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Tailoring climate information and services for adaptation actors with diverse capabilities

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Abstract
With louder demands in public discourse for action on adaptation to climate change, efforts to improve the provision and use of climate information and services (CIS) are also gaining prominence. Drawing on literature about uptake of CIS for climate risk assessment and adaptation, plus our own practical experiences, this Essay examines modes of user-provider interaction in CIS. By employing a customer-tailor analogy, three overlapping types of CIS transaction are identified: 'off-the-peg', 'outsourced' and 'bespoke'. Evident across all modes are 'loyalty card' customers who return to the same provider(s). We then offer a set of prompts to facilitate more meaningful engagement and dialogue between adaptation actors and providers. These questions could also be used to seed discussions within communities that research and provide training in CIS, as well as amongst stakeholders, funders and other institutions involved in the governance of CIS systems. Such searching and timely conversations could advance a more tailored approach to CIS delivery, regardless of the technical and financial starting point of users and providers.

Keywords Climate information and services · Adaptation · User-provider interaction · Resilience · Climate change

1 Introduction

Global initiatives to adapt and build resilience to climate change are now well underway. At the United Nations Climate Change Summit in September 2019, the Global Commission on Adaptation (GCA) launched a flagship report on adaptation and a year of action (GCA 2019). The GCA called for leadership and immediate efforts to scale up adaptation in key areas covering food security, water, cities, infrastructure and finance. Meanwhile, after decades of modest progress on adaptation—primarily within the public sector (CPI 2019)—recent years have seen a plethora of activities around climate risk management by new entrants from the private sector. This is largely in response to the recommendations and subsequent national and regional regulatory development of the G20 Financial Stability

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Board's Task Force on Climate-related Financial Disclosures (TCFD 2017; Government of New Zealand 2021; BEIS 2021; EU 2021). Considerable resources are also being committed via bilateral and multilateral development banks (MDBs), as well as by dedicated climate funds, to support climate change adaptation (e.g. GCF 2020; World Bank Group 2021). Efforts to strengthen the climate resilience[1] of societies and economies have intensified since the adoption of the 26th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) agreement which called for a significant scaling up of climate finance, technology transfer and capacity building for adaptation.[2]

Provision and use of climate information and services (CIS) lie at the very heart of much adaptation decision-making.[3] However, there may be instances where such information is missing, without historical benchmarks, unnecessary for adaptation action, contradictory or contested (e.g. Dosio et al. 2019). The *State and Trends in Adaptation Report 2020* (GCA 2021) called for better access to climate data for assessing climate change impacts, informing adaptation and pursuing resilience at scale. Although substantial investments are being made to develop and incorporate science-based climate information and insights into planning, policy and practice on the global, regional and national scale—for example, through the Global Framework for Climate Services, World Climate Services Programme of the World Meteorological Organization, the European Union's Copernicus Climate Change Services, and NASA's Climate Data Services—it is important to take stock of the current state and practices around the provision and use of CIS. Care must also be taken to avoid an exclusively linear supply chain assumption, given that interactions can also be iterative and co-productive (Ghate 2018).

So far, there have been extensive research and discussions around the (1) typologies of climate service formats, users and providers (e.g. Bessembinder et al. 2019; Cortekar et al. 2020; Visscher et al. 2020); (2) forms of uptake and uses of climate services (e.g. Yegbemey and Egah 2021; Tart et al. 2020; VanderMolen et al. 2020); (3) ways to create more useful and usable climate information (e.g. Tembo-Nhlema et al. 2019; Mabon 2020); (4) most appropriate use of climate information in shaping adaptation and climate-resilient development decisions (e.g. Wilby et al. 2009; Singh et al. 2018; Nissan et al. 2019) and (5) degree to which the climate information needs of various decisions can be met given the recognized limitations of climate science (e.g. Griggs et al. 2021; Fielder et al. 2021).

Some assert that the interface and communication between users and providers is the least developed aspect of CIS (Hewitt et al. 2017). Nevertheless, user surveys tend to focus on climate data and products (such as required variables/indices, spatial–temporal scales, portals for accessing data, intended applications) (e.g. Bessembinder et al. 2019; Larsen et al. 2021; Soares et al. 2018) or levels of user sophistication (Skelton et al. 2019). Some acknowledge the importance to users of the legitimacy of the supplier (Tang and Dessai 2012), as well as the different scientific and social contexts shaping (national) climate scenarios (Skelton

[1] Here, we adopt the IPCC (2021) definition of resilience as '*The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation learning and/or transformation*'.

