Public and Private Engagement in Hydromet Services:

From Rivalry to Coproduction in Meteorological and Hydrological Service Delivery

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

Abstract

Complexities surround the relationships between the public and private sectors that fundamentally influence the provision of hydromet information and services. This technical note considers the potential conflicting roles of government and the private sector that lead to confrontation and how to shift from rivalry to the coproduction of services. Different methodologies are described including approaches to modernization, the issues and possible benefits of outsourcing through classical contracting, and the potential to coproduce services through partnerships and collaboration. This technical note considers the importance of legal frameworks, open data policies, and regulation to maximize the benefits of weather enterprise and expand public–private sector engagement.

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Introduction

Meteorological and hydrological (hydromet) services are critical to helping any society cope with weather extremes and to adapt to a changing climate. The World Bank and other development partners have financed numerous National Meteorological and Hydrological Services (NMHSs) modernization projects, and continue to explore ways that public service delivery can be further enhanced by better engaging the public and private sectors (World Bank 2019).

In this technical note, we explore the relationships between the public and private sectors, covering the gamut from how NMHSs are improved to how public and private weather, climate, and hydrological services are delivered to users. The tenet of this discourse is the potential benefit to the public sector of the increasing role of private providers of hydromet services in fulfilling the public sector's acknowledged responsibility for the protection of life and property from hydrometeorological hazards.

We start with a brief overview of some of complexities surrounding the provision of public services and the notion of rivalrous and nonrivalrous goods, and how this influences the relationships between the public and private sectors. As we explore this relationship, we consider different methodologies to contracting starting with approaches to transforming NMHSs, then discuss some of the issues and possible benefits of outsourcing through classical contracting followed by an analysis of the potential for coproduction of services through partnerships and collaboration.

The technical note draws heavily on *Rethinking Public Service Delivery: Managing with External Providers* (Alford and O'Flynn 2012), The Power of Partnership: Public and Private Engagement in Hydromet Services (World Bank 2019) and Weathering the Change: How to Improve Hydromet Services in Developing Countries (Rogers et al. 2019).

Conflicting Roles

Club goods and public goods are considered nonrivalrous since they can be consumed over and over again without depleting their supply.

Political and often ideological considerations determine how governments use rivalrous and nonrivalrous resources and club goods (**Figure 1**). Often this is strongly influenced by extant public and private sector institutions and sometimes international agreements. There are ongoing debates regarding the efficacy of the provision of services to the public by the public and private actors in many sectors including security services, transport, weather, and climate services among others. From an economic perspective, in nearly all including hydrometeorological services, is inherent an element of public goods, an element of private goods, and an element of club goods (**Figure 1**). Club goods and public goods are considered nonrivalrous since they can be consumed over and over again without depleting their supply. Data, including meteorological and hydrological observations, are nonrivalrous because they are infinitely useable (Jones and Tonetti 2020, Coyle et al. 2020). Private goods and common-pool resources are rivalrous since they can be consumed by a single user. At the same time common-pool resources and public goods are nonexcludable because nonpaying users cannot be excluded from using them or it is too costly or impractical to exclude them. Groundwater, fisheries, and forests are examples of common-pool resources.

In the field of meteorology, the path in favor of the provision of public goods is well trodden since basic meteorological services are nonrivalrous—that is a product provided to one person is available for all to use without losing its value (WMO 2015)—and a public

Figure 1. A definition matrix of private, public and club goods, and common-pool resources.

Note: Meteorological observations and data are nonrivalrous; however, products and services may be public, club or private goods depending on how they are used.

task of all NMHSs is to help ensure the safety of life, livelihoods, and property. However, in actual practice, the public goods are only a subset of the data and information available and funded by the government, which otherwise may be regarded as club goods shared among the NMHSs of the World Meteorological Organization (WMO) Members or restricted for the exclusive use of the originating NMHS.

Let us take public weather forecast as an example that shows that there is an element of both public and club goods in one. Although public weather forecasts—a part of a basic meteorological service—are considered nonrivalrous and nonexcludable **public** goods, these forecasts are created by combining data and information, which may be either public or club goods (**Box 1**).

In reality, when it is impossible to draw a clear line between public, private, and club goods, the importance of a clear and pragmatic national data policy cannot be underestimated. Among all WMO Members,[1] very few adhere to data policies that can be considered fully open; in other words, data that are freely available to everyone to use

Box 1. What good is data?

Many NMHSs treat some of the data from their publicly funded national observing networks as **public** goods, shared openly and freely, and some of their data as **club** goods making these data available for purchase to other parties, including other public sector institutions. This is often in compliance with a national data policy, which emphasizes cost recovery over the beneficial use of these data by the recipient. By convention, all NMHSs are expected to share a subset of their national meteorological observations (essential data) freely and unrestrictedly with the World Meteorological Organization (WMO) via the Global Telecommunication System (GTS), which is a network enabling NMHSs to exchange observations with each other and with a limited number of specialized WMO centres. In addition, NMHSs are urged to share additional data, often significantly larger datasets than essential data, with all Members of WMO; however, restrictions may be placed on these data limiting their reuse, especially for commercial purposes. These observations are in effect **club** goods; that is, they are highly excludable.

