

Accounting and Finance

# The role of accounting in supporting adaptation to climate change

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## Abstract

The study is one of the first concerned with the topic of accounting and climate change adaptation. It proposes that the accounting role can support organisational climate change adaptation by performing the following functions: (i) a risk assessment function (assessing vulnerability and adaptive capacity), (ii) a valuation function (valuing adaptation costs and benefits) and (iii) a disclosure function (disclosure of risk associated with climate change impacts). This study synthesises and expands on existing research and practice in environmental accounting and sets the scene for future research and practice in the emerging area of accounting for climate risk.

*Key words:* Accounting; Adaptation; Climate change

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## Introduction

The recently released 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) has sent a clear message: Human interference with the climate system is occurring, and climate change poses severe risks for human and natural systems. Many impacts are already observable. The atmosphere and ocean have markedly warmed since the 1950s, the amounts of ice and snow have diminished, sea level has risen, and the concentrations of greenhouse gases have increased (IPCC, 2014). The scientific evidence points to the need to respond to the threats posed by climate change across businesses, industry and society (Linnenluecke and Griffiths, 2010; Surminski, 2013), and to adapt to those changes that will occur even if greenhouse gas emissions were stopped immediately. Adaptation to climate change can be defined as ‘the process of adjustment to actual

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or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities' (IPCC, 2012).

Despite scientific warnings that climate change will have a significant impact on climate-exposed sectors such as water, agriculture, forestry, health and tourism (Hoffmann *et al.*, 2009; IPCC, 2012; Linnenluecke and Griffiths, 2013), the corporate world has been slow to react, possibly also due to a lack of legislative guidance and formal changes to risk assessment, governance and disclosure requirements. While high-polluting companies in regions with emerging carbon legislation had to start addressing carbon reduction and energy efficiencies, other businesses not captured by regulatory regimes have been grappling with the business case for climate action. Beyond legislated mitigation schemes and some voluntary initiatives aimed at greenhouse gas emission reduction efforts (Herbohn *et al.*, 2012; Clarkson *et al.*, 2014), adaptation to the physical impacts of a changing environment is still not yet high on the corporate agenda.

Companies are typically focused on adaptation to short-term changing business conditions (including technological and legislative changes and changes in competitors and market demand) – and a substantial body of studies exists studying the conditions and measures supporting successful adaptation in these contexts (e.g. Fox-Wolfgramm *et al.*, 1998; Schindehutte and Morris, 2001). Lesser attention has been paid to adaptation to conditions that include long-term changing dynamics of the natural environment (Linnenluecke *et al.*, 2013). Finance and accounting systems are set up accordingly and focus on short-term outcomes and the management of short-term costing, reporting and disclosure, rather than on longer-term climate risks. Accountants have viewed their role as largely technical and nonstrategic (Lovell and McKenzie, 2011). In response to the need to account for carbon emissions, progress has been made in regards to the development of mitigation accounting standards, such as the Greenhouse Gas Protocol Corporate Standard (<http://www.ghgprotocol.org/>), which provides standards and guidance for companies and other organisations preparing a greenhouse gas emissions inventory. This study proposes that there is scope for the accounting function to support climate change adaptation.

Companies will increasingly and inevitably have to address climate change adaptation as an integral aspect of their business strategy and risk management (West and Brereton, 2013). Failure to manage the impacts of a changing climate can expose organisations to considerable risk: infrastructure and supply chains are adversely impacted due to climate and weather extremes with resulting financial impacts, business models and their limits are exposed (e.g. insurance companies and investment funds facing changing risk profiles), and reputational, legal and regulatory obligations arise. Companies' risk profiles and their strategic positioning are directly affected by global and local changes in temperature, extreme weather and resource availability. Greater storm activity, water supply variability and a larger number of high-temperature days

impact on health and safety, productivity and financial performance (BHP Billiton, 2014). Keef and Roush (2005), for example, show that sunshine and wind levels in New Zealand impacted on stock return indices and stock prices. The impact of climate change has also received attention in securities filings in cases where direct financial risks or opportunities can be identified (Cogan, 2006; Morrison *et al.*, 2009).

As the impacts of climate change become more visible, particularly impacts from trend changes in weather extremes, they will need to be reflected in the costing, reporting and disclosure of impacts, vulnerabilities and adaptive capacity, with resulting implications for corporate governance. Decision-makers will need decision-relevant information valuing the economic implications of climate impacts and adaptation to support cost-benefit analyses, identify risks, vulnerabilities and liabilities, devise adaptation plans, and derive information in the form of adaptation performance and benchmarking metrics. A question primarily for managerial accounting is how risk assessment approaches and related metrics can be developed and presented so that decision-makers have the necessary information available for managing adaptation processes. One key issue which is not just related to the assessment of vulnerability and adaptive capacity, but to strategic planning in general, is how to overcome a focus on short-term budgets and targets to adopt long-term adaptation planning (Chartered Institute of Management Accountants, 2010).

Companies will also need to address broader questions around how to measure climate change vulnerability, adaptive capacity as well as adaptation costs and needs. Investors, ratings agencies and lenders are increasingly demanding information on climate change impacts and the consequences for capital allocation decisions (West and Brereton, 2013). A growing number of institutional investors are organising themselves in groupings such as the Global Investor Coalition on Climate Change, requiring companies to consider climate impacts as part of their corporate governance agenda. Investors' growing concern about climate change has already resulted in a wave of shareholder proxy activity – such as witnessed in the United States (Cogan, 2006). In private politics, shareholder resolutions filed against companies increase the likelihood that the company's practices will be consistent with climate change strategies (Reid and Toffel, 2009). Institutional investors have also collectively influenced the extent and quality of climate change information provided in disclosures (Cotter and Najah, 2012). Even voluntary reporting initiatives, such as the Carbon Disclosure Project (CDP), are now asking companies to report on the physical risk associated with climate change. In doing so, they have moved beyond their original remit of reporting on mitigation activities.