[2] https://unfccc.int/process-and-meetings/conferences/glasgow-climate-change-conference-october-november-2021/outcomes-of-the-glasgow-climate-change-conference.

[3] Here, 'climate information and services' refers to data, information, and knowledge required to assess and respond to the impacts of climate variability and change on human society, natural environment and the economy, typically spanning timescales of months to decades, and sometimes, centuries ahead.

et al. 2017). It is also recognized that climate scientists tend to struggle to meet the needs of users except those who are like themselves—highly technical and numerate (Porter and Dessai 2017). From a user perspective, a good CIS provider: (1) stays in touch and keeps users informed of technical developments; (2) knows sectors well; (3) provides support and/or training to use climate services correctly; (4) is free or has a good price offering and (5) offers data that are more trustworthy than other sources (Tart et al. 2020:5).

To further improve the provision and use of CIS, there have been calls for, among others (1) more dialogue and interaction between providers and users, including through co-production of climate services (e.g. Fischer et al. 2021; Hewitt and Stone 2021; Larosa and Mysiak 2019); (2) moves from a product-focused, academic-driven and data-oriented production mode to a more service-focused, context-driven and decision-oriented approach (Weichselgartner and Arheimer 2019); (3) a shift in norms, governance and institutions of science in order to integrate social science in the provision of decision-useful climate services (Findlater et al. 2021) and (4) a 'cultural turn in climate risk management' to bring together climate services (science) with place-based narratives (humanities) (Amundsen 2015; Krauß 2020; Phillips and Murphy 2021). Others offer practical suggestions around capacity building; customer-focussed programmes; formalizing partnerships and eliciting feedback on services (Hewitt et al. 2017). Whilst fully acknowledging a deficit in availability of useful and usable climate information for guiding climate-resilient decision-making, many contend that there is also a shortfall in good practice of applying what is *already* available. Alternatively, good practice when evident in grey literature and project experiences may not always be widely visible.

All the strategies outlined above for strengthening the provision and use of CIS are clearly important. However, we also assert that most will require considerable efforts to achieve the required shift in culture, *modus operandi* or governance structure of science. In our view, such profound changes are unlikely to materialize in the immediate future, yet decisions around climate-resilient development plans and investments are urgently needed now. Hence, whilst concerted efforts are being made to accelerate these transformative changes, it is also important to pursue incremental progress towards improving the provision and application of climate services such that vital investment decisions are better supported. This essay draws on the literature cited above plus our own practical experiences in climate adaptation, to typify user-provider *interactions*, noting that ours is intentionally a user-led approach. A set of prompts is offered to help prospective users and providers navigate the complex landscapes of CIS and thereby deliver intended adaptation outcomes. Throughout the essay, we refer deliberately to 'users' of CIS rather than 'partners' or 'stakeholders' except where the mode of interaction is characterized by collaboration and/or co-production.

2 Three types of 'customer-tailor' interaction

To frame the state of CIS user-provider interactions, we apply the analogy of customer-tailor relations. Depending on the nature of interactions with the tailor, three types of customers may be discerned. We stress that the following may overlap and are not mutually exclusive:

'Off-the-peg shoppers' want to buy a new suit but do not know what exactly works best for them (e.g. two or three piece, something more professional-looking or flamboyant), nor have the time, resources or inclination to involve the services of a tailor. They go to a chain store to purchase a branded item to meet their perceived needs, but do not interact with the suit maker. The jacket fits but the trouser length is not quite right and later they find the cloth is uncomfortable in hot weather.

