
# Open Data:
## A Path to Climate Resilience and Economic Development in South Asia?


### Authors

**David P. Rogers,** Lead Meteorological Consultant, World Bank

**Vladimir Tsirkunov,** Lead Specialist, Head of the GFDRR Hydromet Program, World Bank


*Technical Note from the series focusing on specific aspects of Public and Private Engagement in Hydromet Services*


### Abstract

The World Bank's strategy for South Asia emphasizes promoting sustainable and inclusive growth, investing in people, and strengthening resilience. The economic recovery following the adverse impacts of COVID-19 is an opportunity for the region to benefit from an expanding digital ecosystem. Large gains would accrue from data that are generated, collected, organized, and exchanged broadly for the purpose of deriving value from the accumulated information. South Asia is the most exposed region in the world to flooding and heavily impacted by other hydrometeorological hazards. The technical note explores the potential benefits of adopting national policies that support the free, unrestricted use and re-use of data, and in particular, the effect on the development of hydrometeorological services by the public and private sectors. We conclude that open data policies would jump start the transformation to data economies increasing climate resilience, and increase the ability of the weather enterprise to create and distribute the knowledge needed by everyone to make weather-informed decisions.


### Introduction

Economic development in South Asia, which has experienced a long period of robust growth averaging 6 percent, is expected to contract by 7.7 percent in 2020 on account of the adverse impacts from COVID-19 that are hindering consumption and services.[1] The World Bank's strategy for South Asia emphasizes promoting sustainable and inclusive growth, investing in people and strengthening resilience. It accentuates support for policy reforms for private sector-led job creation, and addresses climate risks through disaster preparedness and management.[2] The 2020 assessment of the region's hydrometeorological (hydromet) services highlights the increasing exposure of all of countries


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## Abbreviations

| | |
|---|---|
| **APIs** | application programming interfaces |
| **ARRCC** | Asia Regional Resilience to a Changing Climate |
| **CARE** | Climate Adaptation and Resilience for South Asia |
| **ECMWF** | European Centre for Medium-Range Weather Forecasts |
| **EU** | European Union |
| **HVDs** | high-value datasets |
| **ICT** | Information and Communication Technology |
| **IoT** | Internet of Things |
| **ITS** | Intelligent Transport System |
| **NMHSs** | National Meteorological and Hydrological Services |
| **RIMES** | Regional Integrated Multi-Hazard Early Warning System |
| **SAARC** | South Asia Association for Regional Cooperation |
| **SAHF** | South Asia Hydromet Forum |
| **SAR** | South Asia Region |
| **WMO** | World Meteorological Organization |

in South Asia to the impacts of growing hydromet hazards caused by economic growth, greater capital stocks, rising population, and continued urbanization (World Bank 2020). South Asia is the most exposed region in the world to flooding that affects 64 percent of the population of the region (World Bank 2012).

The economic contraction and increasing financial constraints in most South Asian countries are jeopardizing physical flood mitigation measures due to decreased capacity for borrowing, at least in the short term, and heightening the need to use non-structural measures, such as early warning and evacuation, to mitigate the adverse impact of weather, climate, and hydrological hazards on people and the economy.

We argue that all economies are beneficiaries of an expanding digital ecosystem in which data is generated, collected, organized, and exchanged for the purpose of deriving value from the accumulated information, and that large gains would accrue from data being used broadly. Efforts to mitigate the impact of COVID-19 on people's health and the economy, for example, highlight the vital importance of sharing data and ideas as widely as possible—nationally, regionally and globally (Rogers et al. 2020a).

Our technical note considers the weather-sensitive nature of all South Asian economies and the strategic importance of increasing private sector-led job creation. We explore the potential benefits of adopting national open data policies, and in particular, the potential bearing on the development of hydrometeorological services by the public and private sectors.

*The Power of Partnership* report (World Bank 2019) highlighted the tendency of governments to underestimate the social and economic benefits of a well-developed hydromet value chain with the consequence that the development of a holistic business model is not prioritized in many countries, potential benefits are unrealized, and regulatory policies focus mainly on their effect on public institutions rather than on the development of the wider economy.

The key finding of the technical note is that the adoption of national data policies that support the free, unrestricted use and re-use of data would have significant economic benefit in general, and would increase opportunities for the provision of bespoke services for manufacturing, agriculture, water management, telecommunications, insurance, transportation, energy, healthcare, and other sectors.