The overall impact is the global underutilization of publicly funded meteorological and hydrological observations and products; high value data, which if shared and used widely and without restriction, would approach a global social optimum helping many more people.

and republish as they wish, without restrictions from copyright, patents, or other mechanisms of control (World Bank 2019). The international data and information sharing requirements agreed by the Members of the WMO are relatively conservative and, in most countries, these relate to a small fraction of the total data available. Governments in many developing and some developed countries underfund their public services and then encourage or require their public institutions to recover or supplement the costs of the provision of public services by selling both basic and additional data as nonrivalrous, excludable club goods. These data may also be closed; that is only available to the originator of the data in a such a way that it enables it to develop private goods to compete with nongovernmental commercial services.

Since most public institutions are not structured as commercial services—often they are under regulations that directly prohibit any commercial activity—they have to use the following tactics: limiting access to their publicly financed data; legislating against the private sector providing services; and cross-subsidizing the provision of rivalrous services with public funds (World Bank 2019). Where the agencies are authorized to have commercial activities, they may apply the same methods. The net effect is poorer public forecasts of extreme weather, and the fallout in economic costs that could be avoided: (i) the underutilization of meteorological services by weather-sensitive businesses; (ii) the suboptimal development of the weather enterprise in countries that support these practices; and (iii) higher transaction costs (World Bank 2019). Achieving the sustainable development goals (SDGs) requires the weather enterprise to develop significantly (Thorpe and Rogers 2018). The World Bank report on public–private engagement emphasizes that maximum growth in the weather enterprise is achieved when the public service functions are properly supported by government and when the private sector is the sole provider of rivalrous, excludable services, citing the United States and Japan as exemplars (World Bank 2019).

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In some cases, the motive for the provision of club goods by public sector institutions is the notion that the sale of club goods—for example, observational data—and private goods such as forecasting services, can somehow subsidize the provision of public goods—national observational networks and public weather services—thereby reducing the cost to governments in the provision of public services. This approach is frequently mooted in developing countries but has its antecedents in practices introduced in Europe and elsewhere, which permitted government entities to compete with the private sector. In practice, this leads to directing limited human and financial resources available in NMHSs in developing countries to produce excludable goods. This diversion of resources leaves delivery of public goods in an unfavorable position, putting people and property at greater risk. An exception is the provision of aeronautical meteorological services, which are heavily regulated and provided on a cost recovery basis usually, but not necessarily, by a public sector institution. Since the service is mandatory, the provision does not fall in the bracket of club goods. However, the aviation industry is keen to ensure that the services they pay for are not a subsidy to the public sector and that the reuse of the data should be on commercial terms creating club goods and used to reduce the cost of services to the industry.

By providing private goods' services, the public service provider puts itself in competition with the private, commercial sector. In and of itself, this would not necessarily be an issue if competition rules exist and if those rules apply equally to all parties. For example, each entity should have access to the same information, which might otherwise be exclusively available to the public sector body. However, restrictions are often placed on data, which enhance the monopolistic position of the NMHS to the detriment of both public weather services and commercial markets (World Bank 2019).[2] By providing commercial services, the public sector also contributes to blurring the roles of the public and private service providers to the extent that the private sector may consider directly competing with the NMHS to provide public forecasts as a by-product of its commercial interests. Unless carefully managed and properly regulated, there is a risk to the provision of warnings where competition is, in principle, counterproductive to the responsibility of governments for warnings.

The Importance of Regulations and Policies

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In the case of weather and climate services, only a few countries have enacted appropriate legislation and have proper regulatory processes or the means to enforce them (World Bank 2019). Unfortunately, most meteorological laws appear to be construed to reinforce the monopoly of the public sector in the creation and sale of club goods—observational data—and private goods—bespoke forecasting services. The net effect is reduced opportunities for the provision of a wide range of weather and climate services by the private sector (World Bank 2019) and the inevitable underutilization of publicly funded data. Simply put, the public sector cannot, on its own, provide the range of commercial weather and climate services required in most countries. This can have a number of related consequences including: (i) having no influence over the quality and provision of private sector service providers, which provide services but cannot operate within national boundaries; (ii) missed opportunities for growth and development in weather-sensitive economic sectors; and (iii) an absence of sectoral advocacy with government in support of the public service provider if no consensus exists on the economic and safety value of these services. The latter is a powerful tool in persuading governments to make public sector investments, and the lack of advocacy invariably contributes to the marginalization of the NMHSs as a service provider, especially where services are really bad, creating a low-quality trap.