These developments will eventually require companies to develop risk assessment methodologies to investigate climate and broader investor risks, to implement frameworks for evaluating adaptation options and to disclose climate risk. To respond to these challenges, this study is one of the first

concerned with the role of accounting and climate change adaptation – in particular its role in (i) assessing climate risks and adaptive capacity, (ii) valuing adaptation costs and benefits and (iii) climate disclosure. To date, the literature has virtually been silent on how the accounting function is adding to climate change adaptation beyond discussions of accounting requirements for carbon units and carbon trading purposes, as well as compliance with emergent mitigation (i.e. carbon reduction) policies. Given the technical knowledge required to account for climate change adaptation issues (combined with costs of potentially outsourcing this knowledge), questions such as how clients of accounting firms will receive climate change adaptation services in practice are critical. This study contributes to this emerging area by synthesising existing knowledge and sets the scene for future research and practice in this area. It is also a first step in the direction of understanding how the accounting profession can support adaptation to climate change.

### **A brief history of accounting and the natural environment**

The need to consider the natural environment in accounting decision was first introduced in the 1960s and 1970s (e.g. Beams and Fertig, 1971). At the time, growing environmental problems led to increased awareness of organisational impacts on the environment, and the idea emerged that these issues could – at least in part – be addressed by identifying, measuring and possibly valuing the interchanges and interactions between organisations and the environment. Contributions identified different methods for accounting for environmental impacts, including input/output accounting (analysing the physical flow of inputs such as materials, energy, waste and output such as carbon emissions or waste), sustainable and full-cost accounting (accounting for the amount of money a company would have to spend to return the environment back to the state where it was at the beginning of the accounting period), and natural capital accounting (accounting for natural capital such as habitat or biodiversity costs usually not factored into pricing decisions) (see Mathews, 1997 for a detailed review).

These initial studies led to further research into the topic of environmental accounting, and since the late 1980s and early 1990s, a growing body of literature has emerged highlighting that the accounting profession should be actively involved in examining a company's interdependence with its natural environment. Much of the early conceptual development in this domain has been attributed to Gray (1990) who suggested that a paradigm shift would be needed to include environmental and social considerations into accounting literature and practice, considering the aspects such as compliance and ethical audits, waste and energy reporting, environmental impact assessment, environmental and social reporting as well as accounting for environmental assets and liabilities. Subsequently, Elkington (1997) coined the term 'triple-bottom-line' (TBL) and argued that companies should not only report on

their financial performance, but also on their social and environmental performance. Elkington's publication prompted researchers to propose that accounting could and should support companies' efforts in addressing their environmental and environmental performance. Environmental accounting developed into a rich field of research, including areas such as voluntary disclosures (e.g. Deegan and Blomquist, 2006; Herbohn *et al.*, 2014), ethical issues (e.g. Gray *et al.*, 1997), costing of externalities (e.g. Deegan, 2008) and capital market impacts (e.g. Bachoo *et al.*, 2013; Chapple *et al.*, 2013; Clarkson *et al.*, 2014).

In parallel, other developments emerged and included new reporting awards schemes and attempts to standardise reporting practices. The Global Reporting Initiative (GRI) was launched in 1997 as a joint initiative of the United Nations Environment Programme (UNEP) and the US-based nongovernmental organisation Coalition for Environmentally Responsible Economies (CERES), with the aim to improve the quality, rigour and utility of TBL reporting. This development culminated in the design of a comprehensive Sustainability Reporting Framework and the release of the Sustainability Accounting Guidelines at the World Summit on Sustainable Development in Johannesburg in August, 2002. The GRI started to provide sector guidance and support, such as standard templates, checklists, certified software and tools to assist with data collection and report preparation. The guidelines set out the principles and standard disclosures which companies can use to report their economic, environmental, and social performance and impacts, and are now widely used across sectors. The framework enables greater organisational transparency and accountability (Global Reporting Initiative, 2015). Companies with a higher pollution propensity have been found to disclose more environmental information to the GRI (Clarkson *et al.*, 2011).

Facing increasing pressures to address sustainability in their activities, many companies started to issue reports that include social and environmental performance measures. In Australia, the National Environment Protection (National Pollutant Inventory) Measure (NPI NEPM) has required companies since 1998 to report on pollutants that are seen as important due to their possible effect on human health and the environment. Some companies have gone a step further and also produce a separate stand-alone sustainability report (e.g. Qantas Ltd, BHP Billiton Ltd, CSR Ltd). These reports feature sections on governance, employees, the environment and society.

Subsequently, the emerging carbon legislation (with emissions trading as a primary policy response) gave rise to new roles for the accounting function, ranging from internal carbon accounting to determine a company's liability to the accounting of tradable rights arising from emissions taxes and emissions trading schemes (West and Brereton, 2013; Ascui, 2014). Companies needed to consider their reporting requirements under new and emerging legislation. To

provide guidance for reporting under the European Emissions Trading Scheme, the International Accounting Standards Board (IASB) issued IFRIC 3: Emissions Rights through the International Financial Interpretations Committee (IFRIC) in 2004. The Interpretation specified that the rights (allowances) issued to participating companies to emit a specified level of emissions were to be recognised in the financial statements as intangible assets. As the participating company produces emissions, it recognises the provision for its obligation to deliver allowances which is measured at the market value of the allowances needed to settle it. IFRIC 3 was subsequently withdrawn because of negative reactions from a large number of stakeholders concerning where to account for carbon and how to balance assets and liabilities (Lovell and McKenzie, 2011).

