales	National	Annual	Understanding emissions in the energy sector	ND
Fossil fuel transportation, storage, and distribution data	National	Annual	Understanding emissions in the energy sector	ND
Purchased energy consumption and sales (electricity, district heating/cooling, and CHP)	National	Annual	Understanding emissions in the energy sector	ND
Share of renewable energy in total energy use and generation	National	Annual	Understanding emissions and progress towards renewable energy policy goals	ND
Amount of energy subsidies by type of fuel and per unit of GDP (production and consumption)	National	Annual	Understanding the politics and economics of reducing emissions	International Energy Agency's *World Energy Outlook* (covers only price transfer subsidies) OECD's *Inventory of Support Measures for Fossil Fuels* Global Subsidies Initiative

Note: This table encompasses stationary energy data, separate from the electricity data listed in Table A4.

Source: WRI Authors.

Table A6 | **Transport Data**

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Average passenger travel distance (km/year)	*No standard identified*	Annual	Understanding passenger travel pattern	ND
Average passenger vehicle travel distance (km/year)	*No standard identified*	Annual	Understanding vehicle travel pattern to estimate energy consumption and emissions	ND
Occupancy rate	By type of vehicle	*No standard identified*	Understanding sharing conditions of vehicles	ND
Vehicle registration statistics	National	Annual	Understanding vehicle fleet information	ND
Modal share (% of distance traveled by different modes of transportation, including public transit modes)	*No standard identified*	Daily, weekly, monthly or annual, depending on needs	Understanding passenger travel pattern and estimating distance traveled by each transport mode	ND
Vehicle efficiency or fuel economy by type of vehicle (e.g., average vehicle efficiency of light duty vehicles)	By type of vehicle	*No standard identified*	Understanding the efficiency of vehicles and estimating energy consumption	ND
Fuel consumption and sales by type of fuel for on-road vehicles, rail, aviation, and waterborne transport	By type of vehicle	*No standard identified*	Understanding fuel consumption by sector	ND
CO_2 emissions factor of different fuels	By fuel	*No standard identified*	Understanding carbon content of different fuels to estimate emissions	ND
Vehicle age (e.g., average age of a certain type of vehicle)	By type of vehicle	*No standard identified*	Understanding vehicle fleet information to estimate fleet level energy consumption and emissions	ND
Transport infrastructure stock, lifespan, and age	*No standard identified*	*No standard identified*	Understanding future need of construction and related emissions Understanding current and future climate risks to transport infrastructure	ND
Total freight distance (tonne-km/year)	*No standard identified*	Annual	Understanding vehicle travel pattern to estimate energy consumption and emissions	ND
Freight load factor (average load/ maximum vehicle freight capacity)	By type of vehicle	*No standard identified*	Understanding average freight capacity	ND

Notes: The transport sector constitutes one of the largest sources of global CO_2 emissions.[a] At the same time, the impacts of climate change on transportation infrastructure can have highly localized effects. Access to transport data enables communities, municipalities, and the private sector to plan locally-relevant resiliency initiatives and invest in low-carbon transportation systems. "Vehicle" here includes on-road, rail, aviation, and waterborne vehicles (passenger and freight).

[a] Cooper, E.M., B. Lefevre, and X. Li. 2016. "Can Transport Deliver GHG Reductions at Scale? An Analysis of Global Transport Initiatives." Working Paper. Washington, DC: World Resources Institute. http://www.wri.org/publication/transport-ghg-initiatives.

Source: WRI Authors.

Table A7 | **Waste Data**

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Waste composition, mass, and moisture content	Landfill-level	*No standard identified*	Understanding emissions in the waste sector	ND
Waste disposition rates (solid waste, biologically treated waste, incineration (non-energy), recycling)	*No standard identified*	*No standard identified*	Understanding emissions in the waste sector	ND
Landfill locations and capacities	Landfill-level	*No standard identified*	Understanding regional distribution of emissions in the waste sector	ND
Wastewater treatment types and capacity	Plant-level	*No standard identified*	Understanding emissions in the waste sector	ND
Wastewater treatment location	Plant-level	*No standard identified*	Understanding regional distribution of emissions in the waste sector, as well as climate risks to treatment plants (e.g., flooding causing overflows)	ND
Sludge removal and methane recovery	Plant-level	*No standard identified*	Understanding emissions in the waste sector	ND

Note: Access to waste sector data allows better tracking of emissions and impacts of mitigation activities deployed in the sector.

