5

Information

Laws for Producing, Sharing, Aggregating, and Analyzing Information

Links with Other Chapters

- Chapter 1 explains how examples used in this chapter were chosen.
- Chapter 2 synthesizes key challenges related to information and introduces the CIRCle Framework of regulatory functions for addressing cumulative environmental problems.
- Chapter 3 sketches the landscape of laws that may respond to cumulative environmental problems, including those that focus on information.
- Chapter 4 ("Conceptualization") discusses rules for articulating what and who we want to protect from cumulative impacts (the "matter of concern"), about which information is needed.
- Chapter 6 ("Regulatory intervention") discusses how rules can influence behavior to ensure that cumulative harm to the matter of concern stays within acceptable limits.
- Chapter 7 ("Coordination") covers coordinating between and among agencies and levels of government, nongovernment, and quasi-government entities, including to gather and share information.
- Each case study (Chapters 8–10) focuses on specific CIRCle Framework functions. Chapter 9 examines information in detail using the context of the health of the Great Barrier Reef, Australia. It focuses on strategic environmental assessment as a key tool for information, and explains its links to regulatory intervention.

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5.1 INFORMATION AS A REGULATORY FUNCTION

Acting to restore or protect something that we care about (the "matter of concern") from unacceptable cumulative harm[1] depends on information. As described in Chapter 4, the matter of concern can take diverse forms, from a species, to an atmospheric concentration of greenhouse gases, or the ecological integrity of a river. I define information expansively as the outcome of analyzing data (quantitative or qualitative, including concepts and theories, produced in a Western scientific tradition or otherwise)[2] about the matter of concern, impacts to it, and rules and actors relevant to those impacts.[3] Information may be produced by governments, regulated entities, community members or other stakeholders, or it may be "co-produced" between multiple of these parties.[4]

Legal literature on the environment and information tends to focus on issues such as defining "best available" science or knowledge, or environmental impact assessment (EIA) laws, or, increasingly, the risks posed by technology related to environmental information.[5] I take a few steps back, and argue that laws for dealing with cumulative environmental problems should be information-making, not just information-taking. That is, rules can and should actively provide for producing, sharing, aggregating, and analyzing data to produce information that helps us understand the things we care about, and the cumulative threats that they face, so that rules for intervention can restore them or protect them from cumulative environmental harm.

As discussed earlier in this book,[6] effectively producing and using information to deal with cumulative environmental problems faces key challenges to which the design of information-related rules must respond. Impacts may accumulate in slow, complex, and sometimes nonlinear ways, which can

[1] For the full definition of cumulative environmental problems used in this book, see Section 1.1.

[2] Modified from National Research Council, *Using Science as Evidence in Public Policy* (National Academies Press 2012) 8.

[3] Section 5.1.1 expands on this.

[4] See further Section 5.2. For a general review of principles for knowledge coproduction and a review of the relevant literature, see Albert V. Norström and others, "Principles for Knowledge Co-Production in Sustainability Research" (2020) 3 *Nature Sustainability* 182–190.

[5] E.g., see generally, Bruce Lindsay, Dru Marsh and Rebecca Nelson, "Conceptualising and Activating Knowledge in Environmental Protection Law" (2023) 46 *Melbourne University Law Review* 422–466; Jaap C. Hanekamp and Lucas Bergkamp, "The 'Best Available Science' and the Paris Agreement on Climate Change" (2016) 7 *European Journal of Risk Regulation* 42–48; Holly Doremus, "The Purposes, Effects, and Future of the Endangered Species Act's Best Available Science Mandate" (2004) 34 *Environmental Law* 397–450.

[6] See Section 2.2.2.

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make these problems hard to perceive. Generating information about the matter of concern and actions that cause relevant impacts can be costly and sharing it can encounter commercial, political, and community resistance. Contributors to the problem may be unwilling to share their data and information with government, and government may be unwilling to make information public or listen to community concerns about impacts and even ways of understanding what matters in the first place. This last point is especially important in the context of Indigenous and traditional knowledges, as this Chapter discusses further. Communities may raise concerns that collecting "big data" may harm privacy, or have potential discriminatory effects or a "chilling effect" on legitimate human activities.[7] These social issues related to information also deserve the attention of regulatory designers.[8] Finally, comparable data related to a matter of concern are often in short supply, making it difficult to build a picture of cumulative environmental change, and information can be subject to unavoidable uncertainty because of multiple, interacting, and complex cause-and-effect relationships.

Addressing these challenges is fundamentally about power, rather than just an instrumental technical issue about measuring things to understand them better. Rules for information about a cumulative environmental problem can address the power asymmetries that exist among the public, government, contributors to a problem, and those affected by it.[9] Gathering, aggregating, and making public the information about past, present, and future conditions of a matter of concern and impacts on it allow the public and decision-makers to see how the effects of multiple activities can aggregate to harm the environment. This is critical for environmental democracy, environmental justice, and the rule of law.[10] Information facilitates meaningful civic engagement and enables the public and affected communities to demand accountability and action from governments and

[7] Nathan Young and others, "Ethical Ecosurveillance: Mitigating the Potential Impacts on Humans of Widespread Environmental Monitoring" (2022) 4 *People and Nature* 830–840, 833–835.

[8] This chapter touches on some of these social matters, leaving others for attention in Chapter 7 (Coordination), and noting existing research on this topic, e.g. ibid.

[9] Federica Fusi, Fengxiu Zhang and Jiaqi Liang, "Unveiling Environmental Justice through Open Government Data: Work in Progress for Most US States" (2023) 101 *Public Administration* 1088–1114, 1091.

[10] See, e.g., Jesse Worker and Lalanath de Silva, *The Environmental Democracy Index: Technical Note* (World Resources Institute 2015); Swatanter Kumar and others, *Environmental Rule of Law: First Global Report* (United Nations Environment Programme 2019) 21, 63–70; Fusi, Zhang and Liang, "Unveiling Environmental Justice," 1092–1093.

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contributors to the problem; information without an advocate may have little impact on intervention.[11]

Informed by these challenges, information is one of four central functions that this book argues that regulation must deliver to respond to cumulative environmental problems. These four functions, of conceptualization, information, regulatory intervention, and coordination, form the "CIRCle Framework" of regulatory functions advanced by this book.

This chapter begins by exploring the broad types of information needed to respond to cumulative environmental problems and regulatory methods of making links with conceptualization, regulatory intervention, and coordination. Section 5.2 then discusses a key factor likely to vary between cumulative environmental problems: the key actors involved in information. Section 5.3 considers types and examples of legal mechanisms to help address the key challenges associated with information outlined in Chapter 2: obtaining comprehensive, high-quality, and shareable data and analysis; allocating and reducing the associated costs; and sharing and accessing data and information. Chapter 7 (Coordination) then focuses on information as an important issue in coordination among governments and stakeholders.

5.1.1 *What Information Helps Address Cumulative Environmental Problems?*

We turn first to exploring the information required to deal with a cumulative environmental problem, summarized in Figure 5.1. Addressing cumulative environmental problems first requires understanding the matter of concern subject to cumulative change (see Chapter 4 "Conceptualization"). This means having information to establish cumulative threshold conditions – that is, the limits of acceptable conditions – against which a set of current or expected conditions or impacts can be compared to determine whether intervention is required. Monitoring ongoing environmental conditions is needed to reveal trends and unexpected changes in the condition of the matter of concern.

Dealing with cumulative environmental problems also requires attention to the other side of the picture: understanding impacts to the matter of concern caused by (1) actions that are regulated and lawfully undertaken, (2) actions

[11] For research that suggests this in the context of the Chapter 8 case study context of California groundwater, see Debra Perrone and others, "Stakeholder Integration Predicts Better Outcomes from Groundwater Sustainability Policy" (2023) 14:3793 *Nature Communications* 1–14, 9–10.