As a result of increases in disclosure, many (especially high-emitting) companies started to develop informational infrastructure for assessing, measuring, reporting and managing greenhouse gas emissions and set up greenhouse gas accounting capabilities to establish emission baselines, measure actual emissions and budget for the future purchase (or sale) of emission credits (Kolk *et al.*, 2008). Recognising that many companies were lacking capabilities in these areas, professional accounting firms began to specialise on providing advice on assessing, accounting for, reporting on and auditing carbon emissions information (KPMG, 2015). Companies utilising these services are now reporting the costs associated with sustainability and carbon-related assurance services. For CSR Ltd, these costs have almost doubled between 2013 and 2014 (\$86 000 and \$156 200, respectively). The assurance of this information has been associated with increases in the quality of the information disclosed (Moroney *et al.*, 2012). However, companies have started to engage with and invest in carbon management not only to meet compliance standards, but also to improve competitiveness, explore opportunities associated with carbon disclosure and assess the impacts of carbon constraints on firm strategy.

Until recently, the accounting profession's focus has largely been confined more to the short-term accounting for environmental impacts of a company on its environment, and even these efforts have not been without criticism (Gray, 2010). Less attention has been given to the broader question as to how the accounting function and profession can assist with evaluating the larger threats long term from environmental changes on the company and its broader operations. The next section looks at the rising impacts of climate change and associated impacts that arise, in terms of measuring and disclosing risks to investors, rating agencies and a range of stakeholders, but also in terms of integrating climate change adaptation costs into investment and capital allocation decisions. The risks to public and private organisations are very tangible and also reflected in recent lawsuits: in April 2014, US-based insurer Farmers Insurance Co. filed nine class-action lawsuits against nearly 200 local councils in the Chicago area, arguing that these councils failed to prepare water infrastructure for heavier rainfall and subsequent flooding caused by climate

change even though they were aware of the risks, resulting in substantial flood in Illinois during April 2013.<sup>1</sup>

### **What are climate changes' current and future impacts on organisations?**

The scientific community has put forward a large body of evidence which shows that climate change is occurring and that resulting impacts are presenting very real and significant threats. The reports by the Intergovernmental Panel on Climate Change (IPCC), which summarise the latest body of knowledge on climate change, show that the impacts of climate change such as rising temperatures, changes in sea levels and changes in ice and snow covers are already observable (Casti, 1997). Impacts from climate change are expected to significantly increase in the future especially due to larger climate variability – characterised by changes in the frequency, intensity, spatial extent, duration and timing of extreme weather events such as extremely hot days or heat waves (IPCC, 2012). It can be expected that vulnerabilities of business and industries are in particular related to these trend changes in extreme weather events, rather than to gradual climate change (Wilbanks *et al.*, 2007).

Any changes to the occurrence of weather extremes have the potential to bring about considerable adverse impacts (Hertin *et al.*, 2003; Keef and Roush, 2005; Wilbanks *et al.*, 2007), often with significant flow-on effects such as disruptions to or impacts on critical infrastructure (Wilbanks *et al.*, 2007). Insurance statistics are already showing greater losses due to the occurrence of weather extremes over past decades (Munich Re, 2012), which can be attributed to a number of underlying drivers including an increase in exposure (due to population growth and industrial expansion into higher risk areas such as coastal zones and cities) and adverse climate impacts (due to climate change and weather extremes) (Munich Re, 2009). Impacts are thereby dependent on the particular sector and location, with greater vulnerability expected in those sectors and locations that are climate sensitive or dependent on stable climate conditions.

The question of how organisations should best respond to climate change has led to much debate. The best way to avoid dangerous levels of climate change would be to take immediate action aimed at mitigation and substantially reducing greenhouse gas emissions (Kates, 2000). However, despite some efforts, progress on a global scale has been slow to date, and greenhouse gas emissions continue to rise globally. Given that it now seems increasingly unlikely that climate change can be successfully mitigated, researchers and policy-makers are paying greater attention to the development of strategies that will enable society to adjust, alongside mitigation mechanisms. Such strategies are commonly referred to as *adaptation* (Dow *et al.*, 2013) and are aimed at

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<sup>1</sup> This lawsuit was since withdrawn by Farmers Insurance who believed that the lawsuit brought important issues to the attention of cities and counties and that the policyholders rights would be protected going forward.

initiatives and measures to reduce the exposure and vulnerability to actual or expected climate change. Adaptation strategies can take a number of different forms, including structural or physical changes (e.g. upgrades to infrastructure), ecosystem-based measures (e.g. investing in ecosystem health), as well as financial mechanisms such as insurance (Noble *et al.*, 2014).

Despite the significance of adaptation to climate change, many companies have only started to engage with the topic of climate change, often with a focus on mitigating their greenhouse gas emissions due to emerging legislative requirements. Adaptation is largely a voluntary exercise (there is no mandated requirement to undertake or disclose adaptation activities); most companies have not yet undertaken comprehensive assessments to account for the impacts of climate change on their operations. In the ASX top 100, only 25 companies address issues relating to climate change adaptation (West and Brereton, 2013). As the impacts of climate change become more visible, companies will require (i) a risk assessment function (assessing vulnerability and adaptive capacity), (ii) a valuation function (valuing adaptation costs and benefits) and (iii) a disclosure function (disclosure of risk associated with climate change impacts). In our view, the accounting role can support climate change adaptation by performing these functions. In addition, it can promote a framework for preparing organisations pre-emptively through the design of accounting practices. The study offers a discussion of these aspects in the following sections.

### **Risk assessment function: assessing vulnerability and adaptive capacity**

Both managerial accounting and financial accounting have a role to play as a risk assessment function to determine climate risks and how they affect value-creating activities (i.e. to determine the vulnerability of assets and operations to climate change). Investors will increasingly require information about climate change-related investment risks. While existing financial accounting standards address the disclosure of risk (e.g. IFRS 9 Financial Instruments and IFRS 13 Fair Value Measurement), areas such as vulnerability and adaptive capacity are not usually covered, and there is no robust consolidated approach to financial risk assessment of climate change (West and Brereton, 2013). Decision-makers, on the other hand, will require information on climate impacts as they affect the organisation and the adaptive capacity inherent in value-creating activities to understand how vulnerability can be reduced. To provide this information, an understanding of how climate change impacts an organisation's value-creating activities is an important starting point for risk assessments.