While impacting all segments of the economy, open data would also expand the opportunities for home-grown commercial hydromet services[3] in all South Asian countries contributing to job growth, development of weather-dependent sectors of the economy, and greater climate resilience through more effective knowledge creation based on access to national data. The expansion of the sector should also support continued investment in national meteorological and hydrological services (NMHSs) since these provide the foundation for nationally available data, and can act as the regulatory authority for the provision of non-public goods services—if they do not provide commercial services themselves—and could benefit public security through enhanced severe weather warning services.

## Economic Benefits of Shared Data

The ability to use data effectively is at the centre of all modern economies and should be equally accessible in developing countries. Data are an essential resource for job creation, social progress, economic development, and innovation. Because hydromet data are non-rival, potential gains are apparent to data being used broadly to increase social efficiency (Jones and Tonetti 2020). Sharing data widely may be encouraged through markets that provide financial incentives, but the focus is on maximizing the benefit of publicly funded data through its free use and re-use without restriction. In the European Union (EU), the direct effect of open data on the EU28+ economy was estimated at €325 billion between 2016 and 2020 with a 36.9 percent increase in the share of GDP for the same period (**Figure 1**).[4] The weather derivatives market, driven by freely available weather data in the USA, grew from US$4.6 billion in 2004 to US$19.2 billion in 2007.[5] Across all core public sector data assets, open data was generating 0.5 percent more GDP than paid data[6] as of March 2016.

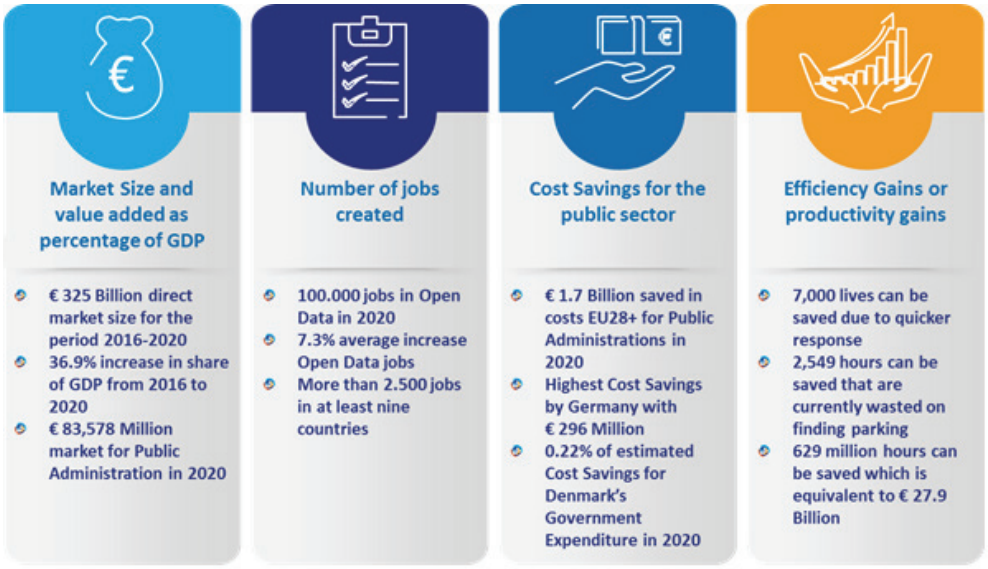


**Figure 1. Benefits of open data in the European Union. Estimated values for 2020 for the EU 28+.**

*Source:* European Data Portal. www.europeandataportal.eu/sites/default/files/analytical_report_n9_economic_benefits_of_open_data.pdf

In its directive on open data and the re-use of public sector information (**Box 1**), the EU identifies high-value datasets (HVDs) that organizations would have to make available free of charge, in machine readable format and via application programming interfaces (APIs), and where applicable, as a bulk download.[7] One of six thematic categories is meteorological, which is recognized as having important socio-economic benefits and high value for the economy and society. In situ meteorological data from instruments and weather forecasts are identified as HVDs.