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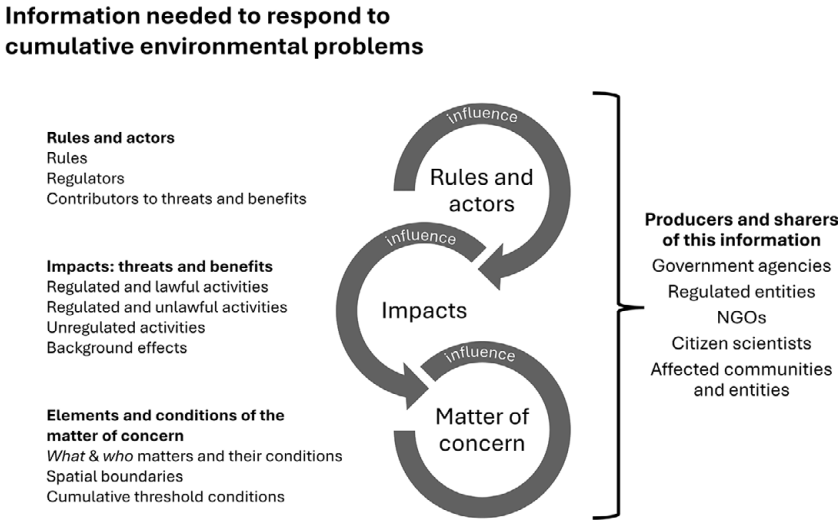


FIGURE 5.1 Information needed to analyze and respond to cumulative environmental problems using formal rules

that are regulated but carried out in a way that exceeds their authorization (e.g., emitting more pollution than an authorization permits) or that are carried out without required authorization (for brevity, "unlawful actions"), (3) actions that are not subject to regulation ("unregulated actions"), as well as (4) "background" effects that are difficult to attribute to an individual actor or action, but affect a matter of concern, for example, dust storms or wildfire affecting air quality, or invasive species affecting threatened species.[12] Sources of impact may be outside the spatial boundaries of the matter of concern – something that laws are not always good at recognizing.[13]

Addressing cumulative environmental problems may also involve predicting the likely cumulative impacts of proposed actions. This is especially important for cases in which, by the time significant change is detected, it can be difficult or impossible to reverse the environmental damage. Groundwater pollution, for example, may be practically impossible to remediate either due to cost or limitations of current technology.[14] EIA laws are an important, though not the only, area of law that provides for this type of predictive

[12] Commissioner for Environmental Sustainability Victoria, *Victorian State of the Environment 2023 Report: Summary Report* (2023) 46–47, 49–50.

[13] Rebecca Nelson, "Regulating Hidden Risks to Conservation Lands in Resource Rich Areas" (2021) 40 *University of Queensland Law Journal* 491–530, 500, 522–525.

[14] Nicholas P. Cheremisinoff, *Groundwater Remediation: A Practical Guide for Environmental Engineers and Scientists* (Scrivener 2017) 14.

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analysis. Predictions of cumulative change at the regional scale, involving many actors, are also used in addressing cumulative environmental problems, for example, through strategic and regional environmental assessments and natural resources planning.[15] The resulting information can then be used to inform regulatory processes for individual future actions in these regions.

The outcome of understanding impacts – whether direct or indirect, anthropogenic or not, current or planned – is the ability to consider existing and potential interventions that seek to modify impacts or take other action to address unacceptable harm. This also requires information about the landscape of existing regulators and rules for regulatory interventions that "highlights their collective capacity to serve as a barrier to pressures" (i.e., their effectiveness).[16] Different types of intervention may produce different information needs, and there is theoretically a higher need for information about effectiveness for regulatory interventions that have relatively low outcome reliability.[17] For example, allowing an impact to go ahead with compensatory (offset) measures requires special attention to monitoring to ensure that those measures are effective and maintained over the long term.[18]

There will likely always be more data to gather, analyze, and share to better understand a problem. The important thing is not that the public or decision-makers know everything there is to know about the problem, but that the rules provide for having enough usable information to support the other interlinked functions of the CIRCle Framework. We turn now to distilling these connections.

5.1.2 *Information as an Integrated Regulatory Function in the CIRCle Framework*

Though legal scholars focus relatively rarely on data collection and analysis as the subject of rules,[19] many strands of regulatory theory assume that information has an important place in implementing regulatory

[15] See the case studies for examples: Chapter 8 in relation to groundwater planning and Chapter 9 in relation to strategic assessment. Chapter 3 describes the landscape of areas of law relevant to cumulative impacts.

[16] Effah Kwabena Antwi and others, "Risk Assessment Framework for Cumulative Effects (RAFCE)" (2022) 10 *Frontiers in Environmental Science* 1–23, 20.

[17] See Table 6.1.

[18] European Commission and Directorate-General for Environment, *Managing Natura 2000 Sites – The Provisions of Article 6 of the "Habitats" Directive 92/43/EEC* (Publications Office of the European Union 2019) 66.

[19] A notable exception is Eric Biber, "The Problem of Environmental Monitoring" (2011) 83 *University of Colorado Law Review* 1–82.

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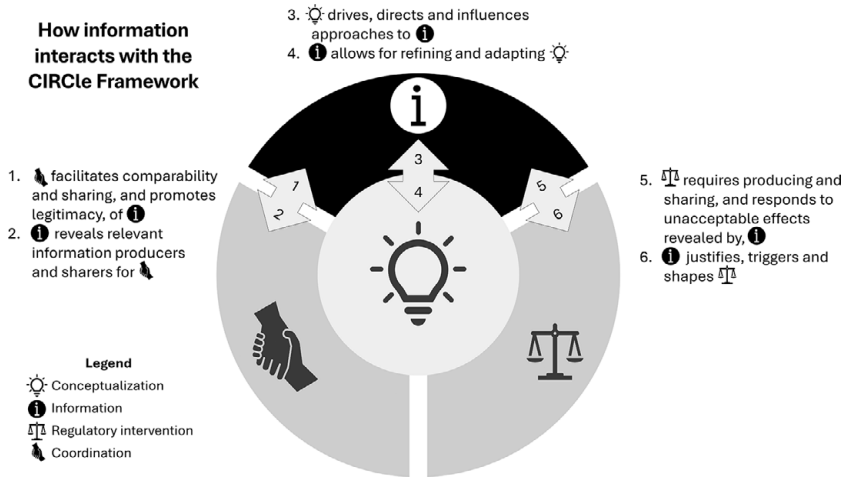


FIGURE 5.2 Integration of legal mechanisms for information with other CIRCle Framework functions, each necessary for regulating cumulative environmental problems

interventions.[20] Coglianese's "regulatory excellence" framework, for example, highlights the importance of regulators using trustworthy data supported by peer review processes and making the information that they use accessible to regulated entities and the public.[21] Risk-based regulation requires regulators to "continually gather and assimilate information to inform better strategy and tactics, and to inform the allocation of finite resources."[22] The use of technology to produce information is a prominent emerging theme more generally in regulatory theory.[23]

As shown in Figure 5.2 (building on Figure 2.1, which depicts basic links between regulatory functions), information may both influence and be influenced by regulatory functions related to conceptualization, intervention, and coordination – the other functions of the CIRCle Framework for rules to respond to cumulative environmental problems. First, the conceptualization of a cumulative environmental problem points to the information that must be gathered

[20] Information can also be used intentionally to change behavior as a regulatory "sermon," a form of intervention: see Section 6.3.

[21] Cary Coglianese, *Listening, Learning, Leading: A Framework for Regulatory Excellence* (University of Pennsylvania Law School 2015) xi, xii.

[22] Christopher Taylor and others, "Selecting Policy Instruments for Better Environmental Regulation: A Critique and Future Research Agenda" (2012) 22 *Environmental Policy and Governance* 268–292, 287.

[23] Neil Gunningham and Cameron Holley, "Next-Generation Environmental Regulation: Law, Regulation, and Governance" (2016) 12 *Annual Review of Law and Social Science* 273–293, 281–283.

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about the characteristics of a matter of concern, its condition, and the actions and actors that impact it. Before generating information, it is important to have a clear initial idea of what the matter of concern is (Chapter 4 "Conceptualization"), recognizing that this conceptualization may change.[24] Information can also lead to refining and adapting how a matter of concern is conceptualized because processes for generating information may shift participants' values. Information collection and analyses undertaken in the context of cumulative environmental problems heighten this transformational potential because it engages values-rich questions about who is affected by environmental change in space and time, and what level of harm or change a society will accept.[25]

Secondly, information about cumulative environmental change may affect whether and how existing regulatory interventions address unacceptable change. Of course, decision-makers might ignore information about cumulative change in making decisions about interventions, but legal mechanisms can help counter this. Most national EIA laws around the world expressly require decision-makers to consider cumulative impacts.[26] This can theoretically affect the kind of assessment or the kind of mitigation measures required for a project, and whether the project will go ahead.[27] Outside the impact assessment context, interventions can draw on information in a range of context-specific ways, from extending the reach of endangered species laws if an endangered species is found in a new location to modifying a limit on groundwater withdrawals in response to new information about recharge rates. Information about environmental challenges can also influence how many people take up voluntary interventions ("regulatory carrots"), such as financial incentives for private land conservation, even where information is not designed for these persuasive purposes.[28]

Information about trends in environmental conditions might also trigger a change to interventions. Just as information about the number of babies born each year informs planning for school places to respond to anticipated demand[29], information about trends in cumulative environmental change

[24] As described in Chapter 7, forming this conceptualization involves resolving conflicting values associated with environmental disputes.