Overcoming these issues requires new approaches to data policies. The European Union (EU) is making progress in this area with efforts to make high-value datasets available free of charge, without restrictions via application programming interfaces (APIs) to ensure that public sector data have a positive impact on the EU's economy and society.[3] It is intended that meteorological data be included in the list of high-value datasets. The strategy also considers business-to-government (B2G) data sharing and setting up national governance structures, developing ethical guidelines, and incentives for companies to share data making a significant contribution to public goods. It recognizes that data and the reuse of data can serve to combat emergencies such as floods and wildfires, environmental degradation, climate change, and epidemics.

Innovative reuse of data includes creating artificial intelligence and machine learning tools. These could be applied for example, to the entire hydrometeorological value chain to create more effective citizen-centric Multi-Hazard Impact-Based Early Warning Systems and Services (MHIEWS) by accessing data from as wide a range of sources as possible that meet individual's needs.

In studying the economics of data, Jones and Tonetti (2020) conclude that because data are nonrivalrous, the largest gains are made by using data broadly. In other words, if all meteorological, hydrological, and ancillary data were free to use and reuse without restriction, there would be huge gains in efficiency and social benefits everywhere. Algorithms trained on very large datasets, which would become available to all for example, are likely to perform better as forecasting tools.

NMHSs are often reluctant to share data broadly, and particularly with the private sector out of concerns that the private sector will compete with them for the provision of public services and may eventually displace the public institution. This is a risk of creative destruction, which is more applicable to competition within the private sector and could be readily addressed by regulating the services.

Regulating Services

An overarching data policy, which encourages the use and reuse of data free of charge within and between business, government, and citizens is axiomatic to modern economy and society. In addition, a well-regulated national meteorological and hydrological system would have a few critical components:

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- **The public sector body focuses on its public mission and makes available its products to all people and entities.** The public sector body engages in any nonpublic—rivalrous and excludable—activities with strict adherence to competition law and in manner that supports a level playing field. A clear understanding is needed of the public interest defined by a legislated list of services that government considers public and provided freely by the government. This is likely to vary considerably from country to country and should be flexible but defined by the regulator or authority.
- **The provision of timely and actionable warnings of life-threatening weather-related hazards is the responsibility of government.** Such information should be provided as a public good and at no charge to the user of the information. Basically, the safety of life and property is the primary reason to be the national provider of weather and climate services. The cost of providing such services should be borne by the public purse, except where sectoral agreement dictates otherwise, as in the case of aeronautical meteorological services.
- **The private sector does not offer unauthorized public services** but works within a legislative framework that encourages reuse of public sector information and nonexclusive cooperation between the private and public sectors aimed at improving their respective services.
- **A standards-setting body and regulator are required to oversee the commercial provision of services.** In countries where the public sector service provider does not provide commercial services, these functions may be part of that body, otherwise they should be separate functions to minimize conflicts of interest (Rogers et al. 2021).
- **Nonpublic services should be provided within a competitive market with clear rules and regulations that permit open access to all qualified suppliers** (Rogers et al. 2021). Some countries may opt for a model where the public services provider has a separate commercial branch for nonpublic services. This can be seen as a transitional approach from fully public service delivery to the autonomous state enterprise or to a model where nonpublic services eventually are outsourced to a private sector. However, as a permanent solution, it is complicated to manage and suboptimal for the country. The

commercial branch would have the same access to public information as any commercial competitor and would be subject to the same rules applied to any other commercial entity. This would require advanced legislation in the civil service, making sure that no cross-subsidies or any potential conflict of interest exist from the government side to the commercial side of the business. The competitiveness of the commercial branch would likely require exemption from normal civil service hiring practices and pay structures. The commercial branch would also be free to form joint ventures and other partnerships with private companies. All this begs the question, why create a government-owned commercial venture in the first place? Sometimes this is used: (i) to create a more competitive market; (ii) as a step toward the privatization of certain public functions; (iii) to generate revenue as a state enterprise; (iv) as a means of measuring the quality of services offered by the NMHS; and (v) to transfer knowledge and know-how to the public sector. Deciding whether or not to create a state enterprise should factor the overall capacity of the NMHS to fulfil its public obligations, and cannot be a means to prop up a poorly performing public sector organization. It is not considered a viable option in developing countries.

Outsourcing in Meteorological and Hydrological Services

Considerable and mostly positive discussions take place about public–private engagement in the hydromet community. These discussions are supported by the GFDRR-led Global Weather Enterprise Forum (GWEF) and the WMO-led Open Consultative Platform (OCP). However, the difficulties of engagement between public bodies and the private sector should not be underestimated, nor is it a panacea for fundamental challenges like chronic underfunding of public sector institutions. While most governments probably accept the obligation that actionable and timely warnings of weather hazards are a fundamental right of people, this is not necessarily matched by their priorities for public sector financing.

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Are there more affordable ways to provide the required public services and create enabling environment to develop a mature national weather enterprise? In many countries, the level of public investment in this area is so small compared with the normative level of GDP that this cannot be addressed until the level of support is increased to a sustainable level on which improved services could be developed. While some jockeying goes on among private providers to replace public institutions, this option is equally untenable without adequate operational expenditure from government.