Competitive advantage has long existed in the USA because of the value of the public good provided by government data through its policy of open access that complements data available to the private sector (Hughes-Cromwick and Coronado 2019). These authors note that with advances in data capabilities and information technology, public data collection and sharing are increasingly important to keep pace with economic structural changes. Growth in the value add of government data has been achieved by the ability to link directly to government data sources through APIs and their integration with business data through advances in data analytics. Technology is an important com-

### Box 1. Open data and the re-use of public sector information (based on EU Directive 2019/1024)

Open data refer to information collected, produced or paid for by public bodies, and made freely available to be used, re-used, and shared by anyone for any purpose.

The public sector collects, produces, reproduces, and disseminates a wide variety of information in many areas of activity, such as social, political, economic, legal, geographical, environmental, meteorological, hydrological, seismic, touristic, business, and educational areas. Documents produced by public bodies constitute a vast, diverse, and valuable pool of resources that can benefit society. Providing that information, which includes dynamic data, in a commonly used electronic format allows citizens and legal entities to find new ways to use them and create new, innovative products, and services.

Intelligent data usage, including their processing through artificial intelligence applications, can have a transformative effect on all sectors of the economy.

Allowing the re-use of documents held by a public sector body adds value for the benefit of re-users, end users, and society in general, and in many cases, for the benefit of the public sector body itself, by promoting transparency and accountability and by providing feedback from re-users and end users that allows the public sector body concerned to improve the quality of the information collected and the performance of its tasks.

ponent of open data. Open formats that are machine readable through APIs at zero cost are an important aspect of accessing government data for any sector of the economy—public, private, and academic.

The World Bank is a strong advocate of open data policies and is actively engaged in promoting open data policies in developing countries, highlighting the significant economic and social value of open data (World Bank 2017). The World Bank has identified four areas where open data can have significant impact: (i) direct and indirect benefits to the economy; (ii) improved efficiency and effectiveness of public services; (iii) government transparency and accountability; and (iv) better information sharing and decision making within governments. Among the World Bank open data initiatives, the South Asia Region (SAR) has a relatively low number of funded projects, well below the World Bank average. One example is from Mysuru (Mysore), India where the World Bank assisted a public transport corporation to open its bus location data (World Bank 2017). The data were being generated by the Intelligent Transport System (ITS), installed with the funding of a World Bank lending project. The World Bank's Development Data Group provided just-in-time customized assistance to what was to become one of the first examples of open urban transport data in India.

While open data policies exist in many SAR countries with public sector environmental data, for example, shared on open data portals, these datasets are not necessarily up to date, and therefore, the value of these initiatives may be marginal.[8,9,10] The open data barometer, which is published by the World Wide Web Foundation, measures how governments are publishing and using open data for accountability, innovation, and social impact. Bangladesh, India, Myanmar, Nepal and Pakistan in South Asia are ranked, and only India is within the leader group with a score of 43 out of 100, with the other countries showing a negative trend between the fourth and third editions of the survey report with scores between 1 out of 100 and 15 out of 100.[11] These low scores reflect unwillingness of governments to allow open data to be used without restrictions, particularly if the use involves criticism of the government. These restrictions spill over into meteorological and hydrological data that could be used to highlight weaknesses in the government services. Ideally, closer scrutiny should be an opportunity to improve public services.

## Reflections from World Bank Open Data Initiatives

A critical component of open data is meaningful engagement between the government and business users in order for countries to benefit from investments in open data policies and infrastructure. The World Bank (2017) identified a number of other issues that must be addressed for open data policies to work effectively, and that may require external technical assistance to accomplish.

- Creating advocacy at a senior level of government above the operational level of ministries to ensure sharing of data across government as well as with the wider society.
- Encouraging governments to be explicit about transparency related to data and the digital economy, or economic use of data for relevant officials to develop detailed data policies.
- Creating action plans on open data that are matched with implementation plans within government and appropriately resourced.
- Creating legislation on open data that includes freedom of information and data protection provisions, or includes these provisions in separate Acts.
- Creating procedures and clarity on who can release data; ideally, this should be automated through APIs.
- Overcoming the culture of official secrecy for open data policies to work without risk to individual government officials. In many instances, open data policies sit alongside digital security and social media usage policies that create a restrictive legal environment for data access.
- Amending national security legislation, as required, to permit open government data.
- Reviewing and amending prevailing practices on collecting charges for electronically available data. In the case of charges for meteorological data that has often been on a cost-recovery basis, the fees are usually less than one percent of the total budget of the agency. In some cases, the cost of fee collection exceeds the fees collected. Charging for data has its antecedents in European policies (Rogers et al. 2021) that are being replaced with free access to use and re-use data without restriction.
- Implementing clear policies on copyright and licensing of government data. Restrictive copyright laws applied to government data are a major obstacle.
- Helping agencies understand that maximum social welfare is achieved by sharing government data, rather than by sharing in the profits generated by data re-use.
- Helping governments recognize the value of information for their economies and its pivotal presence within the structure of government for data policies.
- Developing policies that encourage regional data sharing are of high value. For example, RIMES (Regional Integrated Multi-Hazard Early Warning System) Council members, including the South Asia Region, have agreed to share additional meteorological observations and climate records with the European Centre for Medium-Range Weather Forecasts (ECMWF) in exchange for improved forecast products from the center. Future efforts may also lead to development of a regional approach to optimize weather, water and climate observational networks.