Table 1 Characteristic interactions between CIS users and providers

Tailoring analogy	*Off-the-peg*	*Outsourced*	*Bespoke*
	Strength of user-provider interaction		
CIS users	• Context: Wanting something done but not sure exactly what or how • Solution: Making use of what is readily available	• Context: Looking for specific products and services but not so concerned about the process • Solution: Contracting experts to deliver the required outputs	• Context: Seeking specific data, tools and/or services to support decision making • Solution: Engaging with experts through shared efforts
Example users	• Small businesses • Local authorities • Communities • Schools and colleges	• Large corporates • City authorities • Banks and financial services • Development agencies/ NGOs	• Government agencies • Utilities • Professional bodies • Charitable organisations
User-provider interactions	• Climate information and services based on elicitation of needs of group(s) of potential users • Limited meaningful interaction either before or post development of information • One-off, transactional	• Climate information and services shaped by the user objectives to assess and manage climate risks • User procures expert services for technical analyses, capacity building and mentoring • Commissioned	• Climate information and services customized by well-informed users to serve specific purposes • Users and providers co-develop specific analytical tools and/or information • Mutual learning, collaborative
Examples	• UK Climate Projections • Climate Ireland portal • World Bank and Asian Development Bank Climate Risk Country Profiles • KNMI Climate Change Atlas	• Climate risk assessments as part of technical assistance and due diligence for infrastructure projects within MDBs • Portfolio climate risk assessment for TCFD by investors or corporates • Sector risk assessment and planning	• Government agencies co-developing climate change allowances and standards for detailed engineering design • Water utilities seeking specific climate analytical tools to stress test water plans

'Outsourcing shoppers' have a general sense of what they need (e.g. a smart, dark, two-piece suit) but do not have the time to go to the shops. They surf online and select a suit based on broad descriptions of the various products available and customer reviews. Apart from clicking on the given criteria (size, colour, design, etc.) then tracking the progress of their order, there is little interaction with the manufacturer or wholesaler before the suit is delivered. The jacket and trousers fit nicely but, when worn in daylight, the fabric weave and pattern are not quite as expected from the online photos.

'Bespoke shoppers' have a good idea about the type and colour of material they want, so work closely with a tailor who has the skills to make the desired suit. Through personal and frequent interactions, customers gain deeper insights to tailoring techniques and are better placed to specify instructions in future orders; the tailor learns more about the decision processes and unique needs of various customers, so is able to offer a better service in future to this and other clients.

Applying the tailoring analogy to CIS user-provider encounters, we identify the following three modes of interaction (summarized in Table 1). Again, these are overlapping and actors may find themselves dealing in more than one mode—by analogy, the same customer may buy an off-the-peg suit for work but a bespoke outfit for a special occasion. Customers with 'loyalty cards' may be found in all three modes because a history of engagement with 'trusted' providers or products is likely to be a strong determinant of future choices. We also stress that 'off-the-peg' does not imply a less technically inclined user than a 'bespoke' user. This is because the form(s) of engagement depend on the project objectives and decision context (Bamzai-Dodson et al. 2021). Moreover, the institutional environment, time pressures, available resources and past arrangements may orchestrate

user behaviour, regardless of their own technical competencies and inclinations. With these points in mind, the interactions may be:

Off-the-peg: Generic climate information is laid out for broad audiences with diverse needs. These might include information for raising awareness and facilitating dialogue within organizations about climate risks or providing input to high-level/generic risk assessments. Climate information may be developed from best available science, data and analytical capabilities of the provider and packaged such that users can 'help themselves'. Standard sets of 'essential' climate variables or 'decision-relevant' indices may be created by climate centres by post-processing massive data archives into more accessible formats (e.g. Arnell et al. 2021; Bornemann et al. 2019). For instance, the UK Climate Projections (UKCP) portal[4] provides 'wholesale' access to climate projections, technical reports describing the nature of the data provided, analytical tools for data processing and visualization, plus guidance and case studies on the use of projections. Prospective users navigate the content and select pre-prepared climate information. Similarly, the World Bank-Asian Development Bank Climate Risk Country Profiles[5] were created to facilitate upstream discussions around climate change 'hotspots' and to support the development of climate change adaptation strategies and resilience investment planning. Others have developed analytics aimed at investment and business groups. For example, the company 427 offers local climate risk scores for floods, heat stress, hurricanes and typhoons, sea level rise, extreme water stress and wildfires derived from over 2 million corporate facilities to obtain physical climate risk metrics for over 5000 corporates.[6] Then, based on geographic location and sector, subscribers may obtain scores for operational, supply chain and market risks associated with exposure to the analysed climate hazards.