#### *Assessing vulnerabilities of value-creating activities*

Climate risks not only result from gradual changes in climate, but in particular from trend changes in weather extremes – those types of impacts that



exceed certain thresholds or climate records. In order to assess their organisation's vulnerability to change impacts as they affect the location(s) in which the organisation is operating, corporate decision-makers need data in regards to future climate change impacts, changes in policy, economy, society and technology that exacerbate or mitigate climate change impacts; and an assessment of how vulnerable value-creating activities are as a result. Additional vulnerabilities can result from flow-on effects from climate change impacts that affect an organisation's supplier, buyer or resource base. Information about vulnerabilities can be derived from hazard maps that overlay the organisation's location with future climate data (Linnenluecke and Griffiths, 2014; Noson, 2015) and can be used as a basic input for future risk assessments to understand which assets and activities might be affected. As part of a vulnerability assessment, organisations can also use scenario planning exercises which evaluate vulnerabilities of assets and operations to climate change under different climate change scenarios to achieve a quantification of the likelihood of adverse climate impacts and resulting consequences for the organisation.

#### *Assessing adaptive capacity*

While adaptive capacity is regarded as important to adapt the organisation to future climate impacts and risks, many investors currently view adaptive capacity as idle resources 'in excess of the minimum necessary to produce a given level of organisational output' (Nohria and Gulati, 1996: 1246). Examples for adaptive resources that can aid with climate change adaptation are changes to the organisational infrastructure (such as changes to buildings) to be able to adjust to climate change impacts above the level that would be deemed necessary for an organisation to continue operating within its current business environment (West and Brereton, 2013). For example, BHP Billiton reports that the identification and assessment of increasing storm intensity and storm surge levels has resulted in raising the height of the trestle at their coal port facility in Australia (BHP Billiton, 2014).

To date, the creation of adaptive capacity to respond to climate change impacts has not yet been given much consideration in the accounting framework or standards, neither in external financial reporting nor in internal planning and decisions. Companies such as BHP Billiton are in the minority. On the contrary, the creation of adaptive capacity may incur detrimental accounting treatment if it occurs in the absence of tax relief under certain accounting principles and standards (West and Brereton, 2013). In addition, investments in adaptive capacity may be regarded by investors as 'unnecessary' investments in the short run and perceived as disadvantageous to the organisation's overall competitive position. These issues are likely to change as climate change adaptation standard development progress, but are still important investment considerations in the short term.

**Valuation function: understanding adaptation costs and benefits**

There are methodological challenges involved in estimating the effects of climate change, such as impacts on natural capital (organisational inputs), and accounting for the distribution of costs and benefits across different timescales and parts of the organisation. Existing managerial accounting systems may inadvertently favour activities that have been highly profitable and subject to low risk and low-frequency shocks in the past (Herring and Wachter, 2005) – which includes expansions into sectors or locations highly vulnerable to climate change. Given that the impacts of climate change are not fully visible and foreseeable yet, many existing company activities may appear misleadingly profitable. Appropriate provisions for potential future vulnerability and resulting losses due to climate impacts are often not fully included as costs in investment and infrastructure decisions, and are also not incorporated and monitored within current accounting systems. For organisations, the question arises how to calculate climate losses (and climate adaptation allowances, see below), and how to derive appropriate discount rates to a portfolio of climate-impacted assets. Some assets may change in vulnerability over time – for example, because of changes in their life expectancy and changes in climate impacts. Using a climate change-free risk assessment is clearly much simpler from an operational viewpoint, but does also not reflect future impacts and vulnerabilities.

A common assumption in the literature on the adaptation of socio-economic systems to climate change is that early investment in climate change adaptation will likely be more cost-effective and bring greater incentives in the long run, compared to a ‘wait and see’ approach. However, in contrast to climate change mitigation (i.e. efforts targeted at the reduction of greenhouse gas emissions), there are no established frameworks for evaluating adaptation success and the effectiveness of different adaptation options over time. While the cost and benefits of undertaking mitigation efforts can be established through mechanisms such as greenhouse gas emissions accounting, similar approaches do not yet exist for adaptation. The difficulty here is that adaptation strategies, as compared to mitigation strategies, cannot as easily be linked to financial performance benefits for organisations. Mitigation strategies such as emission reductions efforts that encourage resource (e.g. energy) savings directly correspond to decreased expenditure for resource inputs, while adaptation strategies are intended to deliver outcomes in the long run. These aspects also make it easier for companies to evaluate their progress and benchmark themselves against others within the industry in terms of carbon footprint and emission reductions objectives and achievements.

Overall, while mechanisms for accounting for mitigation have become more established, the accounting for adaptation needs, costs and benefits associated has proven to be more difficult. The 4th Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) concluded that mecha-

nisms for understanding adaptation costs and benefits are 'quite limited and fragmented' (Adger *et al.*, 2007) and that 'comprehensive estimates of adaptation costs and benefits are currently lacking' (Parry *et al.*, 2007: 69). Other studies on adaptation costs and benefits (Agrawala and Fankhauser, 2008) have come to similar conclusions. Recent survey results shows that few businesses have established comprehensive adaptation strategies, plans and activities alongside indicators to track their adaptation progress (United Nations Environment Programme, 2012).

Difficulties in establishing indicators to track progress on adaptation and evaluating trade-offs between adaptation costs and benefits can be attributed to a number of reasons. First, the effectiveness of any adaptation measure depends on the level of future climate change (which, in turn, is dependent on mitigation outcomes) and other socio-economic factors, such as population growth and development in high-risk areas. In addition, adaptation outcomes are also dependent on the actions taken by others (e.g. greater investment by legislators in the adaptation of communal infrastructure to climate change is likely to bring benefits to businesses dependent on this infrastructure). Lastly, adaptation success is more difficult to evaluate and less directly visible than the outcomes of other forms of investments and more difficult to capture (i.e. data would be needed on the losses avoided due to climate impacts) (Linnenluecke and Griffiths, 2015).