Source: WRI Authors.

Table A8 | **Natural Hazards and Impacts Data**

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Historical temperature and precipitation data	Highest resolution available	Daily or monthly	Understanding changes in weather variability, extremes, and averages	Global Precipitation and Climatology Center
Occurrence of natural extreme events, including date of occurrence, location, type, and extent/ magnitude attributes where applicable	Highest resolution available	Annual	Assessing climate risks and their change over time	ND
Distribution and number of cases of vector-borne diseases	Highest resolution available	*No standard identified*	Assessing potential impacts of climate change on public health	ND
Mortality rates of natural extreme events	Highest resolution available	Annual	Assessing climate risks and impacts on public health	EM-DAT
Historical data on property damages resulting from natural extreme events	Highest resolution available	Annual	Establishing baseline for measuring asset damages of natural extreme events	EM-DAT
Historical data on economic loss as a result of natural extreme events (% of GDP)	Regional or national	Annual	Establishing baseline for measuring economic impact of natural extreme events	EM-DAT
Projected water stress under different climate scenarios	*No standard identified*	*No standard identified*	Understanding impacts of climate change on water availability and societal water use	USGS Daily Streamflow Conditions (United States) Aqueduct Water Risk Atlas
Geo-referenced streamflow measurements	Gauge-level	Highest resolution available	Assessing flood risks	USGS Daily Streamflow Conditions (United States)
Projected change in natural extreme events under different climate scenarios	*No standard identified*	*No standard identified*	Understanding human impact of extreme weather events	ND
Projected yield rate of major crops in different climate scenarios	*No standard identified*	*No standard identified*	Understanding potential impacts of climate change on food security	ND

Note: Up-to-date data on natural hazards and their impacts are crucial to disaster risk management and adaptation planning. The effectiveness and long-term viability of these strategies require the awareness and engagement of local communities. Public access to natural hazard and impacts data is therefore relevant to both public and private sector risk management and adaptation planning.

Source: WRI Authors.

Table A9 | Socioeconomic Data

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Water quality, access, and scarcity data	*No standard identified*	*No standard identified*	Identifying groups vulnerable to increasing water stress and designing responsive resilience strategies	ND
Data on use of agricultural practices and crop varieties resilient to extreme temperature, rainfall, and pests	*No standard identified*	*No standard identified*	Informing policies on resilience for agriculture, farming livelihoods, and food security	ND
Data on population access to early warning systems for disease vectors and extreme weather events	*No standard identified*	*No standard identified*	Addressing inequities and vulnerabilities in populations' access to information for adaptation strategies	ND
Extent of coastal protection or setback programs data	*No standard identified*	*No standard identified*	Informing adaptation policies and plans and tracking progress for coastal resilience	ND
Demographic data, including sex-disaggregated data on livelihoods, access to public services, etc.	*No standard identified*	*No standard identified*	Understanding the demographic distribution of climate change risks and impacts	ND
Population and infrastructure density in risk-prone areas (e.g., areas vulnerable to storm surges or landslides)	*No standard identified*	*No standard identified*	Estimating exposure of people and assets to climate risks	ND

Note: The above socioeconomic data types showcase important conditions that contribute to climate vulnerability. Open access to this data is important for the same reasons as access to hazard and impact data, listed in Table A8.

Source: WRI Authors.

