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Adaptation to climate change by organizations

Frans Berkhout*

Organizations will be central actors in societal adaptation to climate variability and change. But highly simplified assumptions are often made about the response of organizations to the stimulus of perceived or experienced climate change. This paper reviews recent literature, arguing that three approaches are applied in studies of organizational adaptation: utility-maximizing, behavioral, and institutional approaches. The paper argues that adaptive responses by organizations are conditioned by the processes of perception, evaluation, enactment, and learning by organizations. Organizational adaptation involves adjustments in each of these processes. The extent to which adaptive measures are taken by organizations will be influenced both by endogenous factors, such as the capability to innovate and attitudes to risk, as well as by the external economic and institutional context. Willingness to exercise available adaptation options will vary between organizations. Evidence of organizational adaptation from case studies and meta-analyses is reviewed. © 2011 John Wiley & Sons, Ltd.

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INTRODUCTION

Climate variability and change generate new climatic conditions to which social actors (people, households, businesses, public-sector agencies) respond through managing emerging risks or by exploiting new opportunities. These responses—adaptation—are usually seen as being specific to place and context; partly because of the granularity of climate change impacts over time and place, and partly because of the diverse features of social actors themselves.¹ Actors will have different exposure to the risks and opportunities associated with climate change, as well as varying capacities to confront them. These specificities of climate vulnerability² and adaptive capacity^a pose an analytical challenge. It means that scholars need to be able to explain how different actors respond to climate change, and to analyze the factors that influence observed varieties of response.^{3–5}

In this paper, I review recent literature on organizational adaptation to climate variability and change.^b This literature draws on the tradition

of social and economic research on the micro-foundations of organizational structure, strategy, behavior, and change. By organizations I mean collectivities of actors whose activities are coordinated within definable social units to achieve certain common goals.^c These will include households, private-sector businesses, public-private organizations such as water boards, public-sector organizations such as municipal governments, and civil society organizations. I see organizations as the primary actors involved in choosing and enacting societal responses to climate change. While individuals (such as a farmer) may be said to adapt to climate variability and change, such individuals can often be seen as acting in the context of an organization. From another perspective it may also be possible to speak of broader societal responses, but these can be seen as being an aggregation of the actions of households, firms, non-governmental organizations (NGOs), and public-sector agencies. Understanding how organizations might adapt to the threats or possibilities represented by climate change is therefore of fundamental importance to the economics and governance of climate adaptation. If organizations are maladapted or fail to adapt at the speed and direction deemed socially desirable, this would be an argument

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for governance aimed at achieving more appropriate types or rates of adaptation.

The paper is concerned with five questions: What models of organizational adaptation exist in the literature? How do organizations adapt? What factors encourage or inhibit organizational adaptation? What is the evidence of organizational adaptation? and What could be the role of public policy in enabling organizational adaptation? Each of these questions will be dealt with briefly, with the intention of mapping literatures relevant to the specialized reader. I draw five broad conclusions at the end which also point to future research.

FRAMING ORGANIZATIONAL ADAPTATION TO CLIMATE CHANGE

This statement of the problem points to a central theoretical question dealt with in the literature on organizational adaptation to climate change: To what extent can organizations be seen as acting autonomously at all? Are climate vulnerability and adaptive capacity a feature of the organizational unit, or are they explained by factors external to the organization? Although from some perspectives it may be useful to assume that organizations have choice and act autonomously, much research on organizational adaptation stresses the embeddedness of organizations in social, institutional, and cultural contexts.⁶ In this, climate adaptation research reflects a well-established debate in organizational studies about the extent to which organizational change is an outcome of internal adaptation or external selection.⁷ Most contemporary theories in organization studies agree that strategic choice and environment interact to constitute the adaptive responses of organizations.⁸ Understanding how organizations are embedded in their social and natural environments and how this shapes their goals, structure, and ways of doing things is also a primary concern of research on adaptation to climate variability and change by organizations.

Related to this question of social embeddedness is the question of whether and when it is appropriate to see climate change as a motivator of social action. Organizational behavior and change may be viewed from a number of different perspectives.^{9,d} But one starting point is to see organizations as unitary actors set up to achieve specific organizational goals, whether that is making a profit, educating children or providing humanitarian assistance. To achieve these objectives, organizations have a particular structure, capabilities, and ways of doing things, a culture shaping how they do these things, resources to carry them out and a system of governance. These primary

functions and activities may be influenced by climate variability and change. But even in organizations, like farming businesses, that appear highly exposed to climate variability, responses to climate change will always compete as a priority with other strategic or operational concerns. To the extent that climate variability and change come to influence the plans and actions of organizations, this will often be through incremental and indirect influences of existing beliefs and activities, rather than directly. Only rarely will the limits or opportunities represented by climate change be so pressing that they lead to a fundamental reconsideration of organizational strategies and behavior.¹⁰ One explanation for this is that organizational change must overcome organizational inertia.¹¹ Tracing the manifold ways in which organizational beliefs, structures, strategies, and activities are influenced by climate change is therefore a complex task of disentangling the primary from the secondary, and the direct from the indirect. Many factors play a role in shaping the decisions and actions of organizations, of which perceptions about climate change will be but one. An analysis of organizational adaptation therefore needs to start with the complex reality of organizations themselves, rather than starting with the climate signal and then seeking to trace its presumed influence on organizational behavior. The analysis needs to be done inside-out, rather than outside-in.