[25] Rebecca Nelson and L. M. Shirley, "The Latent Potential of Cumulative Effects Concepts in National and International Environmental Impact Assessment Regimes" (2023) 12 *Transnational Environmental Law* 150–174, 157–159.

[26] Ibid 160.

[27] See Section 3.2.2.

[28] Kaylan M. Kemink and others, "Exploring Motives for Participation in a Perpetual Easement Program: Going Beyond Financial Incentives" (2023) 284:110193 *Biological Conservation* 1–12, 8.

[29] B. Guy Peters, "Information and Governing: Cybernetic Models of Governance" in David Levi-Faur (ed), *The Oxford Handbook of Governance* (OUP 2012) 113–128, 120.

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can be used to plan future regulatory change. This link might arise directly, because legal provisions expressly provide for it. Alternatively, the link might arise indirectly, when civil society, the media,[30] or independent scrutiny bodies (e.g., auditors-general, comptrollers, ombudsmen, and parliamentary or congressional committees) advocate for an intervention based on information about cumulative environmental change. Conversely, regulatory interventions themselves often require participants to collect and share information, for example, about compliance with a regulatory mandate or the performance of obligations required to obtain an incentive.

Finally, information about the matter of concern and about the actions that affect it points to the agencies, levels of government, and stakeholders that must coordinate to respond to a cumulative environmental problem because they regulate, carry out, or otherwise interact with those actions. Coordination processes themselves facilitate the sharing of data and information between stakeholders, agencies, and levels of government to facilitate standards for data comparability and data aggregation that will shed light on cumulative environmental problems. Coordination processes in relation to information can also increase the legitimacy of the resulting information and make it more likely that decision-makers will use it (both issues that are discussed in Chapter 7 "Coordination"). Coordinating about information can also create relationships between participants that are the basis for coordination more broadly.[31]

5.2 ACTORS AND INFORMATION FOR ADDRESSING CUMULATIVE ENVIRONMENTAL PROBLEMS

The question of who is involved in relation to information is just as important as what information is needed. As argued earlier, public access to information about cumulative environmental problems is necessary for democracy and the rule of law.[32] Accordingly, the public at large generally should be involved in being able to receive information. The question of who produces, shares, aggregates, and analyzes relevant data and information is more involved.

[30] E.g., media reporting on ineffective biodiversity offsets (a regulatory strategy discussed in Section 6.2.1), facilitated by public information about offsets, triggering formal inquiries and policy change: Caitlin Cassidy and Marni Cordell, "The Investigation that Blew the Lid off Sydney's Environmental Offsets" (*The Guardian* (Australia), May 29, 2023) www.theguardian.com/media/2023/may/29/the-investigation-that-blew-the-lid-off-sydneys-environmental-offsets.

[31] Dennis de Kool, "The Perceived Impacts of Monitoring Activities on Intergovernmental Relationships: Some Lessons from the Ecological Monitoring Network and Water in Focus" (2015) 187:689 *Environmental Monitoring and Assessment* 1–11; Andrea J. Reid and others, "'Two-Eyed Seeing': An Indigenous Framework to Transform Fisheries Research and Management" (2021) 22 *Fish and Fisheries* 243–261.

[32] See n 9.

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While relevant actors will vary for different cumulative environmental problems, we can make some general observations.

Governments, regulated entities, nongovernment organizations, and individuals may all contribute to data collection and analysis in ways that are relevant to regulating cumulative environmental problems. Governments can, and do, collect data about background effects and the changing conditions of matters of concern that are the focus of regulation, including using participatory approaches that involve stakeholders to varying degrees.[33] Regulated entities are often required,[34] and are best placed, to collect data about the impacts of their operations, since they have access to relevant sites and management details. Since the impacts of unlawful actions will not usually be self-reported, governments must usually collect these data, sometimes supplemented by citizen scientists.

Nongovernment citizen science or "crowdsourcing" initiatives may collect relevant data, for example, using digital platforms that record individuals' observations, from recording birds or plants to air quality recordings.[35] Some citizen science initiatives deal with unlawful actions, such as illegal gold mining and logging, potentially contributing to enforcement actions,[36] and unregulated but potentially harmful actions, such as the construction of many small dams that reduce streamflow in a watershed.[37] Citizen science initiatives may also deal with background effects that cannot be attributed to an individual actor or activity and may be either unlawful or unregulated, like the spread of invasive alien species,[38] or light pollution at night.[39]

For some matters of concern, data and information collected voluntarily by nongovernment organizations and individuals is indispensable to addressing

[33] See generally, Aparna Bamzai-Dodson and others, "Engaging with Stakeholders to Produce Actionable Science: A Framework and Guidance" (2021) 13(4) *Weather, Climate, and Society* 1027–1041.

[34] E.g., Table 5.1, row 2.

[35] E.g., The Cornell Lab of Ornithology, eBird, https://ebird.org/home; iNaturalist, www.inaturalist.org; see generally, Sachit Mahajan and others, "Translating Citizen-Generated Air Quality Data into Evidence for Shaping Policy" (2022) 9:122 *Humanities and Social Sciences Communications* 1–18.

[36] E.g., World Resources Institute, Global Forest Watch, www.globalforestwatch.org; see generally, Anna Berti Suman, *Civic Monitoring for Environmental Law Enforcement* (Edward Elgar 2024).

[37] Rachel Clayton, "Suspected Unlicensed Dams Multiplying across Stressed River System Reveal Holes in Victoria's Water Compliance," *ABC News* (June 2, 2023) www.abc.net.au/news/2023-06-02/unlicensed-dams-devastating-the-moorabool/102411916.

[38] Petr Pyšek and others, "Scientists' Warning on Invasive Alien Species" (2020) 95 *Biological Reviews* 1511–1534, 1522–1524.

[39] E.g., NoirLab, *Globe at Night*, https://globeatnight.org.

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cumulative environmental harm, for example, when a community experiences cumulative impacts of concern, or holds special knowledge that is central to understanding impacts, as with cultural heritage. Equally, data from citizen scientists can be important where government capacity, resources, or motivation fall short. From a social perspective, using nongovernment-sourced data – and including stakeholders and communities in processes relating to the analysis and use of government data – can help improve the legitimacy and credibility of the resulting information[40] and the regulatory interventions that it may trigger. This is the case for environmental problems in general. However, because cumulative environmental problems implicate so many actions – including those that are individually minor and not regulated, but may cause cumulatively significant harm – there is an especially pronounced need for community involvement and acceptance to counter the increased potential for political and public pushback to producing information.

These issues of the relevant actors, information sources, and types all arise in the crosscutting design features discussed next.

5.3 CROSSCUTTING DESIGN FEATURES

Ideally, data and information about matters of concern, changes in their condition, and cumulative pressures would be comprehensive, standardized, or otherwise made comparable where possible. They would widely be considered technically credible and socially legitimate. They would be either centralized or otherwise aggregated and easily available and understandable to the public and any agency that needed to use this information to inform its decision-making. These are the conditions that rules for information to help address cumulative environmental problems should be designed to create, while also addressing the social, political, and economic disincentives to achieving them.[41] This section deals with design features to address three key areas of regulatory challenge that cut across information contexts: obtaining comprehensive, high-quality data and analysis; allocating and reducing the associated costs; and sharing and accessing data and analysis.

Information-related provisions appear frequently in a wide range of legal situations dealing with cumulative environmental problems, from natural

[40] Ben Orlove and others, "Climate Decision-Making" (2020) 45 *Annual Review of Environment and Resources* 271–303, 17; see generally, Bamzai-Dodson and others, "Engaging with Stakeholders."

[41] See Section 2.2.2 for a discussion that leads to these design features.