Outsourced: Customized climate information is procured then applied in specific decision contexts. Users have an outcome in mind, such as ensuring that public investment in transport, water or sanitation systems deliver expected services during its design lifetime despite climate change. Examples of this mode include consultancy services secured for climate risk assessment as part of the technical due diligence for infrastructure projects by multilateral development banks (MDBs) (e.g. ADB 2017; Wilby et al. 2021).[7] Alternatively, corporates may seek to reduce exposure of financial portfolios to physical climate risks in line with TCFD recommendations (Breitenstein et al. 2021) but lack the specialist in-house capacity to achieve this goal. In both cases, the procurement of CIS may be outsourced to consultants with user-specified terms of reference.[8] Subsequent interactions focus on the results of the analyses (content and presentation) rather than on the climate information per se. Typically, the mode of engagement is for users to (1) provide information about the portfolio or assets to be analysed; (2) (sometimes) scope the analytical

[4] https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/index

[5] https://www.adb.org/publications/series/climate-risk-country-profiles

[6] http://427mt.com/wp-content/uploads/2017/10/Corporate-Physical-Climate-Risk-Scores-Feb-2021.pdf

[7] The climate change assessment report of the Asian Development Bank financed project 'Khyber Pakhtunkhwa Cities Improvement Project' in Pakistan is an example of an output from a consultancy assignment as part of the Project's technical due diligence. See: https://www.adb.org/sites/default/files/linked-documents/51036-002-cca.pdf,

[8] Note that consultants and intermediaries—the providers of CIS here—often draw on publicly available climate information (e.g. UKCP scenarios, KNMI Climate Change Atlas, World Bank Climate Change Knowledge Portal).

approach to be followed (e.g. such as scenario analysis, or selection of a particular storyline linked to projections) and (3) specify the expected output (e.g. a climate change allowance for detailed engineering design of a structure or a 'heatmap' of physical climate risks for an asset portfolio). The climate service provider, then draws on their scientific expertise, networks and best judgement to provide the commissioned outputs.

Bespoke: Climate information is co-developed with users who may not always begin the interaction with clear goals and/or a good understanding of the type of products and services required. Users may have limited technical knowledge of the strengths and weaknesses of various information types, or about the nuanced ways such products can be applied. Service providers are engaged—typically as external consultants or research partners—to work alongside users throughout the analytical process. In addition to contextual information about the analytical subjects, inputs from users also include general data and approaches (e.g. considering the full range of scenarios to facilitate sensitivity analyses or stress testing options). User-provider interactions are collaborative and enable mutual learning; the specification and application of climate information is driven by user requirements and informed by the state of the science. Examples of this mode include collaborations between technical experts and financial institutions participating in Phase II of the UNEP Financial Initiative (FI)'s TCFD Banking Pilot Project (UNEP FI 2020). During this project, global financial institutions were led by expert mentors through a series of modules for identifying, assessing and managing their physical climate risks and opportunities. Through hands-on risk assessment exercises, participating banks developed critical in-house technical capacity, expanded their analytics toolkits and moved towards 'self-sufficiency' (UNEP FI 2020). At the same time, sector experts and climate scientists, gained deeper insights into the decision context, analytical questions and CIS needs of financial institutions to manage physical climate risks. Such understanding could, over time, contribute to improved relevance and utility of, and more nuanced approaches to CIS provision. For example, parts of the UK water sector have co-developed storylines of spatially extensive, multi-year droughts to stress test water resource plans (e.g. Chan et al. 2021).

The above modes overlap to a certain extent, forming a continuum of user-provider interactions that spans passive to proactive. They also correspond broadly with the three categories of engagement identified by Hewitt et al. (2017), namely information provision, dialogue-based and targeted. Having framed typical modes of CIS user-provider interactions, we next consider practical ways of strengthening these relationships for climate-resilient decision-making.

3 Asking for better tailoring

Our working assumption is that 'one size does not fit all'. Although user-specified and collaborative CIS are arguably desirable—in the sense that climate information is customized for particular purposes—the science-led mode is expected to dominate for some time. This is because the costs and practicalities of recruiting in-house climate experts or outsourcing to consultants is prohibitively high for many groups or small organizations. Their adaptation information needs are so diverse and context specific that attention to myriad users is impossible. Nonetheless, centrally produced, national climate change scenarios