Table A10 | Climate Finance Data

INDICATOR	SPATIAL RESOLUTION	TEMPORAL RESOLUTION	KEY UTILITY FOR CLIMATE DECISION-MAKING	EXISTING DATA EXAMPLES
Domestic climate relevant expenditures by source (domestic vs. external) and specific activity funded	National	Annual (in alignment with budgetary cycles)	Assessing the scope and impact of climate investments and strengthening accountability of finance use	CPEIR Database Climate Finance MRV Platform (Colombia)
Source and amount of climate funds received by type (grants, technical assistance, loans, equity, and guarantees)	National	Annual or biannual (in alignment with UNFCCC reporting requirements)	Understanding how climate action is financed in the country, identifying gaps and opportunities, and strengthening accountability of climate finance	ND
Guidelines used to determine "climate relevance"	National	Annual (in alignment with budgetary cycles)	Transparency in climate finance tracking	ND
Budgetary information on climate change programs	National	Annual	Comparing climate finance commitments to budgeting processes and actual use	ND
Fiscal instruments to support climate action (e.g., tax expenditures and revenues, green bonds, tax breaks, subsidies, and carbon pricing mechanisms)	National	Annual	Understanding climate finance instruments and their relative impact	ND
Monitoring and evaluation guidelines used for mitigation and adaptation expenditures	National	Annual	Transparency in climate finance tracking	ND

Note: Access to adequate finance and investment is essential for climate change mitigation and adaptation. Disclosure of climate finance information strengthens accountability and safeguards climate funds from corruption. It can also help investors and civil society understand how these funds are being spent, and how they are making a difference, informing future finance flows. Currently, no standard methodology to quantify climate finance has been adopted internationally.

Source: WRI Authors.

APPENDIX B

World Resources Institute survey to understand country experiences in sharing and publicly disclosing data relevant for climate action

What is your name?	
What is your title/position?	
What is your country?	
Has there been an open data initiative/program in your country that involved datasets related to climate change and climate change mitigation and adaptation? Note: You may include efforts that are no longer active or have stalled. If the answer is "No," you may end the survey. ☐ Yes ☐ No	
If you responded "Yes" to the question above, who was the actor (individual or organizational) responsible for initiating the effort?	
Who was the principal actor (ministry, agency, department, etc.) assigned responsibility for overseeing implementation?	
What year was it initiated and is it still ongoing?	
What was the process for selecting the datasets to be published?	
What challenges, if any, were encountered in the selection of datasets?	
What enabling factors, if any, were there in the selection of datasets? In other words, what factors (i.e. capacity, partnerships, leadership) helped the effort succeed, to the extent that it has?	
How were the datasets to be published coordinated, shared, and published?	
What challenges, if any, were encountered in the coordination, sharing, and publication of the datasets?	
What enabling factors, if any, were there in the coordination, sharing, and publication of the datasets?	
Which governmental and non-governmental actors were involved in the process and what were their roles?	
Were any efforts made to monitor the impact of the initiative and, if so, what metrics were used?	
In your opinion, what have been the major outcomes or lessons learned? For instance, has it facilitated policymaking or implementation in any way? Has it improved collaboration across government or with civil society or the private sector?	
Could you share any examples of the published datasets being used for a climate-related application in your country?	
Is there anyone else we could reach out to for more information on this topic?	

ENDNOTES

1. For more information on Climate Watch, see www.climatewatchdata.org.
2. For more information on the Partnership for Resilience and Preparedness, see www.prepdata.org.
3. For more information on Open Climate, see www.collabathon.openclimate.earth/open-climate-project.
4. An online beta version of this Guide can be found here: https://open-data-charter.gitbook.io/open-up-guide-using-open-data-to-advance-climate-a/.
5. In most countries around the world, ensuring the availability of climate-related data with sufficiently granular spatial and temporal resolutions is a significant challenge. In this regard, new technologies like earth observation (EO) and Internet-of-Things (IoT) are helping to bridge some of these gaps through large-scale digital data collection (Hsu et al. 2020). Participatory approaches like citizen science and crowdsourcing also offer an important solution and are being deployed to collect the data necessary for a broad range of climate and environmental management applications, from mapping urban infrastructures and their disaster-related vulnerability characteristics (World Bank 2014) to detecting deforestation events (Petersen and Pintea 2017) and tracking disease-carrying mosquitoes (Palmer at al. 2017).
6. These are provided as an indication of the dialogues and perspectives that enriched this paper; they are not intended as validation or evaluation of the results of the activities in each country.
7. The other reason being their capacity to understand and use the data as it is published, an issue discussed in later sections.
8. For more information on Aqueduct, see www.wri.org/aqueduct.
9. For more information on Global Forest Watch, see www.globalforestwatch.org/.
10. De Pinto et al., for instance, note that the broad range of data sources used in the preparation of Colombia's NDC highlighted the contribution of many agencies, "along with the high degree of trust across government agencies and coordination necessary to compile the data set" (2017).
11. Though the budget was not available in open data format, this example is nonetheless illustrative of the potential impact of public information.
12. For more information on Right to Information Laws around the world, see https://www.rti-rating.org/country-data/.
13. Such as disclosing data that they perceive as being inconsequential but withholding data that may reveal performance or compliance issues.
14. As an example, Nigeria's President Muhammadu Buhari rose to power in 2015 following corruption scandals of the previous administration and made transparency and anticorruption a major part of his public platform (See Nigeria's 2019-2021 Action Plan for the Open Government Partnership, https://www.opengovpartnership.org/documents/nigeria-action-plan-2019-2021/).
15. New York University's GovLab proposes a methodology to achieve this in "Toward an Open Data Demand Assessment and Segmentation Methodology" (2018).
16. Infraestructura Nacional de Datos para la Gestión Ambiental.