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resources allocation to pollution controls. Other relevant legal contexts – for example, human rights related to the environment – seem rarely to deal with information, though information is crucial to their operationalization.[42] The illustrative examples of regulatory solutions presented here are drawn from many areas of law, and a wide range of jurisdictions, recognizing that jurisdictions vary significantly in their appetite for regulatory detail in prescribed processes and public involvement.[43]

5.3.1 *Obtaining Comprehensive, High-Quality Data and Analysis*

Data about a cumulative environmental problem are comprehensive if they cover all the information needs relating to the matter of concern to understand and respond to cumulative threats.[44] In practice, though, regulations tend to overlook some important types of data. For example, rules more rarely provide for collecting data about actions that are not regulated than they do for regulated actions, even if both types of activities have the potential to cause significant cumulative harm. Table 5.1 provides examples of regulations that expressly address each of these key ongoing information needs. Additional research or information of a non-ongoing nature may also be needed to support conceptualization, for example, to establish "safe" levels of a pollutant, and intervention, for example, to understand the motivations and capacities to change behavior of contributors to cumulative impacts.[45]

Information that is high-quality for the purposes of cumulative environmental problems are produced using analytical methods that are transparently reported, appropriate to the subject matter, and robust (about which it is difficult to generalize, but which policy guidelines may flesh out, as discussed later). It may be unrealistic to avoid significant uncertainty about predicted future conditions of a matter of concern due to nonlinear and indirect effects, and analysis may involve potentially significant simplifications and assumptions.[46] Accordingly, regulations should provide mechanisms to ensure clarity and transparency about these matters, in particular.[47] Given its complexity,

[42] Emily Barritt, "The Aarhus Convention and the Latent Right to a Healthy Environment" (2024) 36 *Journal of Environmental Law* 67–84, 68, 81.

[43] Sheila Jasanoff, "Cultural Aspects of Risk Assessment in Britain and the United States" in Branden B. Johnson and Vincent T. Covello (eds), *The Social and Cultural Construction of Risk: Essays on Risk Selection and Perception*, vol. 3 (Springer 1987) 359–397, 361.

[44] See Section 5.1.1.

[45] See Section 6.3.

[46] See Section 2.2.2.3.

[47] The issue of how to ensure that uncertainty does not stand in the way of decision-making is dealt with in Chapter 6 on Intervention.

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TABLE 5.1 *Mechanisms to fulfill information needs for addressing cumulative environmental problems*

Legal mechanism	Illustrative examples
Requirement to regularly collect data about the conditions of a matter of concern and report on aggregate effects over time	Chapter 9 of this book describes the integrated information system that informs interventions to protect the Great Barrier Reef, Australia. It includes a statutory obligation to produce a five-yearly, peer-reviewed "Outlook report" on the health of the Reef.[a]
Requirement to collect and report data about actions that are regulated and lawfully undertaken	Entities subject to hazardous waste reduction requirements in Indonesia must report periodically on how they implement this duty.[b]
Requirement to collect and analyze data about actions that are regulated by law but carried out in a way that exceeds their authorization (e.g., emitting more pollution than an authorization permits), or that are carried out without any authorization (for brevity, "unlawful actions")	Kenya's statutory National Environment Management Authority has duties to monitor compliance with a wide range of laws, including to monitor "activities that are likely to have a significant effect on the environment" (which is expressed notably broadly), compliance with pollution standards, resource use patterns, climate change duties, and carbon market compliance.[c] New York City's Citizens Air Complaint Program uses payment to incentivize third parties to report unlawfully idling vehicles.[d]
Requirement to collect data about activities that are not (or not yet) subject to regulation ("unregulated actions")	In Australia's Murray-Darling Basin, state governments write statutory plans that must provide for monitoring and assessing the potential of unregulated water uses (such as tree plantations and water withdrawals for domestic purposes) to have cumulatively significant impacts on the availability of water in rivers and aquifers.[e] A Seychelles multistage plan to recover populations of shark pursuant to its international obligations begins with identifying and recording (at that stage, unregulated) artisanal shark fishers, paving the way for phased interventions.[f]
Requirement to collect data about "background" effects that are difficult to attribute to an individual actor or activity	The recovery plan for the endangered California Condor, mandated under the US Endangered Species Act, plans information collection and associated measures in relation to damaging background effects such as habitat loss, poisoning by lead shot, collisions with structures, and natural predators.[g]

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Legal mechanism	Illustrative examples
Requirement to collect data about indirect drivers of cumulative change, which may involve regulated, regulated but unauthorized, or unregulated actions	Italy's environmental accounting law, which requires annual natural capital accounts, is considered "advanced practice" in Europe.[h] Reports estimate subsidies that harm biodiversity[i] and must include proposals to phase out environmentally harmful subsidies.[j]

[a] Great Barrier Reef Marine Park Act 1975 (Australia) s 64.
[b] Peraturan Pemerintah Republik Indonesia nomor 22 tahun 2021 tentang Penyelenggaraan Perlindungan Dan Pengelolaan Lingkungan Hidup [Government Regulation no. 22 of 2021 on Environmental Protection, Organization and Management] (Indonesia) art. 284.
[c] Environmental Management and Co-ordination Act 1999, as amended (Cap. 387) (Kenya) ss 68 (1), 117(2); Climate Change Act 2016, as amended (Cap. 387A) (Kenya) ss 16–17; Climate Change (Carbon Markets) Regulations 2024 (Kenya); National Environment Management Authority (Kenya), "Development of the National Carbon Market Registry" (n.d.) www.nema.go.ke/index.php?option=com_content&view=article&id=412:development-of-the-national-carbon-market-registry&catid=10:news-and-events&Itemid=572#, last accessed March 18, 2025, archived at https://perma.cc/QP8C-3BWP.
[d] New York City Administrative Code § 24-163; NYC Environmental Protection, "Transportation Emissions: Citizens Air Complaint Program" (n.d.) www.nyc.gov/site/dep/environment/idling-citizens-air-complaint-program.page, last accessed March 18, 2025, archived at https://perma.cc/5KE4-YYRS.
[e] Basin Plan 2012 (Australia) ss 10.23–10.25; Rebecca Nelson, "Challenges to Improved Integrated Management of the Murray-Darling" in Barry Hart and others (eds), *Murray-Darling Basin, Australia: Its Future Management* (Elsevier 2021) 339–361, 349–350.
[f] Seychelles Fishing Authority, *National Plan of Action for the Conservation and Management of Sharks 2016–2020* (2016) 68, https://mofbe.gov.sc/wp-content/uploads/2021/09/National-Plan-of-Action-for-the-Conservation-and-Management-of-Sharks-2016-2020-3.pdf, archived at https://perma.cc/7XW9-VPLA; identified international obligations include those under the United Nations Convention on the Law of the Sea, December 10, 1982, Montego Bay, in force November 16, 1994, 1833 U.N.T.S. 396, among other laws: ibid 93.
[g] 16 U.S.C. §1533(f), Lloyd F. Kiff, Robert I. Mesta and Michael P. Wallace, *Recovery Plan for the California Condor* (3rd ed., 1996, US Fish and Wildlife Service) 30–33; see also US Fish and Wildlife Service, "California Condor Recovery Program" (n.d.) www.fws.gov/program/california-condor-recovery, last accessed March 18, 2025, archived at https://perma.cc/7HNM-HQ86.
[h] Directorate-General for Environment (European Commission), *Environmental Implementation Review 2022: Country Report – Italy (SWD/2022/275 Final)* (European Commission 2022) 3; Legge 28 dicembre 2015, n. 221 Disposizioni in materia ambientale per promuovere misure di green economy e per il contenimento dell'uso eccessivo di risorse naturali [Law on environmental provisions to promote green economy measures and to contain the excessive use of natural resources] (Italy) ("Italian Green Economy Law"), art. 67; Comitato per il Capitale Naturale, *Quinto Rapporto sullo Stato del Capitale Naturale in Italia* [Fifth Report on the State of Natural Capital in Italy] (Government of Italy 2022) www.mase.gov.it/sites/default/files/archivio/allegati/CapitaleNaturale/V_Rapporto_CN.pdf, archived at https://perma.cc/V59Q-ZC89.
[i] E.g., Comitato per il Capitale Naturale, *Quinto Rapporto*, 172–176; Italian Green Economy Law), arts. 67 (Natural Capital Committee), 68 (catalog of subsidies).
[j] Italian Green Economy Law, art. 68(2).