THREE PERSPECTIVES ON ORGANIZATIONAL ADAPTATION

An analysis of organizational adaptation needs to start with a conception of the goals of adaptation. One approach would be to take what may be called a 'functionalist' approach to the question.^e This is to relate adaptation to the functional goals of an organization. Adaptations are then viewed as adjustments designed to sustain the organization's capacity to meet this functional goal. So, for example, a water supply company would make adjustments enabling it to provide clean drinking water to its customers under changing climatic conditions, while meeting the economic and environmental performance standards to which it operates. The *status quo* would be preserved, although possibly at the cost of greater organizational effort. However, the common definition of climate change adaptation, '...adjustments in natural or human systems in response to actual or expected climate stimuli or their effects, which moderate harm or exploit beneficial opportunities' (Ref 12, p. 879), suggests that adaptation may not always aim to sustain the

functions or performance levels of an organization. The additional effort involved in maintaining *ex ante* standards of performance may be disproportionate, or conversely there may be opportunities to change or improve performance as a result of climate change. Adaptation may therefore itself imply organizational change.

From a variety of social science approaches to organizational adaptation, I make a distinction between utility-maximizing, behavioral and institutional approaches. The literature on organizational adaptation to climate change can be roughly classified across these three approaches. ‘Utility-maximizing’ approaches assume that adaptive behavior is a question of optimal choices between a set of clear alternatives whose costs and benefits are known and discounted over time. These choices are made by organizations pursuing their own self-interest—hence the notion of autonomous adaptation.^{13,14} This position holds that adaptation can be regarded as efficient if, ‘...the [private] cost of making the effort is less than the resulting [private] benefits...’ (Ref 15, p. 585, brackets added). A utility-maximizing position suggests certain characteristics of organizational adaptation as a response to climate change. For instance, most adaptation is seen as being reactive because organizations have incomplete knowledge to predict changes in climate and variability at their locality; they do not understand fully what will be the climate impacts on their activities; they do not have the capacity to evaluate fully the costs and benefits of the possible actions to reduce vulnerability or to profit from opportunities. In other words, many organizations will adapt once they have experienced the effects of climate change clearly, and will then adapt to the extent needed to maximize their overall utility for some period into the future. The costs of inaction (the damage costs to the organization absent adaptation) and of adaptive responses will then be known, as will be the stream of benefits of adaptive action through time. For instance, it will be possible to give a monetary value to the avoided flood risk associated with a flood-management measure.¹⁶ On this basis, utility-maximizing organizations will choose inaction when that is economically optimal, while making timely investments in adaptation when that is economically justified, given uncertainties.

The utility-maximizing approach has been criticized for making invalid assumptions about the nature of climate impacts¹⁷ and for misunderstanding the decision making by adapting actors.¹⁸ Risbey et al.,¹⁸ Pelling and High,¹⁹ and Berkhout et al.²⁰ argue instead that issues of perception, interpretation, problem-solving, and learning are central to

understanding organizational adaptation. Drawing on a tradition of behavioral economics and organizational studies,^{21–24} these authors stress the importance of uncertainty and the bounded rationality of social actors (including organizations), proposing that actors do not conform to the tenets of expected utility theory, use ‘rules of thumb’ in responding to new situations and that they exhibit satisfying behavior. That is, in the face of uncertainty, organizations choose ‘good enough’ responses that conform to normative ideas of appropriate behavior, rather than optimizing across the full universe of potential options.

Grothmann and Patt²⁵ expand on this approach, arguing that decision makers in organizations face a range of informational, institutional, cultural, and financial constraints that affect their perceptions, framing of risks, and decisions about adaptation. They argue, for instance, that people tend to underestimate large probabilities and overestimate small ones—like the risk of an extreme weather event.²⁶ For this ‘behavioral’ strand of adaptation research, the adaptive response of organizations will be determined by the perceptions and capabilities of the organization, with the strategy chosen depending less on an objective assessment of costs and benefits, and more on a messy process of sense-making, learning, and organizational adjustment. Organizations frequently exhibit inertia to change, so that modifications in structure, goals, and activities can meet resistance.²⁷ Organizational change and adaptation will therefore be seen as serving the goals of specific groups within organizations which can seem distant from the problem of responding to climate vulnerabilities.

A third ‘institutionalist’ strand of research places greater emphasis on the role of the institutional context in which the organization is embedded.^f For these authors, drawing on a tradition of institutional economics and governance studies,^{28,29} the adaptive capacity of an organization rests not only on the perceptions and capabilities of the organization, but also is shaped and constrained by external social, cultural, political, and economic structures and processes.³⁰ Although institutionalist perspectives have been applied across many contexts of climate adaptation, they are especially powerful in sectors such as water resource management, coastal protection, and flood risk management, where national and regional government plays an important role in defining and enforcing the formal and informal ‘rules of the game’ by which organizations operate.^{31–35} Institutional contexts are overlapping and multilayered, some being proximate and others distant. A central concern of this research is the flexibility offered to adapting agents by institutionally

framed rules to define and enact adaptive responses. Contexts may provide the knowledge, resources, incentives, and legitimacy for (collective) adaptive action, but they may also promote climate vulnerability and constrain adaptive responses. For this strand of the literature, the prevailing internal and external incentives and disincentives, and how they influence organizational behavior and interactions will be the critical determinant of adaptive action.

While there are clear differences between the utility-maximizing, behavioral, and institutional approaches, there are also many overlaps. For instance, economists working from a utility-maximizing position acknowledge that uncertainties about climate change impacts have an important bearing on organizational strategies toward climate vulnerabilities, something stressed in behaviorist perspectives. Likewise, behaviorist organizational studies accept that organizations operate in the light of a fairly stable set of preferences and goals, and that maladapted organizations will fail to survive in the long-run, in common with environmental-determinist perspectives. Finally, although some theorists argue that organizational behavior is primarily conditioned by environments,³⁶ most studies find that organizational behavior and change is a product of endogenous and exogenous factors and processes. Behavioral and institutional perspectives therefore share common ground.