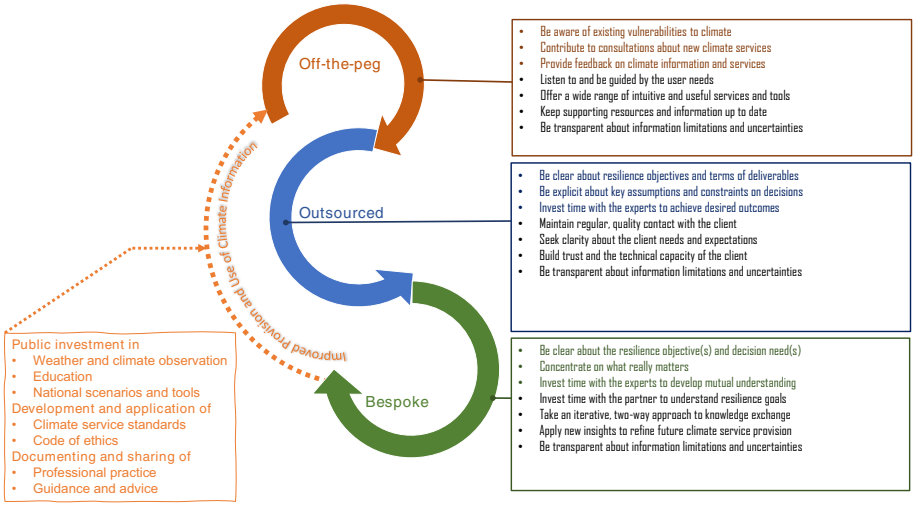

Fig. 1 Actions to be taken, within three modes of user-provider interactions, to improve the supply and application of CIS to climate-resilient decision-making. Enabling actions in the left-hand box (funding, educational and standard setting) are relevant to public bodies, climate experts and adaptation practitioners; actions in the right-hand boxes are to be taken by the different types of user (with colours representing various user types) and providers (in black font)

and guidance increase the likelihood that different users and sectors will harmonize their approaches to resilience planning, whilst the burden of generating such information for statutory assessments and professional bodies is reduced. Essential climate variables and indicators can also raise public awareness of risks, and/or track progress with improving resilience (e.g. Ffoulkes et al. 2021). However, there remains a danger that unsupervised, generic information and tools are used inappropriately, or the extent of uncertainty in the future climate and impacts is not appreciated. This could lead to poorly designed adaptation measures (Schipper 2020). Therefore, steps are needed to improve the 'shopping' experience, regardless of context.

Users and providers could be more proactive in their various interaction modes to improve the usability and value addition of CIS (Fig. 1). On the one hand, users should be clearer about their adaptation goals and decision context; paying attention to the caveats around data sources and analytical methods, and their implications for achieving objectives; open-minded and prepared to draw on their own experiences and insights, plus ready to discuss specific requirements with providers. On the other hand, providers should be open and transparent about the utility of CIS, the major caveats around data, methodological assumptions and associated implications for different adaptation decision contexts and user groups; ready to share specialist knowledge with users and learn more about their decision criteria and process. Previously, the emphasis has focused on raising the capacity of users to better interpret and apply climate information (e.g. Hewitt et al. 2017) but asking, listening and learning is also necessary on the part of the provider. This requires dedicated time and resources in the business plans of providers.

Government agencies and educational institutions also have important roles, including sustaining observing networks as public goods, developing technical skills in climate risk management and contributing to national scenarios and assessments. Competent authorities may have further responsibilities for devising standards, practical guidance and service ethics

Table 2 Prompts for users and providers of CIS to deliver improved to resilience to climate change 'before', 'during' and 'after' engagement

Interaction	Off-the-peg	Outsourced	Bespoke
CIS user	*Before* • How vulnerable am I to climate variability and change? • What products, tools or services are needed to build on what is already known from experience? *During* • Where can practical advice or guidance be found on how to adapt to climate risks? • What are the most important factors affecting local risks and benefits of climate change? *After* • How could the transparency and navigability of information portals be improved? • What opportunities exist to feedback on existing services and shape future CIS? • What personnel and resources are being invested by the CIS provider in user-support and help desks?	*Before* • What forms of support are needed to make adaptation decisions (data/narrative, tools or advice)? *During* • What are the most critical data and/or methodological uncertainties affecting the adaptation decision(s) or investment(s)? • What new tools, scientific and technical advances are on the horizon? *After* • How could the frequency and usefulness of interactions with the CIS provider be improved? • How could the terms of reference be refined for future commissions? • When should any tools or advice provided be reviewed or updated?	*Before* • What do different CIS providers bring to a partnership? • What extra skills, knowledge or information capacity might be needed to fully leverage the collaboration? *During* • What are the most critical data and/or methodological uncertainties affecting the co-produced outputs? • What other information or resources are needed to support the adaptation goals? *After* • What support will be available beyond the duration of the collaborative project? • How will outputs be disseminated beyond the partnership?