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good cumulative impact analysis requires sufficient regulatory timelines to undertake modeling and coordination between multiple agencies to ensure access to expertise and robust work.[48] In addition to models and quantitative data, high-quality data may also include data produced outside Western scientific disciplines. This includes First Nations' knowledges, subject to appropriate protocols,[49] and qualitative information, a form that some cumulative impact analyses adopt.[50]

Regulatory approaches to ensuring high-quality data and analysis and addressing key risks tend to fall into two categories: those that use broadly worded *principles* to describe the kind of data and analysis that decision-makers must use (e.g., "best available science" and related terms) and those that prescribe *processes* to ensure certain aspects of quality or to head off risks. Principles for data analysis may expressly or implicitly require cumulative impact assessment (see Table 5.2).

Using principles ensures flexibility, the ability to evolve over time without amendment, and applicability to a diverse set of situations. A disadvantage of principles is that their precise meaning can be disputed.[51] The risk of such disputes may be heightened where the costs of comprehensive data collection or cumulative effects analysis would be significant. This suggests the value of combining principles and either more detailed guidance about what constitutes high-quality information or the protocols, processes, and institutions that produce it. Important types of processes and institutions that appear in rules include: using independent or nongovernment bodies and observers to avoid political pressure and executive capture; peer review, standards, and accreditation; requirements for transparency about uncertainty and assumptions; and regulatory timelines that are not so short that they prevent good analysis (see Table 5.2). Embedding these requirements in rules can help ensure stability in the face of cost or other pressures.

5.3.2 *Allocating and Reducing Costs Associated with Information*

Large-scale and with diverse contributors to change, cumulative environmental problems are data hungry, which heightens the costs of collecting data and

[48] Emma E. Hodgson, Benjamin S. Halpern and Timothy E. Essington, "Moving Beyond Silos in Cumulative Effects Assessment" (2019) 7:211 *Frontiers in Ecology and Evolution* 1–8, 3 (discussing the need for agency-to-agency links).

[49] Erin O'Donnell and Rebecca Nelson, "Shield Science for Robust Decisions" (2020) 3 *Nature Sustainability* 675–676, 676.

[50] Emma E. Hodgson and Benjamin S. Halpern, "Investigating Cumulative Effects across Ecological Scales" (2018) 33 *Conservation Biology* 22–32, 27–28.

[51] See, e.g., Doremus, "Purposes, Effects, and Future," 424–426 (discussing case law on the meaning of best available science).

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TABLE 5.2 *Mechanisms to promote high-quality data and information for addressing cumulative environmental problems*

Legal mechanisms	Illustrative examples
Protocols for interface between Western and other knowledge systems in understanding a matter of concern	To avoid inappropriately integrating Indigenous knowledges into Western science as a "resource," some frameworks and protocols for knowledge generation, like Two-Eyed Seeing, Etuaptmumk (Miâ•Žkmaw; Eastern Canada), expressly seek to "remedy, rather than reinforce, existing power relations; respect differences, instead of suppress them; and uphold, as opposed to diminish, their unique strengths."[a]
Principle-based standards, like "best available science"	The US Endangered Species Act requires agencies to use "best available science" when determining whether a species is endangered[b] (i.e., determining the conditions of the matter of concern) and when formulating a "biological opinion,"[c] which must include cumulative effects.[d] This standard encompasses both scientific and commercial data.[e]
A "state of knowledge" standard for data collection and analysis	The "state of knowledge" that informs the standard of the environmental protection duty that applies to all persons in Victoria, Australia, includes information from business, government agencies, and independent and international organizations, including guidelines and standards.[f]
Regulatory independent scientific processes that ensure the integrity of data and analysis used by regulators[g]	Australian federal environmental law establishes an independent groundwater expert committee to review impact assessments, including cumulative impact assessments, of proposed coal mines and coal seam gas developments on water resources, and to advise on related bioregional assessments.[h] The committee was established specifically to enhance transparency and public confidence.[i]
Detailed policy guidance for undertaking rigorous cumulative impacts analysis	The US, Canada, and South Africa, among other jurisdictions, provide detailed general policy guidance for undertaking cumulative impacts analysis in general[j] and in specific contexts, e.g., transportation, chemical exposure.[k] Some industry sectors produce their own guidance on cumulative impact assessment.[l]

(*continued*)

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TABLE 5.2 (*continued*)

Legal mechanisms	Illustrative examples
Independent observers of environmentally relevant activities	Papua New Guinea's fisheries legislation provides for independent at-sea observers to collect data for "scientific, management and compliance purposes" in relation to matters including fish taken, fishing methods, and the effects of fishing on the environment. Vessel operators and crew have an obligation to assist observers.[m]
Monitoring undertaken by communities potentially affected by cumulative impacts	Community conservancies, established under Namibia's nature conservation law, combine community development and wildlife protection.[n] A key feature of these arrangements is the community-led "Event Book System," under which conservancies design and undertake wildlife monitoring, trained by nongovernment organizations (NGOs), producing long-term data that are aggregated by government to guide interventions and compliance monitoring.[o] The Event Book System now also includes local-level climate change–related monitoring.[p]

[a] See generally Reid and others, "Two-Eyed Seeing," especially 246, 247.
[b] 16 U.S.C. § 1533(b)(1)(A).
[c] 50 C.F.R. § 402.14(d).
[d] 50 C.F.R. § 402.14(g)(3), (4).
[e] *San Luis & Delta-Mendota Water Authority v. Locke*, 776 F.3d 971, at 995 (9th Cir. 2014).
[f] Environment Protection Act 2017 (Victoria) ss 6(2), 25; Environment Protection Authority (Victoria, Australia), *Reasonably Practicable*, Publication 1856 (September 2020) 10, www.epa.vic.gov.au/-/media/epa/files/publications/1856-english.pdf, archived at https://perma.cc/Z6WK-PR7G. For examples of industry guidelines in relation to cumulative effects assessments, see note 70. See also generally Lindsay, Marsh and Nelson, "Conceptualising and Activating Knowledge in Environmental Protection Law."
[g] Coglianese, *Listening, Learning, Leading*, xi.
[h] Environment Protection and Biodiversity Conservation Act 1999 (Australia) ss 131AB, 505C, 505D.
[i] Australian Government, "About the Independent Expert Scientific Committee on Unconventional Gas Development and Large Coal Mining Development (IESC)" (n.d.) www.iesc.gov.au/about-us, last accessed March 18, 2025, archived at https://perma.cc/C7RU-C7SR.
[j] Council on Environmental Quality (US), *Considering Cumulative Effects under the National Environmental Policy Act* (1997) https://ceq.doe.gov/publications/cumulative_effects.html, archived at https://perma.cc/2HX5-C8SA; Impact Assessment Agency of Canada, *Policy Framework for Assessing Cumulative Effects under the Impact Assessment Act* (May 2023) www.canada.ca/en/impact-assessment-agency/services/policy-guidance/practitioners-guide-impact-assessment-act/policy-framework-assessing-cumulative-effects-under-impact-assessment-act.html, archived at https://perma.cc/EUU2-44PM; Department of Environmental Affairs and Tourism (South Africa), *Cumulative Effects Assessment, Integrated Environmental Management Information Series 7* (2004) www.dffe.gov.za/sites/default/files/docs/series7_cumulative_effects_assessment.pdf, archived at https://perma.cc/32FV-262W.
[k] Transportation Projects: California Department of Transportation, *Guidance for Preparers of Cumulative Impact Analysis – Approach and Guidance* (2005) https://dot.ca.gov/-/media/dot-

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media/programs/environmental-analysis/documents/ser/approach-and-guidance-a11y.pdf, archived at https://perma.cc/6YSU-F74C; US EPA, *Framework for Cumulative Risk Assessment* (2003) www.epa.gov/sites/default/files/2014-11/documents/frmwrk_cum_risk_assmnt.pdf, last accessed March 18, 2025, archived at https://perma.cc/V3F7-LTPK.

[l] RenewableUK, *Cumulative Impact Assessment Guidelines: Guiding Principles for Cumulative Impacts Assessment in Offshore Wind Farms* (2013) https://tethys.pnnl.gov/sites/default/files/publications/Cumulative-Impact-Assessment-Guidelines.pdf; American Association of Highway and Public Transportation Officials (AASHTO), *Practitioner's Handbook: Assessing Indirect Impacts and Cumulative Impacts under NEPA* (2016) https://wsdot.wa.gov/sites/default/files/2021-10/ENV-NSEPA_AASHTOCummHndbk.pdf, archived at https://perma.cc/QLF7-WLGH; Minerals Council of Australia, Cumulative Environmental Impact Assessment Industry Guide: Adaptive Strategies (July 2015) https://minerals.org.au/wp-content/uploads/2023/01/Cumulative_Environmental_Impact_Assessment_Industry_Guide_FINAL_0.pdf.