Assuming this basic level of funding can be achieved, which is by no means certain without extensive efforts to demonstrate socioeconomic value of this public sector to governments, it is possible to consider optimal ways to provide public services and, in the process, to decide what responsibilities should be reserved for public institutions. Could outsourcing, partnerships, and mutual reinforcement of the respective roles and responsibilities of the public and private sector create more efficient and cost-effective public services, and increase the market for commercial services?

Considerable debate continues about the merits of outsourcing functions of NMHSs to reduce operating costs and to enable NMHSs to focus limited human resources on core functions. Several of these outsourcing options are described—more examples in Rogers et al. 2019. However, a number of significant pitfalls come up that must be avoided if this approach is to succeed. These include two important maxims.

Maxim 1: Avoid handing over to external parties those functions that affect the organization's future capacity to manage externalization. For example, if the IT division of the NMHS outsources the design of its systems architecture, this could hamper the NMHS's ability to hold providers to account in the future.

Maxim 2: Avoid a situation in which the public accountability is undermined by the external party. Outsourcing removes the NMHS's direct control over service performance, but it remains responsible for any mishaps. Accountability structures and relationships are complex. The range of activities for which private managers can be held to account is much narrower than for which public servants can be held to account.

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Outsourcing should depend on circumstances and should be part of range of solutions to improve or maintain the effectiveness of the NMHS. Based on Alford and O'Flynn (2012), consideration should be given to four key questions.

1. **Strategic:** Are there no strategic reasons, such as maintaining core competencies, for keeping the function in house?
2. **Service:** Can an external provider do the task better or cheaper? Or both? Are there potential gains in effectiveness or efficiency to be reaped from having an external provider?
3. **Relationship:** Are the costs of managing the relationship minimal? Specifically, is there a competitive market? Is it relatively easy to specify and monitor the service?
4. **Business continuity:** Could essential services be provided in a crisis situation, even if private providers were unable to operate normally?

If the answer to all four questions is "yes", an external provider could take on the task and if the answer to all four questions is "no", then the activity should be produced by the NMHS in house. However, it is more likely that the answers will be mixed and therefore, costs and benefits need to be weighed against each other, and alternative arrangements considered including collaborative relationships. This approach applies equally to subtasks of the NMHS and to consideration of outsourcing of the entire service.

- The strategic costs related to authoritative warnings of extreme hazards would be an important consideration. Who is responsible if the forecasts provided by an external provider result in an inadequate response to a hazard resulting in loss of life and livelihoods? And who pays?
- Accountability is unlikely to be fully transferable to the external provider since the potential liability would be huge and risk to profits too great. Consequently, the government would have to weigh up the risks of retaining responsibility for the output of the external provider versus providing the services itself.
- Very often private weather service providers claim that they can provide better and cheaper services than government-run NMHSs. However, it is usually considered in isolation from the strategic question, and therefore does not account for the full consequences and potential costs of delivering the public weather service. If the private sector were to provide the services of an NMHS, then that provider should bear the full risks. This would make the contract unattractive.

- How much risk can stay with the private contractor depends on: (i) whether the risk is known, bounded, and probabilistic, which makes it possible to ensure; and (ii) the maturity of the public–private partnership market (Hallegatte et al. 2019).

Outsourcing A Turnkey Approach

A turnkey approach for the overhaul, modernization, and operation of NMHSs has been mooted as a desirable method on the grounds that it offers a fully integrated solution and simplified contracting process. However, and especially in developing countries, a limited number of vendors offer design–build–operate–transfer (DBOT) capabilities, which make the market less competitive. This can be addressed by proactive attempts to develop this market through encouraging consortia or subcontracting to enable groups of providers to assemble the required set of capacities. This approach has its limitations and is vulnerable to potential intraconsortium tensions and lengthened accountability chains (Alford and O'Flynn 2012).

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Alternatively, disaggregating a modernization program into elements for which competitive bidders may be used adds to tendering and contract management costs and has the potential to undermine the integrated nature of the intended service. Higher levels of asset specificity are likely in the turnkey approach, which may incur increased costs of licensing or increased switching costs for example, for forecasting software at a later stage. Also, the risk exists that the purchaser will have little or no knowledge of the elements of the turnkey solution and have no say in the acceptance or otherwise of each part. The risk of violating the first maxim (Maxim 1) is high and must be well managed. In either case, the potential low level of competition in the meteorological and hydrological markets and difficulties in monitoring these kinds of contracts will contribute to comparatively higher relationship costs.