Table 2 (continued)

Interaction	Off-the-peg	Outsourced	Bespoke
CIS provider	*Before* • What are the most significant climate vulnerabilities identified by the user group? *During* • How can intended and appropriate uses of the products, tools or services be better explained? • How should critical uncertainties be communicated? • What ancillary support would be helpful and why? • What other CIS providers and portals could be sign-posted to improve user choice and relevance? *After* • What measures (if any) were taken by the users in the light of the CIS provided? • How much time and resource is needed to support user engagement and to capture 'client feedback'?	*Before* • What are the climate risk management priorities or expected adaptation outcomes identified by the client? • What is the decision time-scale, context and most significant external constraints on the client? • How is climate resilience understood by the client? *During* • What adjustments should be made to the products and services to better meet the deliverables expected? *After* • How could the technical and institutional capacities of the client be further enhanced for adaptation? • What new capacities (if any) were gained by the client following the consultancy? • What resilience measures (if any) were adopted following the provided information and services?	*Before* • What is the 'user collaborator' trying to achieve? • How would the user gauge collaborative success? *During* • How could opportunities for more meaningful engagement be improved throughout the collaboration? • What opportunities exist for secondments and knowledge exchange between partner organizations? • What other partners and resources could be brought into the collaboration? • What new opportunities for collaboration are emerging from the partnership? *After* • What was the legacy of the collaboration on partner practices and/or policies? • What was the legacy of the collaboration on the provider?

(Fig. 1) (Adams et al. 2015). Climate experts and adaptation practitioners can contribute to collective capacity by routinely documenting and sharing good practices, as well as calling out malpractices associated with the inappropriate provision and use of CIS. There is a particular need for more tools for and examples of economic valuation of climate services.

Table 2 offers some searching questions that users and providers could raise in various interaction contexts and stages. 'Before' questions are mainly self-reflective; 'during' require dialogue and 'after' are directed at the other party. This 'pull out' resource is intended to stimulate more proactive engagement and effective outcomes, whether in organized stakeholder forums, or within an institutional context. The questions could also be used to seed discussions within communities that research and provide training in CIS, as well as amongst stakeholders, funders and other institutions involved in the governance of CIS systems. More specifically, national hydromet agencies could use them when consulting about the scope and format of next-generation climate projections and services. By raising these points, more fruitful conversations between users and providers could follow. In turn, such dialogues would help users better assess the utility of information being offered, whilst providers could benefit from direct interactions to refine their technical approaches to ensure that information and services are fit for purpose. We believe that more focused, user-provider dialogue around these searching questions, represents a practical step towards a more tailored approach. Inevitably, the framing of issues by this essay reflects our own cultural lenses and experiences. However, our call for more meaningful asking and listening on all sides is applicable in any CIS user-provider context.

4 Concluding remarks

There is a long way to go before users, knowing much or little about climate science, with or without the ability to pay, can obtain tailored CIS. But, progress is urgently needed to guide adaptation and resilience investment decisions in diverse contexts and at different levels of capability. We have suggested prompts to help users and providers discern ways of improving the utility of CIS. Through these two-way interactions, users would be helped to better articulate their vulnerabilities and adaptation goals, attitude to risk and uncertainties, decision context, operational constraints, capacities and indicators of successful adaptation. Providers should allocate time and resources to deepen their understanding of what really matters, better communicate key risks and uncertainties, develop more practical advice, improve sectoral knowledge and find ways to maximize the legacy/impact of their services. Other aspects of user-provider interactions, including unequal power relationships, contested value systems and heterogeneity of cultures are all worthy of further exploration. In the meantime, we contend that a few searching and timely questions could go a long way to help tailoring CIS and thereby resilience outcomes—regardless of whether the user-provider transaction is off-the-peg, outsourced or bespoke.

Data availability Not applicable.

Code availability Not applicable.

Declarations

Conflict of interest The authors declare no competing interests.

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