While we see organizations as responding to the stream of costs and benefits of adaptive action over time, as learning incrementally how to adjust their routines in the face of uncertainty and organizational inertia, or as following rules of the game that are only partly of their own making, it is evident that organizational adaptation to climate variability and change is not explained by assuming a simple stimulus-response relationship. Most organizations will not translate in any straightforward way a 'climate signal' into an adaptive response. Many intervening factors and habits will play a role in conditioning whether the

organization recognizes a climate risk or opportunity, and what it comes to see as an appropriate response. This may also include doing nothing or muddling through.

PROCESSES OF ORGANIZATIONAL ADAPTATION

Having addressed three different, but overlapping, frameworks for looking at organizational adaptation, we now turn to the question of how organizations adapt. In order to make adjustments to goals, strategy, or structure, organizations need to do work, based on a set of perceptions, capabilities, and resources. This work is generally assumed to have a number of aspects. There is quite a measure of consensus in the climate adaptation literature about what these are: perception, evaluation, enactment, and (for some studies) feedback (Table 1). These aspects of organizational process may be seen as constitutive of organizational learning.^{20,37–39} While some authors see these processes as being sequential,⁴⁰ many studies offer a picture of a more interactive pattern. In this view, these processes are seen as operating continuously and in parallel with each other, periodically reinforcing or constraining one another, and thereby precipitating change and adaptation. This comes closer to a view of organizations as processes in which structure and change are always emergent properties.

Organizational adaptation needs to be considered as occurring across a spectrum of action, ranging from private to public. Mendelsohn⁴² argues, for instance, that adaptations by farmers can be seen as purely private, adaptations related to water management as mixed public-private, while adaptations oriented to biodiversity are purely public. Generally, the more public the context, the more complex the institutional setting, with adaptation processes being distributed across different actors and organizations. Transactions and coordination between organizations

TABLE 1 | Organizational Processes in Adaptation

Organizational Process	Risbey et al. ¹⁸	Arnell and Delaney ⁴¹	Berkhout et al. ²⁰	Grothmann and Patt ²⁵	Moser and Luers ³³
Perception	Signal detection	Awareness and concern	Signal recognition and interpretation	Climate change risk appraisal	Awareness
Evaluation	Evaluation	Adaptation strategy	Experimentation and search	Adaptation appraisal	Analytic capability
Enactment	Decision and response	Selection of options	Knowledge articulation and codification	Adaptation intention/adaptation	Action
Feedback	Feedback		Feedback and iteration		

then become an aspect of adaptation and adaptive capacity. In these cases, learning—including both cognitive development and behavioral adaptation—will also be distributed across different organizations. It is striking that most published studies of organizational adaptation to climate change refer to public-private contexts, with water and flood management featuring especially prominently.

Perception

Organizations continually monitor their own performance, the performance of competitors, and similar organizations and seek to make sense of factors that influence their operating environment. So, for instance, a farmer will monitor the progress of his/her crops through the growing season, learn how other farmers are doing and hear how the prices for crops and inputs are developing in the market. These will together influence his/her sense of whether things are going well or whether things are going badly, in which case adaptive action may need to be taken. Perception is highly structured according to what is salient to an organization's strategy and performance, and according to a repertoire of interpretive frames that prevail in the organization at any given time.^{43,44} Only a limited set of signals will be monitored, because these have proven to be reliable indicators with which to judge performance and because they conform to the cognitive frames held by the organization. This may explain why in many apparently vulnerable sectors there continue to be limited awareness of climate change impacts and the value of adaptations.⁴⁵ Likewise, Hoffmann et al.⁴⁶ found that Swiss ski lift operators' adoption of adaptation measures was not correlated with their absolute (independently measured) climate vulnerability.

Studies of organizations show that there is generally resistance to drawing conclusions that challenge prevailing frames of reference, so that organizational processes may not be adapted, even in the face of counter-evidence. For instance, Grothmann and Patt²⁵ found that farmers in Zimbabwe, when provided with seasonal climate forecasts, did not use this information in their decisions about whether to plant maize or millet (a more drought-resistant crop), partly because of the greater cultural and economic value of maize. In a similar result, Hoffmann et al.⁴⁶ found that awareness of the effects of climate change among ski lift operators was only weakly correlated to the number of adaptation measures they had introduced to manage the risks of less-reliable snow seasons. On the other hand, Grothmann and Patt²⁵ found that *over time* farmers appeared to become

more sensitive to seasonal forecasts and more likely to act on this information. This points to the finding in organizational research that the more frequent, unambiguous, and salient evidence from experience is, the greater the likelihood it will be recognized and interpreted as significant.⁴⁷ In the climate adaptation literature there is evidence that sudden and extreme weather-related events create both a greater awareness of climate change impacts and raises preparedness to take more decisive adaptive action.⁴⁸

We may conclude that climate variability and change are likely to be perceived by organizations both directly and indirectly through impacts on performance indicators salient to them. In this sense, climate change looks different to each sector and across different organizations within a sector. For instance, Arnell and Delaney⁴¹ found that UK water companies were generally aware of climate change as potentially affecting the balance between water supply and demand. In making periodic water resource plans in 2005, water companies were obliged to make 5-year and 25-year projections using demand, stream-flow, and groundwater scenarios defined by national economic and environmental regulators (The Water Services Regulation Authority [OFWAT], and Environment Agency [EA]). The effects of climate change were *not* included in these models in 2005 because the EA believed that the effects would be small in the period to 2020. Only a few of those companies facing longer term water supply security problems made explicit mention of climate change in their business plans (in the Arnell and Delaney survey conducted in 2004, two of 24 companies). None associated experienced climate variability with climate change—that is, none had experienced a direct climate signal precipitating a revised cognition about climate vulnerability. Other factors, including increasing demand and tighter environmental standards—market and institutional pressures—were seen by companies as having a greater impact on their supply security.