[m] Fisheries Management Act 1998 (Papua New Guinea) ss 50–55. A similar approach is used in Canada: Fishery (General) Regulations, SOR/93-53 (Canada) ss 39–40, 46–48.

[n] Nature Conservation Amendment Act 1996, No. 5 of 1996 (Namibia) s 3.

[o] Michael Wenborn and others, "Lessons on the Community Conservancy Model for Wildlife Protection in Namibia" (2022) 31 *The Journal of Environment & Development* 375–394, 384–389; Greg Stuart-Hill and others, "The Event Book System: A Community-Based Natural Resource Monitoring System from Namibia" (2005) 14 *Biodiversity and Conservation* 2611–2631, 2613.

[p] See generally, John Kazgeba Elijah Mfune and Kopang Bonadei Thekwane, "Empower to Adapt: Creating Climate Change Resilient Livelihoods through Community-Based Natural Resources Management (CBNRM) in Namibia: Final Independent Evaluation Report" (Green Climate Fund, 2023) www.greenclimate.fund/sites/default/files/document/fp024-final-independent-evaluation-report.pdf.

undertaking analysis,[52] and makes cost cutting and corner cutting significant risks. This puts issues of cost in focus: how to allocate costs, and how to contain costs in an absolute sense in a way that avoids the temptation to overlook impacts that may be individually minor but cumulatively significant. That, in turn, raises thorny issues associated with using technology.

A first element of the cost question is determining how to allocate the costs associated with data collection and analysis among contributors to a cumulative environmental problem and the state. As with standards for information quality, some jurisdictions use broad principles. Some focus on allocating costs to the contributors to a problem, like the "polluter pays" principle; others allocate costs to those who benefit from a resource or project, like the "beneficiary pays" principle; still others support a combined approach through principles like "shared responsibility" (Table 5.3). Governments with

[52] Hodgson and Halpern, "Investigating Cumulative Effects," 27 (in relation to mapping methods).

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TABLE 5.3 *Mechanisms to share and reduce costs related to information*

Legal mechanism	Illustrative examples
Polluter pays principle – cost recovery for data collection based on cumulative risk	In Melbourne, Australia, municipal water service providers charge to accept trade waste into their sewerage systems; charges are based on a cumulative "risk rank" score, which considers the higher costs of more closely monitoring more complex types of discharges.[a]
Principle of shared responsibility to share costs among government and different categories of actions	In Canadian fisheries, "[t]he responsibility to pay for catch reporting and monitoring is shared between [the government agency Fisheries and Oceans Canada] and fish harvesters," with detailed policy for sharing specific costs between government, commercial fishers, recreational fishers, and Indigenous groups.[b]
Higher standard of information and burden of proof for proponent where existing cumulative impacts are close to cumulative threshold conditions	To protect streamflow that depends on groundwater, water law in the US state of Montana requires a permit applicant for a groundwater withdrawal right in a fully appropriated basin (in which no further surface water is available) to prove, using a hydrogeologic report, that any adverse effect on a connected stream would be offset.[c]
Stable source of government funding for data collection and sharing	Namibia's statutory Environmental Investment Fund was established to provide stable financial support to manage natural resources sustainably and gain associated benefits for local communities.[d] It receives money from parliamentary appropriations, statutory levies, and donations to fund activities that include "production, monitoring, use and dissemination of environmental information."[e]
Government data collection and analysis to support a regional intervention (e.g., regulatory limit on harm or resource use), used by a proponent to compare a project's impacts to the limit	The Office of Groundwater Impact Assessment (an independent statutory entity) in Queensland, Australia, undertakes regional and cumulative impact assessments for areas in which multiple tenures for unconventional gas developments overlap.[f] Development proponents use these models to identify their project's impacts for

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Legal mechanism	Illustrative examples
	submission in environmental impact assessment (EIA) processes.[g]
Technology to reduce costs of collecting or analyzing data and planning compliance activities	Established under a presidential decree, Brazil's "Action Plan for the Prevention and Control of Deforestation in the Legal Amazon" uses satellite monitoring as a key component.[h] Empirical research suggests this monitoring has significantly improved targeted enforcement of illegal conversion of forests to pasture, both reducing deforestation and having positive economic effects.[i]
Prioritization of data collection to reduce costs	California's groundwater monitoring legislation sets out express criteria for prioritizing the implementation of the duty to monitor groundwater elevations. Relevant matters relate to dependence of the area on groundwater, growth projections, adverse impacts, and ecological matters.[j]

[a] Greater Western Water, *Greater Western Water (previously City West Water) Area – Pricing Handbook 2021–22* (June 2021) 23–30, https://web.archive.org/web/20210809021133/https://www.citywestwater.com.au/sites/default/files/attachments/GWW%20(Previously%20CWW)%20Area%20-%20Pricing%20Handbook%20FY22.pdf.

[b] Government of Canada, "Fishery Monitoring Policy" (n.d.) www.dfo-mpo.gc.ca/reports-rapports/regs/sff-cpd/fishery-monitoring-surveillance-des-peches-eng.htm, last accessed March 18, 2025, archived at https://perma.cc/56RT-ABKX.

[c] Montana Code Ann. 85-2-360(1), (2), (3)(c). For further discussion of offsets, see Chapter 6.2.1.

[d] Environmental Investment Fund Act 2001 (Namibia) s 4.

[e] Ibid ss 3, 25(e).

[f] Water Act 2000 (Queensland) ch 3, 3A.

[g] Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (Australia), "Fact Sheet: Environmental Assessments" (n.d.) www.iesc.gov.au/publications/environmental-assessments, last accessed March 18, 2025, archived at https://perma.cc/KD6N-SLZL.

[h] Decreto nº 11.367, de 1º de janeiro de 2023 [Presidential Decree No. 11,637 of January 1, 2023] (Brazil) arts. 1, 4; Government of Brazil, *Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm): Fifth Phase (2023–2027)* (2023) 110–112, www.gov.br/mma/pt-br/assuntos/combate-ao-desmatamento-queimadas-e-ordenamento-ambiental-territorial/controle-do-desmatamento-1/amazonia-ppcdam-1/ppcdam_5_en.pdf, last accessed March 18, 2025, archived at https://perma.cc/7FFC-DW4Q.

[i] See generally, Erik Merkus, "The Economic Consequences of Environmental Enforcement: Evidence from an Anti-Deforestation Policy in Brazil" (2024) 181(106646) *World Development* 1–12.

[j] Cal. Water Code §§ 10933(b), 10933.5.

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scientific agencies may be better placed than individual project proponents to collect and analyze data on background effects, such as predicted climate change impacts or general environmental trends. Natural resources plans and strategic or regional environmental assessments can then include this information, to be used in assessing projects[53] (a kind of "tiering"). Regardless of where the responsibility falls, rules should provide clarity about who undertakes and pays for monitoring and analysis, and, ideally, consequences of not providing required information.[54]

A second key issue in relation to information and costs is how rules themselves can help reduce the costs of monitoring in an absolute sense. One way to do this is to support coordination between actors to reduce unnecessary duplication.[55] This can occur through tiering and by proponents sharing reusable data, which in some jurisdictions is rarely made publicly available in practice.[56] Another approach to containing costs is to prioritize data collection using a cumulative risk–based approach (Table 5.3) to help identify impacts that are "cross-cutting, multi-sector driven, and synergistic [and therefore] of greatest significance to a region and most urgently require effective management."[57] This can then drive intervention based on cumulative impact scores and ranks that include links to socioeconomic issues, guided by stakeholders, including communities.[58]

Rules can also support technology for monitoring, analysis, and targeting compliance activities to reduce the economic and environmental costs (Table 5.3) of collecting and processing data about large areas and many activities.[59] Bioacoustic monitoring of bird calls and machine learning to identify species,[60] and eDNA (environmental DNA), are examples. Technology can help monitor background levels of environmental stress, for example, vehicle sensors that can detect cumulatively significant local-level air pollution that may otherwise be missed, as used by the US Environmental

[53] Antwi and others, "Risk Assessment Framework," 18.