- Promoting compliance with emerging international standards as an incentive for good national open data policies.
- Encouraging political and institutional leadership with cross-government experience that is essential to implement effective open data policies.
- Using Information and Communication Technology (ICT) ministries, which have an important role in helping governments understand the role of open data and in making it available.
- Supporting the digitization of potentially valuable government data including old records where they may be useful, for example, climate-related data and geospatial data.
- Increasing awareness of senior government staff to the availability of national data.
- Emphasizing the importance of providing data in re-usable machine-readable formats.
- Supporting academia, which has a role to play in developing applications to access government open data for research and business uses.
- Identifying where sufficient data may not be available for all business applications, and taking these gaps into account as new government data sources are developed or improved.
- Encouraging governments, departments and agencies to engage with the users of their data.
- Encouraging wider use of social media, which is an important tool to engage with users of government data.

While national open data initiatives are the goal, countries may benefit by initiating individual programs to put open data into practical use. Given the potential high value of meteorological datasets, this may be an appropriate starting place to test the concepts on smaller scale, but with clear social and economic benefits.

## National Meteorological Services and Data Policies

Despite the high value of meteorological observations, only a small fraction of publicly funded meteorological data is openly available nationally and internationally. Countries agree to share essential data[12] with the World Meteorological Organization (WMO), and additional data are shared at the discretion of the NMHSs. The latter is often a much larger dataset and much less of these data are shared. The spatial and temporal scales recommended for essential data are at very low resolution relative to the data requirements of weather prediction schemes. Improvements in forecasts and warnings are increasingly focused on providing reliable information on street level scales that put much greater spatial and temporal requirements on observational data (Palmer 2019). At the same time, new sources of data from Internet of Things (IoT), sensors, and shared personal data are contributing to forecast improvements (Hygen et al. 2018).

Since nearly all, if not all, data created by an NMHS is financed by government, it should be in the interest of the government to maximize the use and benefit of those data. However, in South Asia, meteorological data are not shared widely, resulting in large costs associated with the inefficiency that arises from the non-rival input not being used at the appropriate scale. Given the nature of meteorological phenomena, this scale ranges from national to global; that is, maximum efficiency and benefit are achieved by sharing data as widely as possible to help many.

While observational data have always been important in meteorological forecasting, the advent of machine learning and artificial intelligence as prediction algorithms highlight the high value of meteorological, hydrological and ancillary datasets. This is especially important in their application to high resolution, very short- and short-range high impact weather and flood forecasts (Palmer 2019, Rogers et al. 2020b, and Hygen et al. 2018).

The World Bank (2017) notes that weather data collected by government weather services are an invaluable resource for agricultural purposes, transportation planning, disaster risk management, and multiple other institutional uses as well as for individual decision making by citizens. In addition, ample evidence supports the practice that regional data sharing increases the utility of observations, and that the co-production and dissemination of forecasts and warnings improves the reliability of information across multiple countries.[13,14,15] When provided in open formats, such data are used by optimization software, visualizations, and analyses that make their re-use easy, fast, and cheap, and can be further enhanced through third-party tools, apps, and services.