REFERENCES

AGESIC (Agencia de Gobierno Electrónico y Sociedad de la Información y del Conocimiento, the National Agency for e-Government and Information Society). 2017. "Ambiente tecnológico: Agesic en Taller sobre INDaGeA." December 12. https://www.gub.uy/agencia-gobierno-electronico-sociedad-informacion-conocimiento/comunicacion/noticias/ambiente-tecnologico-agesic-en-taller-sobre-indagea.

Allan, S., A.V. Bahadur, S. Venkatramani, and V. Soundarajan. 2019. "The Role of Domestic Budgets in Financing Climate Change Adaptation." Rotterdam and Washington, DC: Global Commission on Adaptation. https://cdn.gca.org/assets/2020-01/The_Role_of_Domestic_Budgets_in_Financing_Paper__Final.pdf.

Amaral, L., and A. Steer. 2017. "Save the Forests? There's Now a Deforestation-Tracking App for That." World Economic Forum. January 18. https://www.weforum.org/agenda/2017/01/new-tool-tracks-deforestation-in-supply-chains.

Arcilla, MJD, and D.M. Lagdameo. 2015. "Understanding and Addressing Risks of Flooding in the City: The Case of Barangay Potrero, Metro Manila." London: Climate & Development Knowledge Network.

Badiee, S., C. Rudow, and E. Swanson. 2019. "Open Data and National Statistics." In *The State of Open Data: Histories and Horizons*, edited by T. Davies, S. Walker, M. Rubinstein, and F. Perini, 196–206. Cape Town and Ottawa: African Minds and International Development Research Centre.

Bouyé, M., D. O'Connor, A. Tankou., D. Grinspan, D. Waskow, S. Chattopadhyay, A. Scott. Forthcoming. "Achieving Social Equity in Climate Action: Untapped Opportunities and Building Blocks for Leaving No One Behind." Working Paper. Washington, DC: World Resources Institute.

Brusa, Federico. 2020. Personal communication between the authors and Federico Brusa, Climate Change Sector Specialist, Inter-American Development Bank. January 15.

Carolan, L. 2016. *Open Data, Transparency and Accountability: Topic Guide.* Birmingham, UK: Governance and Social Development Resource Centre, University of Birmingham.

Carranza, D. 2019. Interview between the authors and Daniel Carranza, Co-Founder, DATA Uruguay. December 19.

CHaRIM (Caribbean Handbook on Risk Information Management). "Caribbean Handbook on Risk Management." World Bank and Global Facility for Disaster Reduction and Recovery. http://www.charim.net/ Accessed September 3, 2020.

Chrzanowski, P., G. Bhardwaj, and N. Jones. 2020. "Making risk data work harder for adaptation in small island states." *Data Blog* (blog), World Bank Group. February 3. https://blogs.worldbank.org/opendata/making-risk-data-work-harder-adaptation-small-island-states.

Climate Just. 2020a. "Applying Climate Just in Greater Manchester." https://www.climatejust.org.uk/case-studies/applying-climate-just-greater-manchester. Accessed May 19.

Climate Just. 2020b. "Applying Climate Just in Salford and Trafford." https://www.climatejust.org.uk/case-studies/applying-climate-just-salford-and-trafford. Accessed May 19.