[54] Angus Morrison-Saunders and others, "Reflecting on, and Revising, International Best Practice Principles for EIA Follow-Up" (2021) 89:106596 *Environmental Impact Assessment Review* 1–10, 8.

[55] Section 2.2.2.2.

[56] Productivity Commission (Australia), *Resources Sector Regulation* (2020) 21–22.

[57] Antwi and others, "Risk Assessment Framework," 7–9.

[58] Ibid 8, 17–19.

[59] For a review of large-scale monitoring and related processing technologies, see Alessio Fascista, "Toward Integrated Large-Scale Environmental Monitoring Using WSN/UAV/Crowdsensing: A Review of Applications, Signal Processing, and Future Perspectives" (2022) 22:1824 *Sensors* 1–65.

[60] Zuzana Burivalova, Edward T. Game and Rhett A. Butler, "The Sound of a Tropical Forest" (2019) 363 *Science* 28–29.

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Protection Agency.[61] Environmental monitoring can guide risk-based allocations of inspection resources to maximize the regulatory violations detected from inspections.[62] Satellite imagery, for example, has been used to detect potentially unlawful small dams[63] or water uses[64] that cumulatively reduce streamflows in Australia. The US Environmental Protection Agency considered the introduction of electronic reporting of permitted point source water pollution to be a "game changer."[65] That said, rules about environmental data collection should avoid rigidly requiring the use of any particular technology that might become superseded. Recalling the concerns discussed earlier,[66] the risks posed by technology deserve careful consideration and regulatory safeguards in terms of privacy or data protection laws, which go beyond the current scope of discussion.

Policy guidance about cumulative impact analysis and modeling can guide the use of analytical technology. Artificial intelligence provides a new way to understand complex interactions between impacts, including between climatic and more direct anthropogenic impacts; and to model the effects of a mix of types of interventions.[67] With appropriate safeguards, enforcement policies can contemplate the use of artificial intelligence and machine learning to reduce the time and cost of assessing large amounts of data to identify activities that may constitute noncompliance for further investigation by agencies. Making such predictions is a particularly prominent problem in the context of cumulative environmental effects because of the challenge of choosing where to direct compliance activities among numerous actors.

[61] US Environmental Protection Agency, "Advanced Monitoring GMAP – Field Monitoring NEIC's Field Support Capabilities" (n.d.) www.epa.gov/sites/production/files/2018-05/documents/factsheet-neic-fb-advmonitoring.pdf, last accessed March 18, 2025, archived at https://perma.cc/2255-E2HR.

[62] M. Hino, E. Benami and N. Brooks, "Machine Learning for Environmental Monitoring" (2018) 1 *Nature Sustainability* 583–588, 585.

[63] See above n 37 and accompanying text.

[64] Murray-Darling Basin Authority, Murray-Darling Basin Authority Communique (May 6, 2021) www.mdba.gov.au/news-and-events/newsroom/murray-darling-basin-authority-communique-may-2021, archived at https://perma.cc/6UBU-P58A.

[65] Susan Bodine, Assistant Administrator for US EPA Office of Enforcement and Compliance Assurance, "The Enforcement Angle: EPA's Susan Bodine" (October 14, 2020) Podcast, eli.org/podcasts.

[66] See Section 2.2.2.2.

[67] Christian Simeoni and others, "Evaluating the Combined Effect of Climate and Anthropogenic Stressors on Marine Coastal Ecosystems: Insights from a Systematic Review of Cumulative Impact Assessment Approaches" (2023) 861:160687 *Science of The Total Environment* 1–18, 14.

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5.3.3 *Sharing and Accessing Data and Information*

While access to government-held environmental information is a well-studied legal issue,[68] the cumulative effects incarnation of the issue is about sharing interoperable data from multiple sources, aggregating it, and accessing aggregated data and models or other systems that use it to predict effects, then accessing that information. Sharing data and information is not just technically desirable: Since cumulative impacts intersect with concerns about environmental justice and rights,[69] access to justice also requires access to information about cumulative environmental problems. Even where these problems most directly affect communities and justice, government data may omit important categories of impact, be unusable without special expertise, or not be aggregated.[70]

Law can play a central role in ensuring findable, accessible, interoperable, and reusable (FAIR) and contextualized data,[71] though this seems rarely recognized. Some laws lean in this direction: emerging natural capital and environmental accounting laws;[72] long-established impact assessment laws – EIA and strategic environmental assessment (SEA) – that require the public availability of impact assessment documents for a project or program; legal rights to environmental information, which sometimes link to human rights;[73] statutory "state of the environment" reporting; and legally mandated digital repositories that aggregate data from diverse sources, sometimes with the express rationale of better addressing cumulative impacts[74] (Table 5.4). To varying degrees, these mechanisms provide for synthesized information relevant to a particular matter of concern, as opposed to high-level overviews or reams of isolated documents; and sharing underlying data that are

[68] For a recent notable example, see, e.g., Sean Whittaker, *The Right of Access to Environmental Information* (CUP 2021).

[69] See generally, Office of General Counsel, US Environmental Protection Agency, *EPA Legal Tools to Advance Environmental Justice: Cumulative Impacts Addendum*, Pub. No. 360R22002 (2023) www.epa.gov/system/files/documents/2022-12/bh508-Cumulative%20Impacts%20Addendum%20Final%202022-11-28.pdf, last accessed March 18, 2025, archived at https://perma.cc/5HQ4-GVCQ; Barritt, "Aarhus Convention," 68, 81. See also Section 4.2.2.

[70] Fusi, Zhang and Liang, "Unveiling Environmental Justice," 1096–1106.

[71] See Section 2.2.2.2, especially n 55 and accompanying text.

[72] E.g., see Table 5.1, last row.

[73] E.g., Uzuazo Etemire, "Access to Environmental Information under EU Law" in Marjan Peeters and Mariolina Eliantonio (eds), *Research Handbook on EU Environmental Law* (Edward Elgar 2020) 117–132, 129–132; Barritt, "Aarhus Convention," 68, 81.

[74] Department of Climate Change, Energy, the Environment and Water (Australia), Nature Positive Plan: Better for the Environment, Better for Business (Canberra, 2022), 1–50, 29–30, www.dcceew.gov.au/sites/default/files/documents/nature-positive-plan.pdf, archived at https://perma.cc/H5J8-9Q3V.

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TABLE 5.4 *Mechanisms to promote sharing and access to FAIR data*

Legal mechanism	Illustrative example
Public right to access environmental information from public and private entities	Argentina's constitutional "right to a healthy, balanced environment" is supported by a statutory right to information[a] held by governments and public service companies (whether public or private) about "the state of the environment or one of its components, natural or cultural, including their mutual interactions, as well as to the activities and works which affect them or might affect them significantly" and to "policies, plans, programs and actions relating to the management of the environment."[b] South Africa's constitution allows third parties to request private environmental information if this is required to protect constitutional environmental rights.[c]
Regular publicly available government reports on the state of the environment	The independent statutory "Commissioner for Environmental Sustainability" in Victoria, Australia, must produce publicly available "state of the environment" reports.[d] These include recommendations for government action, to which the government must formally respond.[e] Such reports are also required in other jurisdictions,[f] and may prominently draw attention to cumulative impacts.[g]
Digital repository of information provided by agencies, regulated entities (including environmental impact assessment (EIA) documents) and citizen scientists to ensure accessibility	India's Biological Diversity Act of 2002 provides for a system of registering local knowledge related to biodiversity.[h] In Greece, reforms to EIA intended to increase transparency created a National Electronic Environmental Registry to manage and publish all EIA-related documents.[i]
Standardized data gathering and sharing for interoperability	Federal water regulations in Australia require public and some private entities to provide water data to a federal agency using standard units of measurement and providing detailed metadata.[j] The US Environmental Protection Agency's data standards policy[k] promotes transparency and the exchange and multiple use of data between that agency, states and tribes.