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Despite this, many NMHSs seem unwilling to embrace open data. The reasons vary, including lack of clarity on the part of higher levels of government on open data policies and its application to specific government departments, lack of international guidance from WMO, ambiguous security laws, and lack of ICT capacity and staff to make machine readable data available through APIs. The motivation may also be related to concerns about creative destruction, where the public entity fears that by sharing data, private companies would be able to provide a better service to the public (Rogers et al. 2021). While such concerns might be true, the issue can be readily addressed by policy where the government identifies the authority of the NMHS and its responsibility for public weather forecasts and warnings, and the private sector focuses on commercial fee-paying based services. The wilful misuse of public meteorological information must also be addressed, without contradicting the principle of open data. In the absence of clear legal framework, the NMHS may be justified in its concerns, especially if public expenditures on its operating budget are inadequate to fulfil its public functions, as is the case in most South Asian

countries (World Bank 2021). Nevertheless, open meteorological data would improve the development of nascent private meteorological services, and ultimately an optimum benefit would be derived from government's investment in weather data.

On the assumption that a country accepts the evidence that open data policies can have significant economic benefits (World Bank 2017, 2019), what should a meteorological data policy include, and could this be generalized to meteorological services throughout South Asia? Most NMHSs have long records of weather data that form the foundation of their climate record. Weather data shared in real time would provide huge opportunities for the private sector to generate tailored products to a wide range of users with the potential for supplemental data generated by the private sector to be shared with the government agency (Rogers et al. 2021). While paid services exist—for example, the Kerala State Disaster Management Agency has contracted IBM, Earth Networks and Skymet on an experimental basis to augment services provided by the Indian Meteorological Department[16]—open data sharing based on business-to-government modality is almost non-existent. Civil society and non-governmental organizations, on the other hand, are more actively pursuing open data and making data that they produce freely available to everyone. After the devasting 2015 earthquakes in Nepal, for example, open data activists in the country developed post-quake maps to help responders locate people requiring urgent assistance.[17] In Sri Lanka, high resolution exposure data, critical for impact-based forecasts, are also dependent on community volunteers contributing to open data sharing platforms[18] that in turn break some of the data sharing barriers as authorities preferentially use these datasets.

The basic tenets of a meteorological data policy should consider:

- All meteorological and related data collected by the NMHS should be available free of charge to other government agencies, the private sector, and the citizens to use and re-use as they see fit without restriction for national purposes to empower them make better decisions based on insights from these data. These data shall include quality-assured and quality-controlled meteorological and related datasets and raw data, where quality control is not possible because of latency issues.
- Other government agencies and the private sector should be encouraged to collect meteorological data, and may operate their own observing networks or partner in the maintenance and operation of national networks. These data should be shared with the NMHS to improve the effectiveness of its forecasts and warning services.
- Individuals will generate increasing amounts of data and may share these data. The use of personal data by the NMHS, disaster management agencies and other relevant bodies shall be compliant with strict data protection rules.
- The NMHS shall maintain high availability online data repositories as an open data service to facilitate the sharing of data and datasets nationally and that can be accessed by users at their convenience using APIs. Registration should not be necessary.
- The Creative Commons Attribution 4.0 International license (CC BY 4.0) shall be used by the NMHS open data service.[19]
- The NMHS shall not be liable for any damage, loss, claim, or lawsuit arising from any error, inaccuracy or other problems with the data or results arising from the use of the data or datasets.

- The use and re-use of data shall not infringe on the authority of, or compete with, the NMHS and other government agencies in carrying out their public responsibilities, for example, issuance of public weather and flood warnings and aeronautical meteorological services.

The data policy would be significantly strengthened with a law that establishes the meteorological authority and regulator of meteorological services within a country. Ideally, the function of regulator and service provider should be distinct. This functional separation is particularly important if the public agency also provides commercial services that must comply with competition law. The only formally regulated service is the provision of meteorological service for air navigation, which is governed by the Convention on International Civil Aviation.[20] The role of the authority and the aeronautical meteorological service provider are distinct functions, and, in many instances are separate entities, but not always. A meteorological law can establish the NMHS as the competent authority and point of accountability for weather, climate and, as appropriate, hydrological activities internationally, nationally, and sub nationally, including: the production and communication of warnings; meeting international treaty obligations; and setting standards for observations among other things. However, approving and licensing commercial service providers and public agencies that provide commercial services would be the responsibility of the regulator. The role of the regulator would be to ensure that the customer's interests are respected while setting up conditions for growth and innovation.[21] As the competent authority, the NMHS would be responsible for ensuring that the contributions of individuals and other organizations and institutions are recognized and used optimally for the sound development of meteorological services. This includes individuals and organizations engaged in weather observations, forecasting, services provision, disaster prevention, exploitation of climate resources, and research.