What is striking in the Arnell and Delaney study, and also in the study by Farley et al.³⁴ on perceptions of water supply amongst different users in the Oregon Cascades (fish habitat managers, flood-control managers, municipal water managers, and fishing guides), is the high degree of codification of information about organizational performance, in this case related to water flows and quality. In the Oregon case, different types of spatial and temporal variability in stream flows were salient to each of the groups surveyed. A highly technical apparatus of monitoring and assessment was used by different water users; and a good proportion of this apparatus was fixed by regulators or through voluntary standards. In

other words, the way the organization ‘saw’ its world (and, by definition, what it did not see) was in large part prescribed by rules defined by regulators and the market. Organizations’ ability to perceive climate change variability and change as an influence on their activities was therefore to a great extent dependent on changes in protocols defined not by themselves, but by regulators.

Other studies also found that in cases where information about climate change impacts was tailored to fit organizations’ operating procedures, the significance of information was not always evident to organizations.^{34,45,46,49,50} This may be because more conventional—and therefore more easily recognizable—factors affecting organizational performance appear more important, or because the causal relationship between climate change impacts and organizational performance remained ambiguous. But the most important reason may be that the structure of organizational sense-making, through which perceptions of an organization’s performance and environment are mediated, simply did not ‘see’ climate change.

Evaluation

A wide range of concepts in the organizational learning literature relate to the process of cognition and cognitive development, usually seen as a precursor to organizational change.⁵¹ Amongst the most commonly cited sources in the climate adaptation literature are Argyris and Schön’s⁵² concept of single- and double-loop learning, which refer to lower or higher levels of cognition by an organization. Without rehearsing these debates, it is worth drawing attention to the different levels of evaluation and problem-solving that organizations engage in when confronted with a novel problem like climate change. This will be related to the seriousness of the threat (or opportunity) represented by climate change. Less significant threats may be addressed with operational adjustments, whereas more serious threats may require strategic changes by the organization. For instance, Jones⁵³ shows that wine-growing regions in California will shift toward the coast and upward in elevation under climate change. This suggests quite different future land acquisition strategies of wine growers.

The impacts of climate variability and change on organizational functions are highly specific. Hertin et al.,⁵⁴ for instance, show a range of potential direct and indirect climate change impacts for UK house-building companies, organized by the main business processes of these companies (Table 2). This study showed that different house builders perceived

these potential vulnerabilities very differently, partly because their business model was different (companies operating in higher value segments of the market were able to take on riskier engineering projects and be able to pass these costs on to customers), and partly because of varying perceptions of their capacity to adapt (small engineering-based companies were more innovative than large developers of mass housing). What Grothmann and Patt²⁵ term ‘relative risk perception’ they argue will be linked to ‘perceived adaptive capacity’. In general, the greater the perceived adaptive capacity, the less will be the perceived risk perception. Hoffmann et al.⁴⁶ in a careful econometric analysis of data from 124 ski lift operators in Switzerland found that the greater the perceived capacity to adapt, the greater the number of adaptive measures (ranging from artificial snow-making to taking out snow insurance) they were likely to take to protect their affected business.

The ‘adaptation space’, defined as the set of options potentially available to an organization to adapt to risks and opportunities will include organizational changes, as well as changes in processes, products, and services produced by the organization. Often a wide range of alternative responses are available, not all of which are actively considered, as Scott and McBoyle⁵⁵ show in their assessment of adaptation options on the supply and demand side of the North American ski industry. Naess et al.⁵⁶ in a study of drought coping strategies amongst pastoralists in Ethiopia and Mali also find a range of potential responses, including temporary migration and sales of livestock (Table 3). Arnell and Delaney⁴¹ list of series of supply- and demand-side options for UK water companies includes standard measures already being implemented, such as leakage reduction, as well as exotic options such as desalination and iceberg imports (Table 4). Besides assessing the costs, benefits, and risks of these options, water companies need to contend with the legal and political feasibility of the options available to them. Regulatory and political consent would be required to implement many of the potential options.

Harries and Penning-Rowsell⁵⁷ (forthcoming) show that evaluations of different ways of dealing with climate-related flood risks along the Thames in London were constrained by public opinion. Farley et al.³⁴ in the Oregon water supply study show that response options often required evaluation and authorization through a complex multilevel institutional framework, according to the rules defined in national legislation. For instance, ‘rule curves’ which define reservoir water levels at different times of the year, are mandated by the US Congress,

TABLE 2 | Potential Direct and Indirect Climate Change Impacts on UK Housebuilders⁵⁴