Given that the vendors are profit seeking, at least to some significant extent, it is essential that a competitive market and solutions are specified relative to concrete outputs to use the profit motive to drive them to perform well. If competition is absent and specifying and monitoring outputs is hard, the vendor may be prompted to take advantage of the purchasers, delivering services at excessive cost. Guarding against this possibility, the purchaser has to incur considerable costs, in structuring markets, specification, and monitoring. These costs must be factored in when sizing up the costs and benefits of the different approaches. In the case of NMHSs in developing countries with little or no skill in contract management, it would be essential to acquire such skills, perhaps through separate contracting to monitor the outputs of the vendor, particularly in the case of a turnkey solution.

Outsourcing Systems Integration

Where a modernization program was pursued through its component parts, it was considered highly desirable to contract a systems integrator firm to carry out the integrating function (Rogers and Tsirkunov 2013). The original motivation for the approach was the lack of knowledge on the part of developing countries' NMHSs on how to create a modern knowledge-based, information and communication technology (ICT) driven service delivery organization. In the past, were many projects where separate elements of the system were incompatible or functioned poorly within the overall system. Assembling the appropriate skills within a system integrator (SI) team and convincing the government leaders that such a big foreign consultancy is needed in the first place remain a challenge (Rogers et al. 2019).

When these types of contract are measured against the key questions, the relationship question is more likely to be answered with "maybe". The relationship cost is at best mixed, with relationships with the contractor often achieving a low base from which it is difficult to improve. Trust and adequate contract monitoring are major issues.

As SI contracts require multidisciplinary skills—meteorology, hydrology, ICT, to name a few—they are typically won by consortia, where individual firms may have different and conflicting agendas on what should be implemented. Therefore, the SI team needs to have very strong leadership focused on delivery, based that is on the government client's requirements. Some of the firms may have their own bespoke systems and may only be interested in providing that solution whether appropriate or not.

It is essential for the lead entity and the individuals responsible for the execution of the work to build good working relationships with the client based on trust. This can be difficult, especially if the lead entity is not known to the client and pursues its own interests and agenda. Lack of NMHS experience in managing complex consulting contracts, frequent lack of NMHS's knowledge of recent technological developments and operational practices is another factor complicating the relations with SI. The relatively large cost of the SI staff almost inevitably creates tension between the local staff and the contractor, especially when the former is expected to supervise the contractor's work. Other issues include the disparity between the remuneration of the contractor's staff, which may be an order of magnitude higher than the pay of civil servants responsible for the contract.

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Another risk relates to the perception of the client that since "we are paying so much for the Systems Integrator, they should do everything", the client sits back expecting the SI team to work with little engagement of the client's staff. This can lead to significant divergence between what is really needed by the client and what the contractor recommends with subsequent difficulties reconciling these differences unless managed carefully by both the contractor and client. The client expects the SI experts to add value and insight but if they ask for a lot of assistance from the client and then deliver poor reports, trust is broken. Engagement and trust can be built when the contractor spends time to take the client through the options for modernization with presentation of pros and cons—including capital expenditure and operating expenditure. Without sufficient sensitivity to the reality of the client's situation, it is quite easy for the SI to be critical and culturally insensitive rather than presenting a positive narrative about future improvements. Trust is an essential ingredient in making such contracts actually work in practice.

Similar to the DBOT approach, ensuring that there is a sufficiently competitive market for qualified SI contractors remains an issue.

Outsourcing International and National Advisors

One approach to mitigating these risks is to contract a small group of experts who are treated as members of the government team to support the client's decision making. The success of this approach depends on the availability of a pool of qualified experts with experience in integrated hydrometeorological modernization in developing countries. In addition, the following factors are critical: (i) the experts' level of expertise; (ii) the amount of time they can devote to the client; (iii) the ability to deal with the client's culture; (iv) ability to build trust; and (v) excellent communication skills. Deficiencies in any of these areas undercut the effectiveness of any consultancy.

The drawback is that this approach increases the administrative workload and requires a qualified team on the client side to coordinate input and monitor performance of multiple advisors; however, the cost of managing these relationships is likely to be minimal compared with DBOT and SI contracts. The benefit to the client is access to individual experts with no conflicting agendas and the ability to provide a high level of skill in contract performance management of the SI or other contracted firms.

Outsourcing Observational Networks

Returning to the potential outsourcing of operational subcomponents of the NMHSs, the issues of accountability may be less onerous. It is insightful to consider observational requirements of an NMHS and whether this component of the service could be wholly or partly outsourced. Rogers et al. (2019) consider various models for NMHSs observational requirements including owning and operating, observational networks as a service, and data as a service.

Considerations

- Applying the foregoing arguments, the first question that must be addressed is would handing over responsibility for the meteorological or hydrological observational network to an external provider affect the NMHS's future capacity to manage the externalization of the network? Assuming that the network is operated as a service by an external entity, it would be responsible for maintaining all of the equipment and supplying quality-controlled data that meet the requirements of the NMHS.