Nonetheless, a number of tools and techniques provide initial avenues for evaluating and adaptation options in terms of their costs and benefits. These include qualitative assessments such as expert assessments, stakeholder consultations and scenario-planning exercises, but also quantitative approaches such as cost-benefit analysis and multicriteria analysis. Cost-benefit analysis is a common analytical approach used for decision-making purposes (contrasting costs with anticipated future benefits), while multicriteria analysis is more sophisticated in that this type of analysis does not just contrast cost and benefits, but also includes more sophisticated and multimetric evaluations which can include dimensions such as risk and uncertainty in order to provide more sophisticated support to decision-makers (Chambwera *et al.*, 2014; Linnenluecke and Griffiths, 2015). Some researchers have also started to use Real Options valuation to investigate adaptation costs and benefits (e.g. Kontogianni *et al.*, 2014) In compiling useful analyses about adaptation options using such methodologies, the accounting function can be of great value to organisational decision-makers, in particular in providing information on adaptation costs and a valuation of future benefits considering different time horizons and level of climate impacts alongside other variables.

### **Disclosure function: disclosure of risks associated with climate change impacts**

Institutional investors and other interest groups are already pressing organisations for greater disclosure about climate change impacts, in particular

because of the potential material negative financial effects, but also because of current low disclosure rates (Stanny and Ely, 2008). These groups have the collective power to influence the extent and quality of disclosures (Cotter and Najah, 2012). The CDP already requests information on greenhouse gas emissions, energy usage as well as risks and opportunities associated with climate change from thousands of the world's largest companies and 767 institutional investors with US\$92 trillion in assets. The voluntarily disclosed information is made available for integration in organisational, investment and policy decision-making. While the CDP has mostly focused on greenhouse gas emissions in the past, the scope is increasingly extending to cover information on climate change impacts and risks. The CDP currently provides a disclosure score and a performance score which assesses the level of action taken on climate change. These scores are based on a company's data disclosed to the CDP in response to its questionnaire. The GRI and the CDP are currently working together on future iterations of reporting guidelines and disclosure questionnaires (including questions on climate change) to improve the consistency of disclosure globally (CDP, 2015).

In addition to the CDP, the Climate Disclosure Standards Board (CDSB) is also committed to the integration of climate change-related information into mainstream company reporting (Climate Disclosure Standards Board, 2015). It has developed a Climate Change Reporting Framework which focuses on the disclosure of nonfinancial information. The Framework proposes that companies present this information in their reports and in alignment with the requirements of Integrated Reporting (Table 1).

Integrated Reporting is a process that results in a periodic integrated report about value creation over time. It includes information on a company's strategy, governance, performance and prospects, in the context of its external environment, which lead to the creation of value in the short, medium and long term (Integrated Reporting, 2015). The International Integrated Reporting Council (IIRC) and the IASB entered into a memorandum of understanding to promote the harmonisation and clarity of corporate reporting frameworks, standards and requirements to promote coherence, consistency and comparability in corporate reporting (IASB, 2014). While existing financial accounting standards already address disclosure of risk, such as liquidity, interest rate and exchange rate risks (e.g. IFRS 6 Exploration and Evaluation of Mineral Resources, IFRS 7 Financial Instruments: Disclosures, IFRS 12 Disclosure of Interest in Other Entities and IFRS 13 Fair Value Measurement), the IASB recently issued *Agenda Paper 7: Non-IFRS Information*, which includes the issue of incorporating climate change information into annual reports.

Due to the expected increase in adverse impacts, including more frequent and/or severe weather extremes, financial accounting and reporting standards but also listing rules will likely require more explicit corporate risk disclosure on climate change. The ASX's Corporate Governance Principles and Recommendations have recently been updated to include Recommendation 6.2 which

Table 1  
Emerging disclosure demands for risks associated with climate change impacts

Body	Details
Carbon Disclosure Project (CDP)	The CDP requests (on behalf of institutional investors) information from thousands of the world's largest companies on their greenhouse gas emissions, energy use and climate change risks and opportunities. Disclosure takes place via the CDP questionnaire and is voluntary. Results are collated and presented on the CDP website ( <a href="https://www.cdp.net/">https://www.cdp.net/</a> ).
Climate Disclosure Standards Board (CDSB)	The CDSB is a consortium of global business and environmental nongovernmental organisations (NGOs). The CDSB Climate Change Reporting Framework is a voluntary reporting framework designed for companies to disclose climate change-related risks and opportunities and implications for shareholder value in their financial reports. The reporting framework is available via the CDSB website ( <a href="http://cdsb.net/">http://cdsb.net/</a> ).
International Accounting Standards Board (IASB) International Financial Reporting Standards (IFRS)	The IASB is the independent standard-setting body of the IFRS Foundation. IFRS standards already address the disclosure of a wide variety of risks. A more explicit integration of climate change risks in disclosure standards is likely to occur in the future as climate change becomes more visible.

incorporates environmental groups into its definition of a wider stakeholder engagement programme. Recommendation 7.4 also states that a listed entity should disclose whether it has any material exposure to economic, environmental and social sustainability risks and, if it does, how it manages or intends to manage those risks (ASX, 2014).

The Carbon Tracker Initiative, in conjunction with a former Securities and Exchange Commission (SEC) commissioner, submitted a request to the Financial Accounting Standards Board (FASB) on 10 December 2013, arguing that organisations with significant fossil fuel reserves should be required to submit a financial disclosure of carbon content. While this submission primarily reflects a concern about changes in future demand and prices due to legislative and/or technological changes, it nonetheless demonstrates an increasing awareness around the significant implications of climate change. Furthermore, as climate impacts become more noticeable, the asset allocation of financial institutions as well as investment and superannuation funds is likely to change, with implications for risk accounting in investment portfolios.