Comstock, M. 2018. "Governance." In *NDC Update Report November 2018—Ambition: Taking a Long-Term Perspective*, by X. van Tilburg, J. Luijten, F. Röser, K. Lütkehermöller, and S. Minderhout, 21–22. https://newclimate.org/2018/12/07/ndc-update-report-november-2018-ambition-taking-a-long-term-perspective/.

Dagnet, Y., N. Cogswell, N. Bird, M. Bouyé, and M. Rocha. 2019a. "Building Capacity for the Paris Agreement's Enhanced Transparency Framework: What Can We Learn from Countries' Experiences and UNFCCC Processes?" Working Paper. Washington, DC: Project for Advancing Climate Transparency (PACT).

Dagnet, Y., N. Cogswell, D. Grinspan, E. Reichart, and D. Drew. 2019b. "Data and Ambition Loops for Enhanced Climate Action: Potential Drivers and Opportunities in Asia." Working Paper. Washington, DC: World Resources Institute. https://www.wri.org/publication/ data-and-ambition-loops.

De Pinto, A., A.M. Loboguerrero, M. Londoño, K.O. Sanabria, and R.S. Castaño. 2018. "Informing Climate Policy through Institutional Collaboration: Reflections on the Preparation of Colombia's Nationally Determined Contribution." *Climate Policy* 18 (5): 612–26. doi:10.1080/14693062.2017.1321521.

EGES (Expert Group on Environment Statistics). 2018. "Fifth Meeting of the Expert Group on Environment Statistics." Final report of meeting held in New York, May 16-18. https://unstats.un.org/unsd/environment/FDES/EGES5/Final%20Report.pdf.

Excell, C., and E. Moses. 2017. "Thirsting for Justice." Washington, DC: World Resources Institute. https://www.wri.org/publication/thirsting-for-justice.

FIMA (Corporación Fiscalía del Medio Ambiente). 2020. "Informe. Análisis Cualitativo Entrevistas Actores Clave, Percepción sobre el Uso y Acceso a la Información y Datos Climáticos en Chile" (Report. Qualitative Analysis of Interviews with Key Actors, Perception on the Use and Access to Climate Information and Data in Chile).

Foro de Ministerios de Medio Ambiente de America Latina y el Caribe (Forum of Ministers of Latin America and the Caribbean). 2018. "Buenos Aires Declaration." https://wedocs.unep.org/bitstream/handle/20.500.11822/26515/BuenosAires_Declaration.pdf.

Fritz, S., L. See, T. Carlson, M. Haklay, J. Oliver, D. Fraisl, R. Mondardini, et al. 2019. "Citizen Science and the United Nations Sustainable Development Goals." *Nature Sustainability* 2: 922–30.

Futuro en Común. 2018. "Una Agenda 2030 Transformadora para L=las Personas y el Planeta: Propuestas para la Acción Política." ("A Transformative 2030 Agenda for the People and the Planet: Proposals for Political Action.") https://futuroencomun.net/informe-de-la-agenda-2030-una-mirada-desde-la-sociedad-civil/.

Gil-Garcia, J. R., M. Gasco-Hernandez, and T.A. Pardo. 2020. "Beyond Transparency, Participation, and Collaboration? A Reflection on the Dimensions of Open Government." *Public Performance and Management Review*, 483–502.

GFDRR (Global Facility for Disaster Reduction and Recovery). 2018. "Machine Learning for Disaster Risk Management." Washington, DC: GFDRR. https://opendri.org/resource/machine-learning-for-disaster-risk-management/.

Global Commission on Adaptation. 2019. "Adapt Now: A Global Call for Leadership on Climate Resilience." Global Commission on Adaptation. https://gca.org/global-commission-on-adaptation/report.

Government of Sierra Leone. n.d. "Sierra Leone WASH Data Portal." https://washdata-sl.org/water-point-data/water-point-functionality/. Accessed April 16, 2020.

GovLab. 2018. "Toward an Open Data Demand Methodology in Costa Rica: Focus on Data 4 Climate Change and Environmental Degradation."

Hsu, A., W. Khoo, N. Goyal, and M. Wainstein. 2020. "Next-Generation Digital Ecosystem for Climate Data Mining and Knowledge Discovery: A Review of Digital Data Collection Technologies." *Frontiers in Big Data*, September 10. https://doi.org/10.3389/fdata.2020.00029.