- The NMHS would in effect divest itself of the ability to make observations. Since observations are a critical component of the NMHS's operations, transferring a contract from one vendor to another could pose significant risks to data continuity and may favor the incumbent. A long-term contract would be required consistent with the expected lifetime of the equipment. This would probably take the form of a public finance initiative (PFI), which would take the form of a classical contract; that is, a very formalized and transactional agreement, as opposed to a relational contract, which focuses on the relationship, participation in exchange, reciprocity, or trust (Alford and O'Flynn 2012).

- Reversing such a contract to return the network to government operation would be a significant challenge because of the loss of technical expertise over time, albeit compensated by an increase in local capacity outside of the NMHS. Therefore, it is important to determine whether the maintenance and operation of the observing network is a core competency, which should be retained in house.

- While it may seem a forgone conclusion that the external entity could provide the observational network cheaper or better or accomplish both, this may overlook a critical problem, namely the underfunding of infrastructure and therefore a lack of transparency in the actual costs of maintaining and operating the observational network in

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house. Experience suggests that many observing networks are not maintained and simply operate until they fail.

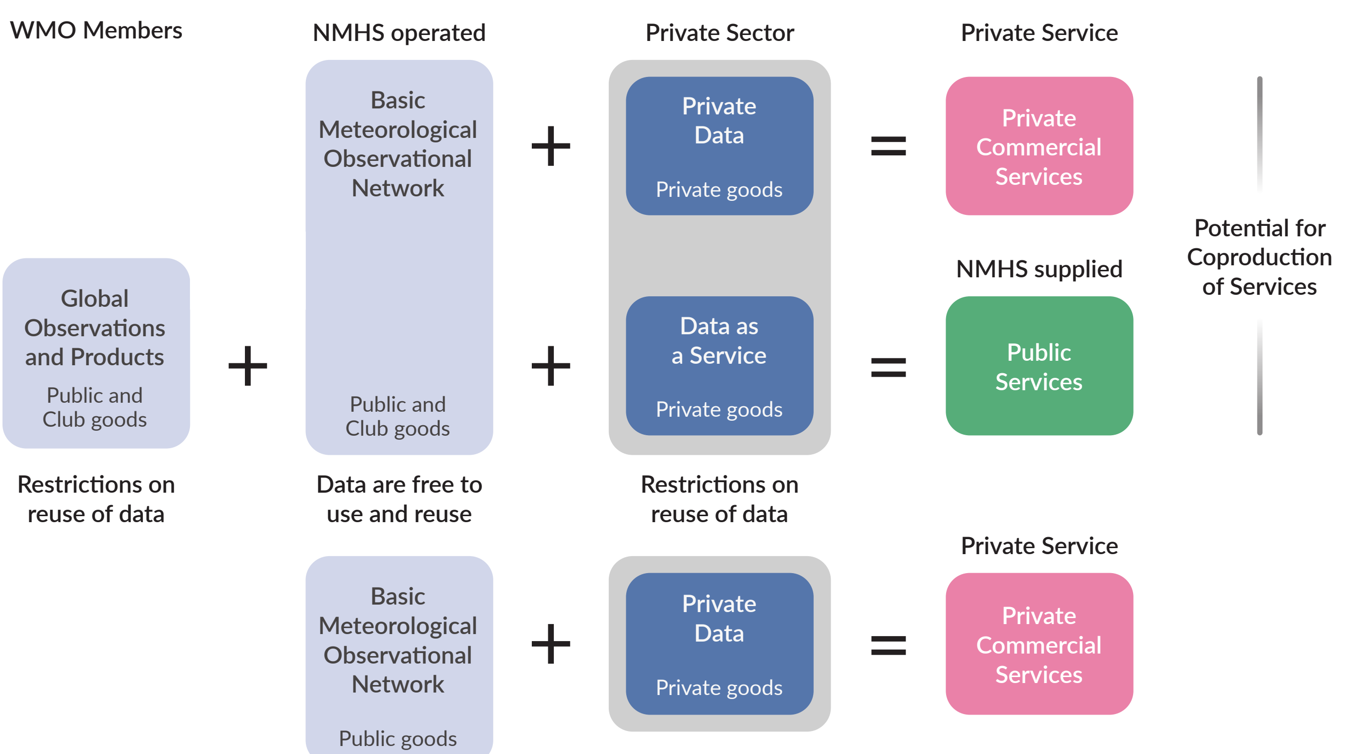
- Hence despite possible access to capital expenditure through development partners or donors, operational expenditure will not be adequate to support outsourcing unless the government commits sufficient funds to the latter. A regulator would be essential to ensure prices remain fair or to have a credible threat of exit by the government. Outsourced, performance-based contracts, where lack of performance translates into reduced payment, can lead the private contractor to bankruptcy leaving the public sector in trouble.

Coproduction in Meteorological and Hydrological Services

Budgetary stress is a term that can be applied to most public service delivery. In the case of the NMHSs, despite the critical nature of the organization's role in society, chronic underfunding has resulted in barely functioning services in many developing countries. The opportunities to contract out functions is virtually nonexistent. This leads to consideration of alternative forms of externalization and different modes of coordination, especially partnering and collaboration that result in the coproduction of services (Alford and O'Flynn 2012) (**Figure 2**).