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## Building a Weather-proofed Economy

It is recognized that the task of ensuring that economies are weather proofed and capable of adapting to the impacts of climate change requires a significant expansion of activities to enable weather information to be created and provided to society (Thorpe and Rogers 2018). The US National Weather Service coined the phrase "weather-ready nation", and developed programs to better prepare the whole of society to cope with and adapt to the prevailing and future meteorological conditions. Agriculture and food security, for example, require early warning systems that can be used to mitigate the impact of droughts and floods. Drought early warning systems can inform governments and aid agencies months in advance to ensure a timely and effective response, and agro-meteorological services can provide farm-level guidance to improve the efficient use of resources. This challenge cannot be met by government agencies alone; rather, it requires a joined-up approach that uses the capabilities of the entire weather enterprise—public, private and academic sectors—to increase the quality of weather information to save lives and property, and support sustainable economic development, in other words, to maximize the social and economic benefit of the full meteorological value chain (World Bank 2019).

The growth of private sector weather services is often viewed as a threat rather than an opportunity in developing countries with many NMHSs resorting to protectionism and not engagement (Rogers et al. 2021). This is partly due to the low levels of budgetary

support that governments provide to NMHSs to fulfil their core responsibilities to protect life and property. Every weather-proofed economy requires a properly budgeted and staffed NMHS capable of discharging its public duty (Rogers et al. 2019, Rogers and Tsirkunov 2013).

The World Bank (2019) has recommended developing country-specific strategies to foster public–private engagement starting with one of three reference scenarios, depending on the particular context of the country.

- **Jump Start** – Jump start the hydrometeorological value chain by taking advantage of the private sector capabilities while laying the foundation for a sustainable NMHS.
- **Strengthen** – Strengthen and focus the NMHS on providing public services and lay the foundation for the private sector to provide non-public services.
- **Optimize** – Optimize the cost of public services by leveraging synergies with the private sector.

Based on *The Power of Partnership* Report (World Bank 2019) and the foregoing arguments in this technical note, several critical steps are essential to provide the knowledge base for a weather-proofed economy. These start with a commitment at a high level of government to the process and are followed by:

- Creating or strengthening the legal and regulatory frameworks that govern the meteorological and hydrological sector, open data, and competition.
- Sustainably funding the NMHS for its public mandate.
- Creating and maintaining an open data environment for public funded data.
- Regulating the non-public sector meteorological services market.
- Regulating the role of the NMHS in the provision of non-public meteorological services through compliance with competition law.
- Creating a single public authority for warnings.
- Promoting engagement and trust through an open and continuous dialogue between public, private, and academic sectors.
- Investing in young professionals with modern IT skills to develop innovative solutions across all sectors including the NMHS.
- Investing in awareness of the social and economic benefits of using meteorological knowledge for government and business decisions.
- Shaping future investment projects based on the above.

In some countries, private sector weather service providers are totally absent. Efforts to improve public and private sector engagement would necessarily require arrangements with international service providers. However, an objective of any national strategy should be to develop national capacity within the private sector. This would require appropriate regulation to encourage entrepreneurship in national universities and international providers to establish national subsidiaries and investment in lean startup companies (Ries 2011). These lean startups would focus on the development of innovative new weather-related products that emphasize fast iteration and customer insights to

bring useful solutions quickly to market, expanding the weather enterprise quickly and sustainably to contribute effectively to weather proofing the economy. The lean startup is equally applicable to government agencies and the approach could be used to develop more useful products for civil society. This may be particularly helpful in the development of messaging and warning applications directed to the needs of individuals at risk.

Once the country is on a sustainable path with measurable societal and economic benefits of engaging the entire weather enterprise, it will be important to maximize the efficiency of the entire system. We return to the value of observations and data. If these are the fuel for the enterprise, it is necessary that they are available in optimal quantities. Namely, the observational networks must satisfy the requirements of all potential data users. Rogers et al. (2021) highlight the potential for the co-production of observations where many different actors could contribute to and use data from large scale national networks.