### Practical implications and research requirements

Undoubtedly, climate change will have a significant future impact on standards and regulations, also affecting the accounting function. The impacts are visible in the case of legislation around greenhouse gas mitigation efforts. As climate change impacts are increasing in the future, adaptation will play a greater role

alongside mitigation. This means that new tools and approaches are required, as well as an improved understanding of climate risks and opportunities. These changes are already evident in the collaborative work of the IASB, the GRI and the CDP. The CDP and the GRI are working together to ensure consistent Frameworks and Guidelines, the ASX has made changes to its Corporate Governance Principles and Recommendations to include environmental issues for a broader definition of stakeholders, and the IASB is collaborating with the IIRC in the promotion of the Integrated Reporting Framework.

The introduction of carbon emission legislation, for example the EU-ETS or the Australian Emissions Trading Scheme,<sup>2</sup> has shown that any legislative changes associated with climate change lead to an increased demand for nonconventional accounting services. Professional accounting firms have expanded their offering of risk consultancies to include climate change and sustainability services (KPMG, 2015). They also have influenced the methodologies of the legislative requirements for members when performing environmental audits (Martinov-Bennie and Hoffman, 2012). Companies are now disaggregating their assurance expenditure to include assurance for sustainability and carbon-related services (CSR, 2014). Professional bodies such as CPA Australia and Chartered Accountants Australia and New Zealand (CAANZ) have the opportunity to run professional training courses, fund research on climate change, and initiate workshops and seminars (Lovell and McKenzie, 2011). Ultimately, this raises the question of whether and how such services will be regulated or left to self-regulation by professional services providers and their representative professional bodies. In terms of practical implications, this means that there is currently a window of opportunity for leading companies, professional services providers and accounting bodies to contribute to climate change adaptation standard development, application and transfer, rather than leaving this opportunity to policy-makers and government bodies.

Future research is necessary on a variety of aspects. For example, future research can build on the ideas presented in this study to expand existing research on asset impairment (see Cotter *et al.*, 1998) to factor in the impacts of climate change. There is growing concern that climate change may lead to some assets becoming so-called 'stranded assets' (Ansar *et al.*, 2013) as climate change leads to their unanticipated or premature write-down, devaluations or a conversion to liabilities. In China, for example, water scarcity, local pollution, improving energy efficiency and growing developments in clean energy technology have started to threaten coal-fired power generation. Such developments have potentially widespread implications for investments in energy infrastructure and asset allocations, but also for impacts on coal and coal-related assets in Australia which is a large and growing exporter of coal to China (Caldecott *et al.*, 2013).

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<sup>2</sup> Abolished in 2014.

Future research can also focus on the creation of a 'best practice' approach for organisations to understand how climate impacts can be accounted for and to deliver decision-makers with clarification of ways in which climate adaptation can be understood, operationalised and economically measured. Companies may implement methodologies such as cost-benefit analysis, multicriteria analysis, Real Options valuation or internal management schemes around climate change (see Tang and Luo, 2014) to help evaluate issues relating to climate change strategies. More insights are needed regarding the relative strengths and weaknesses of these methodologies, and how they can best be integrated within organisations. Further development also needs to be undertaken in the following areas: (i) the development of a consolidated approach to financial risk assessment of climate change, including frameworks for assessing organisational vulnerability and adaptive capacity; (ii) the development of methodological avenues for accounting for the distribution of costs and benefits across different timescales and parts of the organisation; and (iii) and increasing awareness around the need to report on climate impact and adaptation outcomes.

## References

- Adger, W. N., S. Agrawala, M. M. Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit, and K. Takahashi, 2007, Assessment of adaptation practices, options, constraints and capacity. in: M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, C. E. Hanson, eds. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, UK), 717–743.
- Agrawala, S., and S. Fankhauser, 2008, *Economics Aspects of Adaptation to Climate Change. Costs, Benefits and Policy Instrument* (OECD, Paris).
- Ansar, A., B. Caldecott, and J. Tilbury, 2013, Stranded Assets and the Fossil Fuel Divestment Campaign: What Does Divestment Mean For the Valuation of Fossil Fuel Assets? (University of Oxford, Oxford, UK).
- Ascui, F., 2014, A review of carbon accounting in the social and environmental accounting literature: what can it contribute to the debate?, *Social and Environmental Accountability Journal* 34, 6–28.
- ASX, 2014, *Corporate Governance Principles and Recommendations* (3rd edition). Available at: <http://www.asx.com.au/regulation/corporate-governance-council.htm>.
- Bachoo, K., R. Tan, and M. Wilson, 2013, Firm value and the quality of sustainability reporting in Australia, *Australian Accounting Review* 23, 67–87.
- Beams, F. A., and P. E. Fertig, 1971, Pollution control through social cost conversion, *The Journal of Accountancy* 132, 37–42.
- BHP Billiton, 2014, Sustainability Report. Available at [http://www.bhpbilliton.com/home/society/reports/Documents/2014/BHPBillitonSustainabilityReport2014\\_inter-active.pdf](http://www.bhpbilliton.com/home/society/reports/Documents/2014/BHPBillitonSustainabilityReport2014_inter-active.pdf)
- Caldecott, B., J. Tilbury, and Y. Ma, 2013, Stranded Down Under? Environment-Related Factors Changing China's Demand for Coal and What This Means for Australian Coal Assets. Available at: <http://www.smithschool.ox.ac.uk/research-programmes/stranded-assets/Stranded%20Down%20Under%20Report.pdf>.