Rogers et al. (2019) highlight *data as a service* as a different form of outsourcing more closely aligned to a relational contract. In this case, the NMHS operates its own basic observational network as a core function but acquires additional data from an external vendor as a service. There may be restrictions on the reuse of these data, which are related to the value of the data as private goods that can be resold to other users. Data

Figure 2. Schematic of potential arrangements between the public and private sectors for the production or coproduction of services.



Note: Data are restricted or open depending on their source. In this illustration, the basic national meteorological data are assumed to be free to use and reuse by anyone.

as a service also lends itself to the idea of the coproduction of meteorological and hydrological services.

Since weather is a global phenomenon, it requires sharing of information on a planetary scale and among neighbouring countries. This provides a foundation for cooperation and coordination in research and development, in the coproduction of observational networks and the coproduction of prediction systems. Success in the latter has been demonstrated amply by the European Centre for Medium-Range Weather Forecasts (ECMWF), which provides products useful for global, regional, and national applications worldwide and EUMETNET, which has enabled its members to develop a cost-efficient infrastructure for meteorological observations and forecasting in Europe. Inherently, NMHSs exist because of their ability to partner and collaborate with NMHSs and public sector bodies in other countries.

These organizations are almost exclusively public sector entities, but the opportunities to cooperate and collaborate are equally applicable to the private and nonprofit sectors. The need to cooperate has been recognized by government organizations since the 1990s (Alford and O'Flynn 2012); that is, the work of producing public services has been shared with public, private, and nonprofit providers. However, NMHSs, particularly in developing countries, have been relatively slow to adopt these practices, arguing that for reasons of security and often national pride, they should have independent observations and modeling systems, despite their obvious dependence on international commercial vendors for most business functions—Internet access, email, and social media to name a few. This path inevitably marginalizes those countries' public weather services because they do not avail themselves of the advanced global numerical weather prediction products and services or the skills that the private sector can offer (Rogers et al. 2020).

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In this context, partnering is any arrangement where the NMHS shares the function of producing value with one or more external entity, and collaboration is the mode of coordination with more or less joint deliberation, involving shared commitment and trust (Alford and O'Flynn 2012). Inevitably, this requires the NMHS to cede some power to the external providers to secure the benefits of externalization.

Two conditions should be present for partnering:

1. Production by the NMHS and the external provider(s) acting together can create more value than each on its own.
2. The NMHS has some means of inducing the external provider(s) to act in manner that contributes to the realization of the value sought.

(Alford and O'Flynn 2012)

Another condition related to trust could be added:

3. Collaboration should only be adopted when it is judged by the NMHS and the external provider(s) that a reasonable level of trust between the partners is either present already or can be built within the relevant time period.

Using the example of data as a service, this could be structured as the coproduction of the national meteorological or hydrological observing network (**Figure 2**). The NMHS continues to maintain and operate its existing network but needs additional data to create a comprehensive national system. A private firm, with an established high regarded reputation, could provide additional data by installing and operating its own network ostensibly for its own private clients. These data are shared with the NMHS and the NMHS shares its network data with the private firm. This may be particularly attractive if the NMHS's observing network has been upgraded. The expanded network enables the NMHS to provide better short-range weather or hydrological forecasts and the additional data from the NMHS enables the private firm to assure quality of its data and provide enhanced bespoke services to its private clients. The decisions on quality assurance, management of the entire network, public and private, and its use are made jointly. For this to succeed, a major consideration is interorganizational trust and mutual adjustment as well as a favorable legal and regulatory environment. Similarly, observations produced by other government agencies, such as agriculture, irrigation, health, and transport could also contribute to the coproduction of national meteorological and hydrological networks. It would not be sufficient to simply share data. The process of coproduction would contribute to optimization of the observing network. In many countries, another challenge may be the different salaries between public and private sectors, which could impair a balanced relationship.

The national network would be a virtual network maintained primarily through a database of metadata rather than the need to physically combine data in a single archive, although that approach should not be excluded from consideration. The database should allow all users equal access to the observational data.

Observations produced by other government agencies, such as agriculture, irrigation, health, and transport could also contribute to the coproduction of national meteorological and hydrological networks.

Coproduction could also apply to forecasts and warnings. MHIEWS have evolved from delivering warnings of hydrometeorological hazards to warnings of their impact. This approach can provide better guidance to people at risk and those responsible for mitigating those risks in a form that is understandable and actionable. However, it requires combining information about specific hazards with the likely impacts of those hazards on people, livelihoods, and property. Collecting the necessary vulnerability and exposure data is often the responsibility of disaster management agencies, nongovernmental bodies, and the private sector. Both the hydrometeorological hazard and exposure evolve over time; so, frequent updates on risks need to be calculated. This can be readily achieved if the meteorological, hydrological, and disaster management agencies coproduce the forecasts and warnings rather than merely transfer hydrometeorological information to disaster managers.