IPCC (Intergovernmental Panel on Climate Change). 2018. "Summary for Policymakers." In *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*, edited by V. Masson-Delmotte, P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, et al. Geneva: IPCC.

Jairaj, B., A. Agarwal, T. Parthasarathy, and S. Martin. 2016. "Strengthening Governance of India's Appliance Efficiency Standards and Labeling Program." Washington, DC: World Resources Institute. https://www.wri.org/publication/strengthening-governance-indias-appliance-efficiency-standards-and-labeling-program.

Jordan, A., D. Huitema, J. Schoenefeld, H. van Asselt, and J. Forster. 2018. "Governing Climate Change Polycentrically: Setting the Stage." In *Governing Climate Change: Polycentricity in Action?*, edited by A. Jordan, D. Huitema, H. van Asselt, and J. Forster, 3–26. Cambridge: Cambridge University Press.

Khagram, S., A. Fung, and P. de Renzio. 2013. "Open Budgets: Political Economy of Transparency, Participation, and Accountability." Washington, DC: Brookings Institution Press.

Kim, H. 2019. "Data.Gov at Ten and the OPEN Government Data Act." Data.Gov. https://www.data.gov/meta/data-gov-at-ten-and-the-open-government-data-act/.

Lindley, S., A. Kazmierczak, A. Connelly, C. Robinson, and J. O'Neill. 2014. "Climate Just." https://www.climatejust.org.uk/about.

Lizbona Cohen, A. 2019. Interview between the authors and Alexandra Lizbona Cohen, Transparency, open data and climate change in Uruguay. December 18.

Macfeely, S. 2019. "The Big (Data) Bang. Opportunities and Challenges for Compiling SDG Indicators." *Global Policy* 10: 121–33.

Metzger, E., A. Dickerson, D. Drew, N. Joseph, A. Meyer, E. Northrop, A. Prasann, E. Reichart, and G. Yehounme. 2018. "The Ambition Loop: How Business and Government Can Advance Policies That Fast Track Zero-Carbon Economic Growth." UN Global Compact, We Mean Business, and World Resources Institute. https://ambitionloop.org/s/The-Ambition-Loop-rfmw.pdf.

Ministerio de Ambiente (Ministry of Environment). "Política Nacional de Cambio Climático (National Climate Change Policy) (Executive Decree 310/017)." 2017. http://www.mvotma.gub.uy/politica-planes-y-proyectos/politica-nacional-de-cambio-climatico.

Mogelgaard, K., A. Dinshaw, N. Ginoya, M. Gutiérrez, P. Preethan, and J. Waslander. 2018. "From Planning to Action: Mainstreaming Climate Change Adaptation into Development." Working Paper. Washington, DC: World Resources Institute. https://www.wri.org/publication/climate-planning-to-action.

Monge Vargas, R. 2019. Personal communication between the authors and Rafael Monge Vargas, Director, CENIGA, Ministry of Environment and Energy of Costa Rica. November 19.

Morales, M. 2018. "Brechas de Conocimiento en Adaptación al Cambio Climático: Informe de Diagnóstico Costa Rica" (Knowledge Gaps in Climate Change Adaptation: Costa Rica Diagnostic Report.) Red Regional de Cambio Climático y Toma de Decisiones (Regional Network of Climate Change and Decisionmaking). UNITWIN Program, UNESCO, LatinoAdapta Project. http://www.cambioclimaticoydecisiones.org/proyecto-latinoadapta/informe-de-diagnostico-costa-rica-brechas-de-conocimiento-en-adaptacion-al-cambio-climatico/.

Moya, A. L. 2019. Personal communication between the authors and Ana Lucía Moya, Climate Change Directorate, Ministry of Environment and Energy of Costa Rica. December 10.

NASA DEVELOP (National Aeronautics and Space Administration). 2017. "Rwanda Ecological Forecasting." https://develop.larc.nasa.gov/2017/summer/RwandaEco.html.

Open Climate Collabathon. 2020. "Open Climate Project." Open Climate Collabathon. https://www.collabathon.openclimate.earth/open-climate-project.