- Casti, J. L., 1997, *Would-Be Worlds: How Simulation is Changing the Frontiers of Science* (Wiley, New York).
- CDP, 2015, CDP 2014 Climate Change Scoring Methodology. Available at: <https://www.cdp.net/Documents/Guidance/2014/CDP-2014-Climate-Change-Scoring-Methodology.pdf>.
- Chambwera, M., G. Heal, C. Dubeux, S. Hallegatte, L. Leclerc, A. Markandya, B. McCarl, R. Mechler, and J. Neumann, 2014, Economics of adaptation, in IPCC, ed., *Climate Change 2014: Impacts, Adaptation, and Vulnerability: Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Available at: <http://ipcc-wg2.gov/AR5/report/>.
- Chapple, L., P. M. Clarkson, and D. L. Gold, 2013, The cost of carbon: capital market effects of the proposed emission trading scheme (ETS), *Abacus* 49, 1–33.
- Chartered Institute of Management Accountants, 2010, *Accounting for Climate Change: How Management Accountants Can Help Organisations Mitigate and Adapt to Climate Change*. Available at: [http://www.cimaglobal.com/Documents/Thought\\_leadership\\_docs/cid\\_accounting\\_for\\_climate\\_change\\_feb10.pdf](http://www.cimaglobal.com/Documents/Thought_leadership_docs/cid_accounting_for_climate_change_feb10.pdf)
- Clarkson, P. M., M. B. Overell, and L. Chapple, 2011, Environmental reporting and its relation to corporate environmental performance, *Abacus* 47, 27–60.
- Clarkson, P., Y. Li, M. Pinnuck, and G. D. Richardson, 2014, The valuation relevance of greenhouse gas emissions under the European Union carbon emissions trading scheme, *European Accounting Review*, <http://www.tandfonline.com/doi/pdf/10.1080/09638180.2014.927782>. Forthcoming.
- Climate Disclosure Standards Board, 2015, About CDSB. Available at: <http://www.cdsb.net/about-cdsb>.
- Cogan, D. G., 2006, *Corporate Governance and Climate Change: Making the Connection* (Ceres, Boston, MA).
- Cotter, J., and M. Najah, 2012, Institutional investor influence on global climate change disclosure practices, *Australian Journal of Management* 37(2), 169–187.
- Cotter, J., D. Stokes, and A. Wyatt, 1998, An analysis of factors influencing asset writedowns, *Accounting & Finance* 38, 157–179.
- CSR, 2014, CSR Limited Annual Report 2014. Available at: [http://www.csr.com.au/Investor-Centre-and-News/Annual-Meetings-and-Reports/Annual%20Report%202012/sites/default/files/Annual\\_Report\\_2014.pdf](http://www.csr.com.au/Investor-Centre-and-News/Annual-Meetings-and-Reports/Annual%20Report%202012/sites/default/files/Annual_Report_2014.pdf).
- Deegan, C., 2008, Environmental costing in capital investment decisions: electricity distributors and the choice of power poles, *Australian Accounting Review* 18, 2–15.
- Deegan, C., and C. Blomquist, 2006, Stakeholder influence on corporate reporting: an exploration of the interaction between WWF-Australia and the Australian Minerals Industry, *Accounting, Organizations and Society* 31, 343–372.
- Dow, K., F. Berkhout, B. L. Preston, R. J. Klein, G. Midgley, and M. R. Shaw, 2013, Limits to adaptation, *Nature Climate Change* 3, 305–307.
- Elkington, J., 1997, *Cannibals with Forks: The Triple Bottom Line of 21st Century Business* (Capstone, Oxford, UK).
- Fox-Wolfgramm, S. J., K. B. Boal, and J. G. Hunt, 1998, Organizational adaptation to institutional change: a comparative study of first-order change in prospector and defender banks, *Administrative Science Quarterly* 43, 87–126.
- Global Reporting Initiative, 2015, An Overview of GRI. Available at: <https://www.globalreporting.org/information/about-gri/what-is-GRI/Pages/default.aspx>.
- Gray, R. H., 1990, *The Greening of Accountancy: The Profession after Pearce* (Chartered Association of Certified Accountants, London, UK).



- Gray, R., 2010, A re-evaluation of social, environmental and sustainability accounting: an exploration of an emerging trans-disciplinary field?, *Sustainability Accounting, Management and Policy Journal* 1, 11–32.
- Gray, R., C. Dey, D. Owen, R. Evans, and S. Zadek, 1997, Struggling with the praxis of social accounting: stakeholders, accountability, audits and procedures, *Accounting, Auditing, and Accountability Journal* 10, 325–364.
- Herbohn, K., P. Dargusch, and J. Herbohn, 2012, Climate change policy in Australia: organisational responses and influences, *Australian Accounting Review* 22, 208–222.
- Herbohn, K., J. Walker, and H. Y. M. Loo, 2014, Corporate social responsibility: the link between sustainability disclosure and sustainability performance, *Abacus* 50, 422–459.
- Herring, R., and S. Wachter, 2005, Bubbles in real estate markets, in: W. C. Hunter, G. G. Kaufman, M. Pomerleano, eds., *Asset Price Bubbles: The Implications for Monetary, Regulatory and International Policies* (MIT Press, Boston, MA).
- Hertin, J., F. Berkhout, D. M. Gann, and J. Barlow, 2003, Climate change and the UK house building sector: perceptions, impacts and adaptive capacity, *Building Research and Information* 31, 278–290.
- Hoffmann, V., D. Sprengel, A. Ziegler, M. Kolb, and B. Abegg, 2009, Determinants of corporate adaptation to climate change in winter tourism: an econometric analysis, *Global Environmental Change* 19, 256–264.
- IASB, 2014, MoU Between IASB and IIRC. Available at: <http://www.ifrs.org/Use-around-the-world/Pages/IASB-and-IIRC-MoU.aspx>.
- Integrated Reporting, 2015, What is Integrating Reporting? Available at: <http://www.theiirc.org/>.
- IPCC, 2012, Managing the Risks of Extreme Events and Disaster to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY.
- IPCC, 2014, Climate Change 2014: Impacts, Adaptation, and Vulnerability: Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available at: <http://ipcc-wg2.gov/AR5/report/>.
- Kates, R. W., 2000, Cautionary tales: adaptation and the global poor, *Climatic Change* 45, 5–17.
- Keef, S. P., and M. L. Roush, 2005, Influence of weather on New Zealand financial securities, *Accounting and Finance* 45, 415–437.
- Kolk, A., D. Levy, and J. Pinkse, 2008, Corporate responses in an emerging climate regime: the institutionalization and commensuration of carbon disclosure, *European Accounting Review* 17, 719–745.
- Kontogianni, A., C. H. Tourkoulis, D. Damigos, and M. Skourtos, 2014, Assessing sea level rise costs and adaptation benefits under uncertainty in Greece, *Environmental Science & Policy* 37, 61–78.
- KPMG, 2015, Climate Change and Sustainability Services. Available at: <http://www.kpmg.com/au/en/services/advisory/risk-compliance/sustainability-climate-change-water/pages/default.aspx>
- Linnenluecke, M., and A. Griffiths, 2010, Beyond adaptation: resilience for business in light of climate change and weather extremes, *Business and Society* 49, 477–511.
- Linnenluecke, M. K., and A. Griffiths, 2013, Firms and sustainability: mapping the intellectual origins and structure of the corporate sustainability field, *Global Environmental Change* 23, 382–391.
- Linnenluecke, M. K., and A. Griffiths, 2015, *The Climate Resilient Organization* (Edward Elgar, Cheltenham, UK).