The Norwegian Meteorological Institute (Met Norway) and Norwegian Broadcasting Company (NRK) jointly own and operate a website yr.no, which highlights the value of both open data and collaboration between sectors (Hygen et al. 2018). The codevelopment ensured that Met Norway could meet the expectations of the Norwegian public for the publication of weather forecasts in a modern fashion with weather data from public and private sources helping reduce biases in the forecast thereby creating a more reliable service.

Conclusion

Competitive behavior of the public and private sectors in the production and delivery of meteorological and hydrological services and the competing roles the sectors often play contribute to difficulties in creating trust, which is inherent in any partnership, contractual or relational. Whether or not to externalize public service delivery is an important consideration in maximizing efficiency and creating value for money for the public.

We have considered two approaches: (i) outsourcing through traditional contractual arrangements where the service is entirely or partially provided by the external entity, and (ii) coproduction through partnership and collaboration. While neither offers a complete solution, the latter may be more applicable in countries where the funding available to support meteorological and hydrological services would be insufficient to support contracting out and where a competitive market would not exist. This is because coproduction or partnership with collaboration does not involve a monetary price for services, but instead an exchange of behaviors and services in kind (Alford and O'Flynn 2012). A combination of both approaches is also possible, but the arguments are substantively the same. **Table 1** summarizes the activities that could be undertaken to strengthen the engagement between the public and private sectors within a country.

We identified three conditions that should be met for coproduction to succeed related to value, incentive, and trust.

Data as a service and MHIEWS were discussed as examples of the coproduction of public weather services but the approach is applicable to other elements of the value chain supporting user needs. These could be re-assessed from the viewpoint of opportuni-

Table 1. Summary of potential activities related to public-private engagement within a country.

Activity		Optimum	Minimum
1	**Definition of roles –** Clearly understood and agreed roles and responsibilities of public and private sectors.	Legal framework	Policy
2	**Open data –** Government applies open data policy to publicly financed observations and related data.	Governmentwide policy	All NMHS data are made available in line with open data policy for use and reuse. The aim is to gauge the use of the data beyond the NMHS.
3	**Regulation of Services –** the feasibility and cost of regulating the provision of the meteorological and hydrological services.	An independent regulator is created	Adherence to competition law
4	**Outsourcing (1) –** The potential of outsourcing to create more efficient and effective public services and to increase market for commercial services.	A detailed study of strategy, services, relationships, and business continuity is undertaken	A preliminary study of the potential opportunities and risks of outsourcing is undertaken.
5	**Outsourcing (2) –** Public–private engagement focuses on producing value. The aim is to demonstrate the benefit of externalization.	Formal agreements establish joint deliberation mechanism	A project-oriented approach looks at one or more elements of the value chain—such as maintenance of a subset of the observational network. A minimum level of trust must be present.
6	**Coproduction of services –** Public and private agencies focus on improving production and delivery of MHIEWS and other services.	Formal agreements establish shared forecasting and warning service and other services	Prototype service focuses on engaging all stakeholders.

ties to coproduce data and information, ranging from observing networks to production and dissemination of forecasts and warnings, capacity building, and ICT infrastructure. Warning and alerting systems could be enhanced by a coordinated response from both public and private service providers ensuring that each part of society receives actionable information.

We identified three conditions that should be met for coproduction to succeed related to value, incentive, and trust. Since these are often in short supply, a practical approach is needed to trial and test the efficacy of coproduction between public and private entities. It should explore the entire value chain to determine if measurable benefits can accrue to both public and private sector service providers.

Since few countries have enacted legislation that encourages public–private sector engagement in the form of coproduction of services, it might require a third-party arrangement—possibly through a development partner—to create a framework for pilot projects, which minimizes risks to either the public or private entities participating, and substitute for the initial absence of trust.

Notes

1. The definition of WMO Members is laid out in Article 3 of the World Meteorological Convention. It comprises 193 States and Territories. Consequently, decisions of WMO Members are decisions of governments.
2. Local observations for example, are paid for and collected for the provision of public services; the part of the public sector organization providing private services should have access to those data on the same terms as a private, commercial service provider. Arguably, if these are fully consumed in providing public services, then access to these data should not incur any costs beyond the cost of making these data available to everyone.
3. https://ec.europa.eu/digital-single-market/en/policies/building-european-data-economy

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GFDRR
Global Facility for Disaster Reduction and Recovery

The Global Facility for Disaster Reduction and Recovery (GFDRR) is a global partnership that helps developing countries better understand and reduce their vulnerabilities to natural hazards and adapt to climate change. Working with over 400 local, national, regional, and international partners, GFDRR provides grant financing, technical assistance, training and knowledge sharing activities to mainstream disaster and climate risk management in national and regional policies, strategies, and investment plans. Managed by the World Bank, GFDRR is supported and directed by a Consultative Group that has 17 members and 14 observers.

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