Open Data Barometer. 2017. *Global Report: Fourth edition.* The World Wide Web Foundation. https://opendatabarometer.org/doc/4thEdition/ODB-4thEdition-GlobalReport.pdf.

Open Data Charter. n.d. "International Open Data Charter Principles." https://opendatacharter.net/principles/. Accessed March 23, 2020.

Ozbagdatli, N. 2019. Personal communication between the authors and Nurettin Ozbagdatli, CCE Portfolio Manager, UNDP Turkey. November 18.

Palmer, J.R.B., A. Oltra, F. Collantes, J.A. Delgado, J. Lucientes, S. Delacour, M. Bengoa, et. al. 2017. "Citizen Science Provides a Reliable and Scalable Tool to Track Disease-Carrying Mosquitoes." *Nature Communications* 8 (1): 916. doi:10.1038/s41467-017-00914-9.

Pastorino, J.G. 2019. Interview between the authors and Juan Gonzalo Pastorino, Consultant, NAP Cities and Infrastructure, UNDP. December 20.

Petersen, R. and L. Pintea. 2017. "Forest Watcher Brings Data Straight to Environmental Defenders." World Resources Institute. Blog. September 26. https://www.wri.org/blog/2017/09/forest-watcher-brings-data-straight-environmental-defenders.

Pineda, S. 2017. "Aclímate Colombia (Acclimatize Colombia), a New Light for Colombian Farmers." International Center for Tropical Agriculture (CIAT). Blog. August 22. https://blog.ciat.cgiar.org/aclimate-colombia-acclimatize-colombia-a-new-light-for-colombian-farmers/.

Pino Zúñiga, F., A. Cozzi, N. Carfi, and D. Grinspan. 2020. "Final Report: Data for Climate Action in Chile."

Open Data Charter. https://drive.google.com/file/d/1LwSThXTmsNwQQ64MFX2735PhYPaEEMYc/view?usp=sharing&usp=embed_facebook.

Ryan, D., and E. Bustos. 2019. "Knowledge Gaps and Climate Adaptation Policy: A Comparative Analysis of Six Latin American Countries." *Climate Policy* 19 (10): 1297–1309. doi:10.1080/14693062.2019.1661819.

Scobie, M. 2016. "Policy Coherence in Climate Governance in Caribbean Small Island Developing States." *Environmental Science & Policy* 58 (April): 16–28. doi:10.1016/j.envsci.2015.12.008.

Shakya, C., K. Cooke, N. Gupta, Z. Bull, and S. Greene. 2018. "Building Institutional Capacity for Enhancing Resilience to Climate Change: An Operational Framework and Insights from Practice." Learning Paper. Action on Climate Today. https://www.preventionweb.net/publications/view/61584.

Sistema Nacional de Respuesta al Cambio Climático y Variabilidad (SNRCC) Uruguay. 2020. "Sistema de Programación, Medición, Reporte y Verificación de la Política Nacional de Cambio Climático (PNCC) y la Contribución Determinada a Nivel Nacional (CDN) (Programing, Measurement, Reporting, and Verification System for the National Climate Change Policy and the Nationally Determined Contribution)." http://www.mvotma.gub.uy/objetivos-cdn.

Swedish EPA (Environmental Protection Agency). n.d. "Environmental Data Management Strategy." http://www.naturvardsverket.se/strategi-for-miljodatahantering. Accessed March 23, 2020a.

Swedish EPA (Environmental Protection Agency). n.d. "General Process for Making Datasets Available." http://www.swedishepa.se/Guidance/Guidance/Open-data/. Accessed March 23, 2020b.

Tye, S., J. Waslander, and M. Chaudhury. 2020. "Building Coastal Resilience in Bangladesh, the Philippines, and Colombia: Country Experiences with Mainstreaming Climate Adaptation." Working Paper. Washington, DC: World Resources Institute. www.wri.org/publication/buildingcoastal-resilience.

UNECE (United Nations Economic Commission for Europe). 2014. "Conference of European Statisticians Recommendations on Climate Change-Related Statistics." Geneva: United Nations Economic Commission for Europe. https://www.unece.org/stats/publications/ces_climatechange.html.