		Impacts of Climate Change		
		Direct Impacts	Indirect Impacts	
Business Process	Extreme Events (storms, droughts, river flooding, tidal flooding)	Gradual Change (drier summer, wetter winter, more wind, coastal erosion)	Through Regulation	Through Financial Institutions
Buying land			<ul style="list-style-type: none"> • Stricter planning policy in certain areas (e.g., flood plains, coastal zones) 	<ul style="list-style-type: none"> • Insurers' refusal to cover flood risk reduces value of property in floodplains
Designing houses		<ul style="list-style-type: none"> • Ground instability due to more variable ground water levels 	<ul style="list-style-type: none"> • Meet new customer demands for (e.g. flood protection, air conditioning) 	<ul style="list-style-type: none"> • Assessment of climate risk required by lender and/or insurer
Building houses	<ul style="list-style-type: none"> • Disruption of the construction process due to extreme events • damage to building material 	<ul style="list-style-type: none"> • Shorten time for construction due to increased rainfall and wind 		
Selling houses			<ul style="list-style-type: none"> • Reduce value of property in area at risk from flooding / coastal erosion 	<ul style="list-style-type: none"> • Assessment of climate risk required by banks and lenders
Maintaining houses	<ul style="list-style-type: none"> • Damage building under warranty • Damage to managed building, e.g. storm (housing associations) 	<ul style="list-style-type: none"> • Higher maintenance cost/devaluation of managed buildings, e.g. subsidence (housing associations) 	<ul style="list-style-type: none"> • New regulation on insurance for warranty and maintenance 	<ul style="list-style-type: none"> • Higher insurance premiums for warranty

TABLE 3 | Drought Coping Strategies of Pastoralists in Borana, southern Ethiopia⁵⁶

Type	Response Strategy	Wealth Group	Effect
'Negative' (depleting assets)	Increased labour migration	Poor middle	<ul style="list-style-type: none"> • Disruption in community dynamics • Reduction in household labor force, leading to a decline in ability to focus on household's own activities
	Increased sale of livestock	Poor Middle Better Off	<ul style="list-style-type: none"> • Reduction in household asset base from which to draw in the event of future shock • Less potential to exploit opportunities to sell livestock products such as milk, yoghurt, cheese. Inability to optimize profit • Forced to accept lower prices
	Increase livestock migration (travel longer distance for longer periods of time)	Poor Middle	<ul style="list-style-type: none"> • Disruption in community dynamics • Increased competition for limited grazing may result in heightened tension between clans/ethnic groups. Livestock become weak due to distances required to travel
	Increase sale of charcoal and firewood	Poor	<ul style="list-style-type: none"> • Environmental degradation • Increased erosion and run-off
	Change in food consumption patterns—reduction in frequency and quality of food intake	Poor	<ul style="list-style-type: none"> • Increase susceptibility to disease and potential malnutrition • Reduction in energy levels, resulting in lower productivity
'Positive' (establish or increase household assets)	Increase in kallo formation (preservation of pasture)	All	<ul style="list-style-type: none"> • Community cohesion strengthened through participation of all to form kallo • Enables regeneration of pasture • Pasture protected for future
	Harro (pond) creation/water harvesting	All	<ul style="list-style-type: none"> • Households have access to water for specific activities (eg vegetable gardening)
	Planting short maturing crop varieties	All	<ul style="list-style-type: none"> • Increased potential to gain at least some harvest
	Increase in petty trade activities	Poor	<ul style="list-style-type: none"> • Increased income generated
	Increase in sales of gum Arabic and incense	Poor	<ul style="list-style-type: none"> • Increased income generated
	Vegetable farming		<ul style="list-style-type: none"> • Counter-seasonal source of food and income

and changes that may be needed in response to changing temporal variability in stream-flow would require approval from Congress, following evaluation of economic and environmental trade-offs. Even if adaptation is seen as justified and adaptation options have been framed by an organization, whether action follows will depend on leadership, organizational capabilities, and external conditions.

Enactment

Behavioral theorists conceptualize organizations as bundles of routines.^{21,22} Routines are the means by which organizations carry out their activities by fitting appropriate procedures to situations they face, whether conventional or out of the ordinary.⁵⁸ So, for instance, a university research institute

has routines for developing new proposals for research to potential funders. Routines include rules, procedures, strategies, conventions, and beliefs which bind organizations together and through which they operate. Over time, these routines have been shown to be advantageous to the organization are retained and reproduced. Routines are modified or adapted when the organization encounters new situations for which existing routines are perceived to be unsuccessful, or when alternative routines promising better outcomes are discovered.⁵⁹ Adaptation of routines requires special effort and so-called dynamic capabilities, defined as: '... a learned and stable pattern of collective activity through which an organization systematically generates and modifies its operating routines in pursuit of improved effectiveness' (Ref 60, p. 340).

TABLE 4 | Supply-Side and Demand-Side Adaptation Options for UK Water Companies in Response to Climate Change⁴¹

Supply-Side and Demand-Side Adaptation Options	
Supply-side options	
New sources	New or enhanced reservoirs
	New direct river abstractions
	Groundwater development
	Bulk water transfers
	Artificial aquifer recharge
	Aquifer storage recovery (treated water)
	Desalination
	Import of icebergs
Improvements in resource utilization	Conjunctive use of sources
	Improvements to supply network linkages
	Resource sharing
	Seasonal forecasting
Improvements in distribution and treatment	Improvements to raw water treatment capacity and capacity of distribution network
Demand-side options	
	Leakage reduction
	Water efficient equipment and fittings
	Promotion of more efficient use through education
	Promotion of more efficient use through tariff structures
	Control over location of new development
	Water reuse and recycling
	Managing garden use
	Use of rainwater

On the basis of operational and dynamic capabilities, adaptation of routines will occur through trial-and-error experimentation and the search for alternatives.⁶¹ Berkhout et al.,²⁰ in a comparison of house-building and water companies, found that many adaptations to climate risks were quite conventional and already-practiced options based on existing organizational capabilities. Much adaptation was therefore the adoption of known alternative practices or technologies. Recently, Linnenluecke et al.⁶² and Linnenluecke et al.⁶³ have argued that extreme weather could precipitate the development of new capabilities and potentially more radical changes in organizational structure and operational routines.