- Linnenluecke, M. K., A. Griffiths, and M. I. Winn, 2013, Firm and industry adaptation to climate change: a review of climate adaptation studies in the business and management field, *Wiley Interdisciplinary Reviews: Climate Change* 4, 397–416.
- Lovell, H., and D. McKenzie, 2011, Accounting for carbon: the role of accounting professional organisations in governing climate change, *Antipode* 43, 704–730.
- Martinov-Bennie, N., and R. Hoffman, 2012, Greenhouse gas and energy audits under the newly legislated Australian audit determination: perceptions of initial impact, *Australian Accounting Review* 22, 195–207.
- Mathews, M. R., 1997, Twenty-five years of social and environmental accounting research: is there a silver jubilee to celebrate?, *Accounting, Auditing and Accountability Journal* 10, 481–531.
- Moroney, R., C. Windsor, and Y. T. Aw, 2012, Evidence of assurance enhancing the quality of voluntary environmental disclosures: an empirical analysis, *Accounting and Finance* 52, 903–939.
- Morrison, J., M. Morikawa, M. Murphy, and P. Schulte, 2009, *Water Scarcity and Climate Change: Growing Risks for Businesses and Investors*. (Ceres and Pacific Institute, Oakland, CA; Boston, MA).
- Munich Re, 2009, *Topics Geo: Natural Catastrophes 2008: Analyses, Assessments, Positions* (Münchener Rückversicherungs-Gesellschaft, Munich, Germany).
- Munich Re, 2012, *Topics GEO: Analyses, Assessments, Positions* (Münchener Rückversicherungs-Gesellschaft, Munich, Germany).
- Noble, I., S. Huq, Y. Anokhin, J. Carmin, D. Goudou, F. Lansigan, B. Osman-Elasha, and A. Villamizar, 2014, Adaptation needs and options, in IPCC, ed., *Climate Change 2014: Impacts, Adaptation, and Vulnerability: Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Available at: <http://ipcc-wg2.gov/AR5/report/>.
- Nohria, N., and R. Gulati, 1996, Is slack good or bad for innovation?, *Academy of Management Journal* 39, 1245–1264.
- Noson, L. 2015, Hazard Mapping and Risk Assessment. Available at: <http://www.adpc.net/audmp/rllw/PDF/hazard%20mapping.pdf>
- Parry, M. L., O. F. Canziani, J. P. Palutikof and Co-Authors. 2007, Technical summary, in: M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, C. E. Hanson, eds. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, UK), 23–78.
- Reid, E. M., and M. W. Toffel, 2009, Responding to public and private politics: corporate disclosure of climate change strategies, *Strategic Management Journal* 30, 1157–1178.
- Schindehutte, M., and M. H. Morris, 2001, Understanding strategic adaptation in small firms, *International Journal of Entrepreneurial Behaviour and Research* 7, 84–107.
- Stanny, E., and K. Ely, 2008, Corporate environmental disclosures about the effects of climate change, *Corporate Social Responsibility and Environmental Management* 15, 338–348.
- Surminski, S., 2013, Private-sector adaptation to climate risk, *Nature Climate Change* 3, 943–945.
- Tang, Q., and L. Luo, 2014, Carbon management systems and carbon mitigation, *Australian Accounting Review* 24, 84–98.
- United Nations Environment Programme, 2012, *Business and Climate Change Adaptation: Toward Resilient Companies and Communities*. Available at: [http://unglobalcompact.org/docs/issues\\_doc/Environment/climate/Business\\_and\\_Climate\\_Change\\_Adaptation.pdf](http://unglobalcompact.org/docs/issues_doc/Environment/climate/Business_and_Climate_Change_Adaptation.pdf).

- West, J., and D. Brereton, 2013, *Climate Change Adaptation in Industry and Business: A Framework for Best Practice in Financial Risk Assessment, Governance and Disclosure* (National Climate Change Adaptation Research Facility, Gold Coast, Australia).
- Wilbanks, T. J., P. Romero Lankao, M. Bao, F. Berkhout, S. Cairncross, J.-P. Ceron, M. Kapshe, R. Muir-Wood, and R. Zapata-Marti, 2007, Industry, settlement and society, in: M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, C. E. Hanson, eds. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, UK), 357–390.