UNDRR (United Nations Office for Disaster Risk Reduction). 2019. "Global Assessment Report on Disaster Risk Reduction". Geneva: UNDRR. https://www.undrr.org/publication/global-assessment-report-disaster-risk-reduction-2019.

UNFCCC (United Nations Framework Convention on Climate Change). 2017. "Implementation of the Framework for Capacity-Building in Developing Countries: Synthesis Report by the Secretariat." FCCC/SBI/2017/3.

UNFCCC (United Nations Framework Convention on Climate Change). 2018. "Implementation of the Framework for Capacity-Building in Developing Countries: Synthesis Report by the Secretariat." FCCC/SBI/2018/5.

U.S. GAO (United States Government Accountability Office). 2015. "Climate Information: A National System Could Help Federal, State, Local, and Private Sector Decision Makers Use Climate Information." https://www.gao.gov/products/GAO-16-37.

Venkateswaran, K., K. MacClune, L. Tincani, and S. Biswas. 2018. "Using Climate Information for Climate-Resilient Water Management: Moving from Science to Action." Learning Paper. Action on Climate Today. https://www.preventionweb.net/publications/view/59833.

Verhulst, S., and A. Young. 2016. "Open Data Impact: When Demand and Supply Meet." GovLab. http://www.thegovlab.org/static/files/publications/open-data-impact-key-findings.pdf.

Verhulst, S., and A. Young. 2018. "Toward an Open Data Demand Assessment and Segmentation Methodology." Washington, DC: Inter-American Development Bank. https://publications.iadb.org/en/toward-open-data-demand-assessment-and-segmentation-methodology.

Worker, J., and C. Excell. 2018. "Climate Change Open Data for Sustainable Development: Case Studies From Tanzania and Sierra Leone." Global Partnership for Sustainable Development Data. https://www.data4sdgs.org/resources/climate-change-open-data-sustainable-development-case-studies-tanzania-and-sierra-leone.

World Bank. 2014. "Open Data for Resilience Field Guide." Washington, DC: World Bank Group. https://www.gfdrr.org/en/publication/open-data-resilience-initiative-field-guide.

World Bank. 2015. "Open Data Readiness Assessment Prepared for the Government of Sierra Leone." Washington, DC: World Bank Group. https://opendatatoolkit.worldbank.org/docs/odra/odra_sierra_leone.pdf.

World Bank. 2016. "Open Data for Resilience Initiative: Policy Note and Principles." Washington, DC: World Bank Group. https://opendri.org/resource/opendri-policy-note-principles/.

World Bank. 2018. "Design for Impact: Integrating Open Data and Risk Communication for Decision-Making." Washington, DC: World Bank Group. https://opendri.org/resource/design-for-impact-open-data-and-risk-communication-for-decision-making/.

World Bank. 2019. "Readiness Assessment Tool." Washington, DC: World Bank Group. http://opendatatoolkit.worldbank.org/en/odra.html.

WRI (World Resources Institute). n.d. "How Mars Uses Aqueduct." Aqueduct. https://www.wri.org/aqueduct/how-mars-uses-aqueduct. Accessed March 2, 2020.

Young, A., and S. Verhulst. 2017. "Aclímate Colombia: Open Data to Improve Agricultural Resiliency." GovLab. https://odimpact.org/files/case-aclimate-colombia.pdf.

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ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

Our Challenge
Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision
We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

ABOUT OPEN DATA CHARTER

The Open Data Charter is a collaboration of more than 100 governments and organizations committed to opening up data based on a shared set of principles, including that data should be open by default, timely, and interoperable. Our goal is to embed the use of open data as a central tool to help governments solve the most pressing policy challenges of our time.

Mission
To make data open and freely available, while protecting the rights of people and communities. To see this shift help solve some of the most pressing challenges of our time, creating more just societies and innovative economies.

Vision
We want a world in which governments collect, share, and use well-governed data, to respond effectively and accountably to our most pressing social, economic, and environmental challenges. We want this to happen by default unless it would demonstrably infringe human rights.
Specifically, we want:

- public officials to balance the tradeoffs between advancing transparency and accountability using data and protecting the rights of people and communities
- citizens to be able to easily see and influence what their public officials do, and to trust their institutions
- people to be able to use openly available data and accountable automated tools to access equitable public services

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