Several studies have argued that organizational adaptation measures need to be seen as part of a deeper

strategy. Such a ‘climate adaptation strategy’, will be linked to organizational or business strategy. Different taxonomies have been developed (Table 5), including a range of possible responses, from doing nothing, to shifting and sharing risks with other actors. Pelling et al.³⁸ argue that organizations can follow a defined set of ‘adaptation pathways’, including adjustments of organizational routines, as well as seeking to influence external regulatory and market conditions. Hoffmann et al. (Ref 46, p. 259) organize adaptation measures into three ‘strategic directions’: measures to protect the affected business; measures to expand beyond the affected business; and measures to share risks of financial impacts.

Feedback

Adjusted and new organizational routines, including adaptations to climate variability and change, will come to be seen as successful if they are perceived as contributing to meeting organizational goals. Having made investments in adaptations, organizations will seek to assess whether forecast benefits are met in terms of organizational performance. This feedback will influence future decision making and adaptation. But just as organizations have difficulty in perceiving and understanding the implications of climate variability and change, they will often have difficulty evaluating the value of adaptations they make in response to new risks and opportunities that arise through climate change. This is because making such an appraisal faces a formidable attribution problem.

Let us take a relatively simple case of a horticulturalist in a region perceived as becoming more drought-prone and a decision to install drip-irrigation as a way of increasing supply security and reducing the cost of water (assuming water is priced and that the price rises as supply becomes less reliable). Over the operating life of the system (say 10 years), the value of this investment as a ‘climate adaptation’ will be related to the difference in yield and profitability that the farmer experiences against a baseline in which he/she does not invest in drip irrigation and in which no climate change has occurred. In practice, making this kind of assessment—*ex ante* or *ex post*—will be beyond the competences and interests of most farmers. The farmer is most likely to adopt drip irrigation because it is likely to bring benefits under current conditions of climate variability. Possible impacts of climate change may serve as an additional argument in the decision to invest. For instance, economic crop models can make predictions of the links between irrigation and crop sensitivity to temperature and drought,⁶⁵ and this background technical information

TABLE 5 | Organizational Adaptation Strategies

Adaptation Strategy	Willows and Connell ⁶⁴	Arnell and Delaney ⁴¹	Berkhout et al. ²⁰	Hoffmann et al. ⁴⁶
Do nothing			Wait-and-see	
Assess			Risk assessment and options appraisal	
Reduce risk	Manage hazard or manage exposure	Risk avoiding	Bearing and managing risks	Protect affected business
Share risk	Offset risk	Risk sharing	Sharing and shifting risks	Share risks
Diversify	Diversification			Expand beyond affected business

may play a role in farmers' willingness to invest. But specific feedback on the value of an organizational innovation as a response to climate variability and change will be unavailable in most cases, certainly when seen against the background of other economic, social, and institutional factors likely to have a bearing on organizational performance. Only for some adaptations, including long-lived infrastructural investments like flood defenses, will an *ex ante* cost-benefit assessment be feasible against a number of different climate scenarios, and will it be possible to monitor benefits through a project's lifetime (Ref 66 cited in Ref 67). There is currently no evidence in the literature detailing *ex post* assessments of benefits associated with specifically climate-related adjustments and change. Given the attribution problem, there are likely to be difficulties in establishing the benefits of specific climate-related adaptations over the short run. One rare study on the value of precautionary flood-protection measures adopted by households affected by the disastrous 2002 Elbe floods in Germany was able to demonstrate the economic value of specific adaptive measures.¹⁶ For larger public investments such assessments will be more feasible.⁶⁸ Feedback about private 'climate' adaptations may be available only in the longer term as the relative performance of adapting and nonadapting organizations begins to be compared.

FACTORS INFLUENCING PROCESSES OF ORGANIZATIONAL ADAPTATION

Having discussed processes of organizational adaptation, I now turn to the organizational factors which may influence these processes. It is clear that many factors can influence how organizations perceive climate-related risks and opportunities, how they make sense of these, how they evaluate alternative courses of action, enact new routines and finally learn about the effects of these adaptations on their performance.

Following the discussion in the introduction about endogenous and exogenous factors and their role in organizational change, we may talk of factors internal to the organization and those that are external to it. We know this is in most cases an artificial distinction. The internal capabilities and routines of an organization are shaped and fitted to its external social and institutional context, and to its natural environment.

The potential salience of climate change for organizations in different sectors varies greatly (Ref 69, p. 12). Winn et al.⁷⁰ provide a qualitative assessment of impacts across different business sectors (Table 6). Although there will be great variation within a sector—a hotel on a flood-prone river front will have a different risk profile than a hotel located slightly up the hill—and there will be variations in perceived vulnerability across similarly-vulnerable organizations. We may assume that there will be more awareness and concern in more susceptible sectors, even if such awareness is not always translated into adaptive action.