In addition to the expansion of the weather enterprise through national efforts, a huge opportunity emerges for South Asia to benefit from a regional approach to observational networks and services. EUMETNET[22] stands out as a particularly good example of countries cooperating to develop a cost-efficient, world-class, shared infrastructure for meteorological observations and forecasting in Europe that could be applied to South Asia. As members of the RIMES Council,[23] South Asian governments already benefit from cooperation and development through initiatives including the South Asia Hydromet Forum (SAHF),[24] the Asia Regional Resilience to a Changing Climate (ARRCC) Programme,[25] the World Bank Regional Initiative on Climate Adaptation and Resilience for South Asia (CARE) Project,[26] and the South Asia Association for Regional Cooperation (SAARC).[27] These programs can facilitate the introduction of more inclusive data policies. The data exchange agreement between RIMES and ECMWF could be the foundation to design a shared infrastructure for meteorological observations and open data.

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## Conclusions

A vibrant, climate-resilient society can be achieved by harnessing the power of data. This requires expanding national weather enterprises to provide more extensive weather and climate services that meet the varied needs of many different users. Throughout South Asia, this is hampered by national restrictions placed on access to publicly financed meteorological observations and data, and limited engagement between the public and private and academic meteorological sectors. The progress of governments in South Asia is slow in transforming their countries into data economies, despite overwhelming evidence that broadly shared data result in optimum social and economic benefits. Governments are investing in data but are not actively seeking a return on this investment of its re-use and potential to fuel business growth, employment, and revenue. Weather, water, and climate data on their own are not sufficient. It is the ability to mesh, combine, and integrate these data with social and economic data, and business data that will unlock social and economic development. Effective adaptation, building resilience, and risk financing strategies depend on it.

This technical note has laid out some steps that the World Bank Development Data Group (World Bank 2017) has tested, and that we posit, if implemented broadly, could jump start the transformation to data economies. By focusing, initially, on meteorological

data and services, its implementation would make an immediate contribution to South Asia's climate resilience, including countries' nationally determined contributions to reduce emissions and adapt to the devastations of climate change under the Paris Agreement,[28] and to plan resilient infrastructure. And the weather enterprise would be enabled to create and distribute the knowledge needed by everyone to make informed decisions by encouraging and promoting open data and the development of applications widely.

Although necessary and timely, it is not sufficient to rest with creating open data policies and making meteorological data freely available for use and re-use without restriction. It is unavoidable that open data will initially reveal the weaknesses in some NMHSs and other government institutions. Open data consumers should become advocates for service improvements in the public sector rather than be critics of the service providers. Governments also need to ensure that the public funding of observational networks and services are adequate and sustained, and that continued investment encourages entrepreneurship in private and academic sectors of the weather enterprise in South Asia to benefit all.

## Notes

1. https://www.worldbank.org/en/region/sar/overview
2. Ibid.
3. The commercial weather service market in India is estimated to be worth US$100 million and is growing at a rapid pace based on estimates from Skymet, an Indian private sector forecasting service, whose own business has grown from Rs. 2 crore in FY12 to Rs. 41 crore in FY19. However, future growth will depend on cooperation between the Indian Meteorological Department (IMD) and private companies. The global weather forecasting market is estimated to exceed US$2.7 billion by FY23. Cost benefits vary from 1:10 to 1:37 implying that the benefit to India is in the range of US$1 billion to US$37 billion.
4. https://www.europeandataportal.eu/en/highlights/economic-benefits-open-data. These statistics were compiled for the EU28+ prior to Brexit.
5. Ibid.
6. https://theodi.org/article/research-the-economic-value-of-open-versus-paid-data/
7. https://www.europeandataportal.eu/en/highlights/high-value-datasets
8. https://data.gov.in/catalogsv2?format=json&offset=0&limit=9&filters%5Bfield_ministry_department%3Aname%5D=India+Meteorological+Department+(IMD)&sort%5Bogpl_module_domain_name%5D=asc&sort%5Bcreated%5D=desc
9. http://data.gov.bd/dataset?topics=environment
10. http://documents1.worldbank.org/curated/en/274541588741142529/pdf/Bangladesh-Open-Data-Readiness-Assessment-Report-Open-Data-for-Economic-and-Social-Development-and-Improving-Public-Service.pdf
11. https://opendatabarometer.org/4thedition/report/
12. "As many data as possible that will assist in defining the state of the atmosphere at least on a scale of the order of 200 km in the horizontal and six to 12 hours in time" (Annex I of Resolution 40 of the World Meteorological Congress XII)
13. https://www.eumetnet.eu
14. https://www.ecmwf.int
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