(*continued*)

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TABLE 5.4 (*continued*)

Legal mechanism	Illustrative example
Requirements for accessible models and aggregated data	An express legislative purpose of California's groundwater monitoring legislation was to make groundwater level data "readily and widely available."[l] Online, freely available technical models support California's groundwater sustainability plans by predicting how much groundwater pumping depletes surface water.[m]
Environmental information sharing legislation prevails over barriers to information sharing based on commercial reasons	European Union law applies an irrebuttable presumption that it is in the public interest to disclose information about emissions to the environment, even if doing so may undermine commercial business interests or intellectual property rights.[n] Canadian case law implies an exception to copyright legislation in respect of disclosure requirements under recent oil and gas law.[o]
Time-limited confidentiality periods for environmental data with commercial value	UK legislation requires disclosure of oil and gas–related information either immediately, after two or five years or after expiration of a relevant licence.[p]

[a] Maria Onestini, "Human Right to Water: Argentine Cases, Human Rights – Are They Enforceable?" in Erkki J. Hollo (ed), *Water Resources Management and the Law* (Edward Elgar 2017) 118, 126–127 (citing art. 41 of the Argentine Constitution, and the 2016 Regimen De Libre Acceso La Información Pública Ambiental, Ley 25831).

[b] Ibid 127.

[c] Constitution of the Republic of South Africa 1996, ss 24, 32(1)(b).

[d] Commissioner for Environmental Sustainability Act 2003 (Victoria) ss 17–18A; Commissioner for Environmental Sustainability Victoria, *Victorian State of the Environment 2023 Report: Summary Report* (2023) www.ces.vic.gov.au/sites/default/files/2023-11/State%20of%20the%20Environment%202023%20Report_Summary%20Report_DIGITAL.pdf, archived at https://perma.cc/9QPB-YK3A.

[e] Commissioner for Environmental Sustainability Act 2003 (Victoria) s 17(5).

[f] European Environment Agency, *State of Nature in the EU: Results from Reporting under the Nature Directives 2013–2018* (2020) www.eea.europa.eu/en/analysis/publications/state-of-nature-in-the-eu-2020/state-of-nature-in-the-eu-2020/@@download/file, archived at https://perma.cc/8UGN-6TCB.

[g] E.g., European Environment Agency, *The European Environment – State and Outlook 2020: Knowledge for Transition to a Sustainable Europe* (2019) 74 ("key messages" for biodiversity), 134 ("key messages" for marine environment) www.eea.europa.eu/en/analysis/publications/state-of-nature-in-the-eu-2020, archived at https://perma.cc/D33K-7G3Q.

[h] Biological Diversity Act 2002 (India) s 36(5); Biological Biodiversity Rules 2024 (India) rr 11 (f)–(h); Laasya Shekar, "What Is a People's Biodiversity Register?" (July 7, 2024, Mongabay India) https://india.mongabay.com/2024/07/explainer-what-is-a-peoples-biodiversity-register.

[i] Νόμος αριθ 4014 (2011) "Περιβαλλοντική αδειοδότηση έργων και δραστηριοτήτων, ρύθμιση αυθαιρέτων σε συνάρτηση με δημιουργία περιβαλλοντικού ισοζυγίου και άλλες διατάξεις αρμοδιότητας Υπουργείου Περιβάλλοντος" [Law No. 4014 (2011) "Environmental Licensing of Works and Activities, Regulation of Illegal Constructions in Connection with Environmental Stability and Other

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Provisions Falling Under the Competence of the Ministry of Environment"], art. 18, as amended; Kalliope Pediaditi and others, "Greece's Reformed EIA System: Evaluating Its Implementation and Potential" (2018) 73 *Environmental Impact Assessment Review* 90–103 (praising the design of the system, which was not implemented at that time); Ministry of Environment and Energy (Greece), "Access the Electronic Environmental Register" (n.d.) www.gov.gr/en/upourgeia/upourgeio-periballontos-kai-energeias/periballontos-kai-energeias/elektroniko-periballontiko-metroo-epm, last accessed March 18, 2025, archived at https://perma.cc/FM8U-TLSY.

[j] Water Regulations 2008 (Australia) regs 7.06, 7.10, 7.11.

[k] U.S. Environmental Protection Agency, "'Data Standards Policy," CIO 2133.0 (June 28, 2007) www.epa.gov/sites/default/files/2013-11/documents/21330.pdf, last accessed March 18, 2025, archived at https://perma.cc/3LPP-AJ76.

[l] California Water Code § 10920.

[m] California Department of Water Resources, "Data and Tools" (n.d.) https://water.ca.gov/Programs/Groundwater-Management/Data-and-Tools, last accessed March 18, 2025, archived at https://perma.cc/DT4T-XN26; see Chapter 8.

[n] Regulation 1367/2006 of the European Parliament and of the Council of September 6, 2006 on the application of the provisions of the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters to Community institutions and bodies [2006] OJ L264/13, art. 6(1); Madrid, *Private Sector Environmental Information*, 194–195.

[o] Brown, "The Future of Intellectual Property," 122–123.

[p] Ibid 114–115 (citing Oil and Gas Authority (Offshore Petroleum) (Disclosure of Protected Material after Specified Period) Regulations 2018 (United Kingdom)).

enduringly accessible to enable aggregation to shed light on cumulative environmental problems.

As discussed in Chapter 2, political and commercial sensitivities may discourage governments and regulated entities from producing information that is FAIR, and sharing it. Regulated entities may resist attempts to standardize data collection if this imposes additional costs or is seen to pose risks. Agencies can consult regulated entities about standardization to find ways to reduce costs faced by these entities; this may be especially important for small recipients of regulatory "carrots," such as parties to land stewardship agreements that involve reporting requirements.[75]

Regulatory designers should also consider potentially perverse consequences of requiring data sharing: In the context of concerns about nutrient pollution of the Great Barrier Reef in Queensland, Australia, a proposed legal power to require farmers to provide data on fertilizer application, which would have indicated overapplication, led to the deletion of a decade's worth of voluntarily collected data.[76] But, in some cases, mandatory data sharing can

[75] Byron Swift and others, "Private Lands Conservation in Latin America: The Need for Enhanced Legal Tools and Incentives" (2004) 19 *Journal of Environmental Law and Litigation* 85–140, 112.

[76] Evan Hamman and others, "Regulating Land Use in the Catchment of the Great Barrier Reef" (2022) 115:106001 *Land Use Policy* 1–15, 7.

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be welcomed by industry operators who benefit from accessing others' information.[77] One Australian information-sharing initiative to store and share data from project proponents is expected to reduce project application assessment times by six to twelve months.[78] Yielding to industry concerns, some jurisdictions exempt data that constitute business confidential information and trade secrets from environmental information sharing requirements, but this differs between jurisdictions and may give way to the values of public health and environmental protection.[79] Table 5.4 gives further examples of possible approaches.

5.4 CONCLUSION

Information is critical for understanding the things we care about and the cumulative threats that they face, so that rules for intervention can restore or protect them from cumulative environmental harm. This is about much more than just predicting cumulative impacts in the context of project-level EIA. It requires gathering and aggregating, in an ongoing way, comprehensive and high-quality data, analyzing it, allocating the costs of doing these things (probably with an eye to reducing those costs, given the data-hungry nature of cumulative environmental problems), and ensuring that information is shared and can be accessed by governments, affected communities, and other stakeholders. By drawing on formal rules from around the world, this chapter has illustrated diverse possibilities for designing rules to do these things and address the disincentives to gathering and sharing data and information that would otherwise threaten effective action to solve cumulative environmental problems.

More than just a technical issue about having good information to reveal problems and make decisions, information is about power and accountability. The knowledges that are accepted as legitimate and the practical accessibility of information about harm influence environmental democracy, environmental justice, and the rule of law. Regulatory systems, then, should not be mere information-*takers*, they should be information-*makers*. That is, rules should be actively designed not only to include – fairly – diverse sources of information already produced, which are needed to understand and respond to

[77] Abbe E. L. Brown, "The Future of Intellectual Property" in Daniel J. Gervais (ed), *Rights to Do, Rights to Prevent, and an Intersected Approach? Lessons from Intellectual Property, Information Control and Oil and Gas* (Edward Elgar 2021) 105–127, 120.

[78] Productivity Commission (Australia), *Resources Sector Regulation*, 378.

[79] Juliana Zuluaga Madrid, *Private Sector Environmental Information and the Law* (Routledge 2023) 158–202.

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cumulative environmental problems, they should be designed to actively fill gaps in existing knowledge.

By themselves, rules for information cannot solve cumulative environmental problems. Cumulative environmental problems need advocates, both within and outside government, and those advocates need information both to act and to know that action is needed. Rules for information must also be integrated with the other functions of the CIRCle Framework, informing and responding to how the matter of concern is conceptualized, interventions are designed, and government and nongovernment actors come together to address the problem of cumulative environmental harm.

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