Internal organizational factors most often dealt with in the climate adaptation literature include leadership, organizational culture, and risk management capabilities. Wilby and Vaughan⁶⁷ argue that there nine 'hallmarks' of adaptive organizations, including a range of attributes and routines such as 'strong and visionary leadership' and 'partnership working'. In their study of the introduction of water metering for agricultural irrigation as a response to drought in the Kelowna district of the Okanagan region in Canada, Shepherd et al.⁴⁹ highlight the role of key individuals in the acceptance of metering against farmer opposition. Key issue advocates legitimated a critical argument about the 'beneficial use' of water and husbanded the funding application at the provincial level which made adoption of meters possible. Naess et al.³² also emphasize the role of leadership in their finding that the Mayor of Skedsmo was instrumental in the realization of a flood defense

TABLE 6 | Climate Change Impacts by Business Sector⁷⁰

Sector	Floods		Storms		Droughts		Extreme winters	
	Short Term	Long Term	Short Term	Long Term	Short Term	Long Term	Short Term	Long Term
Agriculture	–	---	---	----	---	----	+	++
Assembly	–	---	---	----	–	---	+	++
Auto insurance	–	---	---	----	–	---	+	++
Aviation	–	–	–	----	–	---	o	o
Commerce	–	---	---	----	–	---	+	++
Construction	---	----	---	----	–	---	+	++
Event planning	---	----	---	----	–	---	---	----
Manufacturing	–	---	---	----	–	---	+	++
Private sector	–	---	---	----	–	---	+	++
Transportation	–	---	---	----	–	---	+	++

Table 1. Climate change impacts anticipated by industry sector.

Key: – negative impact; + positive impact; -/+ low; --/+ moderate; ---/+ strong. See Ref 70.

wall in 1995, as a local response to a flood event, through his coordination of a coalition of local political and business interests. In her comparative analysis of flood-control institutions in two Swedish municipalities, Storbjörk³⁹ also finds that continuity and personal commitment of the leader of a technical department in the Coast by municipality explained a more adaptive approach there.

In their comparative study of development organizations in the UK, Boyd and Osbahr⁵⁰ suggest that organizational culture, in particular the existence of informal relationships and means of communication, was important in explaining the extent to which different organizations had begun to ‘mainstream’ climate change adaptation into their strategies. Pelling et al.³⁸ also argue that collaborations between actors in ‘shadow spaces’ outside conventional management and power structures in organizations influence adaptive capacity. Finally, Hertin et al.⁵⁴ in their analysis of UK house builders found that companies with strong risk management capabilities and a track-record in dealing with complex projects were more likely to feel able to manage new risks arising from climate change.

A consistent result across these studies of organizational adaptation and climate change is that external institutional and economic contexts condition the perceptions and adaptive responses of organizations. Naess et al.³² argue that structural relationships between national, regional, and municipal agencies responsible for flood management offer little leeway for municipalities to exercise autonomous choices, except under certain conditions of crisis when local organizations can create space to act independently. Similarly, Ivey et al.³¹ argue that ‘upper tier’ political and institutional arrangements determine to a large

extent the capacity of communities to respond to potential climate-related water shortages in municipalities in Ontario. In their comparative study of two municipalities in the Credit River watershed, they suggest that the characteristics of and relationships among agencies, groups, and individuals in municipalities explain differences in the approach taken in the two cases.

EVIDENCE OF ORGANIZATIONAL ADAPTATION TO CLIMATE CHANGE

If organizations are primary actors in climate adaptation, it ought to be possible to find evidence of organizational adaptation as a response to impacts of climate variability and change. Uncovering evidence has proven difficult, partly because of the methodological challenges involved. Are we interested in cognitive or behavioral change? And once we have identified change, how do we determine whether it has been influenced by perceptions about climate change? Do we count only adaptations that are explicitly concerned with climate, or do we include also those adjustments which may as a co-benefit affect the climate vulnerability? The most comprehensive surveys to date are Tompkins et al.⁷⁰ and Berrang-Ford et al.⁴⁸

Tompkins et al.,⁷¹ using documentary evidence from a range of official sources, produced an inventory of over 300 examples of (climate) adaptation practice in the UK, finding evidence of small adjustments, the building-up of adaptive capacity, as well as deeper changes in public and private sector organizations. Observed adaptation was found mainly in government initiatives at the national and regional levels, and these were dominated by research into climate

change impacts. Sectors requiring large infrastructural investments, such as water supply and flood control, show the most evidence of awareness and adaptations. The authors conclude that climate adaptation has been driven 'top-down' by government initiatives and that this may have generated low-cost anticipatory adaptation in some areas.

Berrang-Ford et al.⁴⁸ survey peer-reviewed English-language scientific literature to track and characterize adaptation action. Like Tompkins et al.,⁷¹ they find that adaptation action is usually a response to multiple factors, with climate rarely the sole or primary driver. Observed climate variability and experienced extreme weather events are more commonly reported as the stimulus for adaptation action in organizations. They do find substantial evidence for anticipatory adaptation, with most evidence coming from North America and northern Europe. As they acknowledge, both of these surveys must be viewed as first impressions since they struggle to overcome methodological problems. For instance, the authors draw on data for which no uniform definition of adaptation held. Moreover, the classification of adaptations as climate-related was on the basis of self-reporting by individuals and agencies, rather than according to an objective measure.

Beyond these surveys, the case study-based and very limited econometric research cited above gives a more fragmentary account of adaptive action by organizations. We may conclude that methods for establishing an evidence base about the scope and depth of organizational adaptation remain at an early stage of development and that evidence of widespread adaptation, while assumed in many studies.^{72,73}

POLICY AND GOVERNANCE IN ORGANIZATIONAL ADAPTATION

Given that organizational adaptation is often conditioned by broader institutional arrangements, many of them determined by the government, it is important to understand what role policy and governance play in enabling and constraining organizational adaptation. The Stern Review⁷⁴ suggested a number of roles for government in adaptation to climate change: (1) in protecting the least able to cope by addressing the causes of vulnerability; (2) providing information and resources for planning and stimulating adaptation; and (3) protecting important public goods such as ecosystem services, coastal defense, and early warning of extreme events. Beyond this, there has recently been much attention for 'mainstreaming' climate change vulnerability and adaptation into government policies.⁷⁵ Barnett and O'Neill⁷⁶ suggest that

maladaptation by organizations may also be a reason for public intervention.

Our survey of the literature reveals that there may be a deeper governance dilemma at stake. In funding and communicating scientific information on climate variability and change, including, for instance, early warning of extreme events like El Niños and tropical cyclones, central governments play a critical role in building societal awareness of climate and climate change. By making declarations and by codifying climate change in regulations and procedures through mainstreaming, governments are intervening in the normative appreciation and responses to climate variability and change. These interventions address informational deficits that exist around climate change, respond to the public-good characteristics of some climate impacts and adaptations, and deal with the need to ensure fairness in the distribution of climate vulnerabilities and the capacity to respond.²⁰ But, as we have seen in the studies of Naess et al.³² and Ivey et al.,³¹ these activities are being made within institutional arrangements which tend to constrain the scope for initiative and flexibility at local levels. In other words, such policy interventions may build adaptive capacity without granting the autonomy to organizations to take adaptation actions that match local needs. This is an age-old dilemma which holds in other fields of public policy such as health and education. It will often be the case that the value of granting local autonomy runs counter to the value of ensuring fairness and uniform quality of provision.

CONCLUSIONS

Organizations are the primary actors in societal responses to the impacts of climate variability and change. Yet, our understanding of how organizations perceive, make sense of and respond to signals about climatic change is still at an early stage. To gain a better picture of the likely extent and rate of adaptation that is already happening and may be expected in the future, more research, theoretically informed by economics, organization studies, and psychology will be needed. I have identified a number of theoretical perspectives that are currently applied to the study of organizational adaptation to climate change, characterizing them as utility-maximizing, behavioral, and institutionalist perspectives.

Empirical and theoretical studies of organizational adaptation published in the past 5 years offer findings with some common emerging patterns. First, organizational adaptation needs to be understood from the perspective of the goals and perceptions of the organization itself, rather than from the climate

signal to which it may be responding through adaptations. Organizational change and adaptation take place in response to many stimuli, with climate risk and opportunity being but one. Second, a complex set of organizational processes are involved in perceiving, evaluating, enacting, and learning about climate impacts and adaptive responses. The ‘climate signal’ will often be difficult to read for organizations against the noise of other signals from its market and institutional environment. In so far as there is a climate signal, this will often be perceived indirectly through, for instance, a regulatory requirement to make a climate assessment. Third, few changes made by organizations will be a response to a climate signal alone. Climate change considerations often play a supplementary role in decisions about technological, organizational, or strategic changes, even in sectors, such as water management, in which climate change is highly salient. Fourth, organizational adaptation is always strongly influenced by the institutional context in which the organization is embedded, including where, like farming, there may be a high degree of strategic choice available to the adapting actor. Adaptations will emerge as an interaction between factors endogenous to the organization and a range of technological, market, and institutional factors exogenous to the organization. Lastly, while organizations, even organizations in highly vulnerable and low income settings, may have a wide range of potential adaptive responses, their willingness and capacity to exercise these options will vary greatly. Whether or not the institutional context is enabling or constraining will play a role, but leadership, resources, and culture of the organization will also be important.

These reflections have a bearing on the central theoretical issue raised at the beginning of this paper: the extent to which organizations can be seen to be acting autonomously. Following Hrebiniak and Joyce⁸ I believe the proper response is to say that organizational adaptation is always an outcome of an interaction between endogenous and exogenous factors, but that the significance of endogenous and exogenous factors varies greatly across organizations. For some organizational decisions a great degree of choice may be available—a locational choice for a new power station by a private sector utility company, for

instance. In these cases, a utility-maximizing perspective may be fully valid as a way of analyzing adaptive responses. But for other organizational decisions the degree of choice is much constrained—the choices available to a public-sector water supply company to ensure supply security, for instance. In such cases, an institutionalist analysis may be closer to the mark. In addition to the specificities of exposure and vulnerability, therefore, studies of climate adaptation in organizations need to be aware of the specificities of organizational position and freedom of manoeuvre.

NOTES

^aBy adaptive capacity I mean the capacity to: influence exposure to risk; to cope with damages as a result of a hazardous event; and to take opportunities to profit from climate change (Ref 69, p. 727).

^bThe review in this paper is based on searches for relevant peer-reviewed papers in Web of Science and Google Scholar. The term: CLIMATE and ADAPTATION and ORGANISATION, was used in the searches. Papers citing a number of more highly cited works were also reviewed, together with ‘grey’ literature by authors of relevant papers. In total, 46 studies were reviewed. The review is further underpinned by selected readings from the organizational studies literature which have no link to climate change. From amongst a huge and conceptually rich literature, I have sought to be parsimonious and refer to canonical texts only.

^cPelling et al. (Ref 38, p. 869) define organizations as ‘collectives that have agency’. The question of whether or not organizations have agency is an important theoretical question in organization studies (cf. Refs 77 and 78).

^dvan de Ven and Poole,⁹ for instance, draw a double-distinction between approaches that view organizations as actors or as a process; and those that make a distinction between variance and process methods for studying organizations.

^eA ‘resilience’ or robustness approach takes a broadly similar view of adaptation.¹⁰

^fI make a clear distinction between an organization (a coordinated collectivity) and an institution (a rule-set that influences how actors behave).

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