Management of climate change risks in Indian organisations: a proposed framework

Aditee Potdar* and Seema Unnikrishnan

National Institute of Industrial Engineering,
Vihar Lake Road, Powai, Mumbai 400087, India
Email: aditip17@gmail.com
Email: seemaunnikrishnan@gmail.com
*Corresponding author

Abstract: This study focuses on determining how climate change risks affect Indian organisations. A framework consisting of four steps (monitoring, analysis, evaluation, and implementation) is proposed to guide organisations to address the climate change challenge. Climate change risks, drivers, and mitigation actions were evaluated by designing a questionnaire and overseeing it to 257 manufacturing organisations. The findings from this study suggest that energy and its price may influence a major impact of climate change challenge. The respondents view on competitive risk is found as the most critical climate change threat. Top management commitment is viewed as a key driver to propose a likely framework. The mitigation action that most organisations have undertaken is energy efficiency. Further, multiple regression analysis shows a significant relationship between climate change risks and drivers, and climate change risks and mitigation activities. The outcomes from this study will be useful for organisations to determine the potential risks and ascertain further actions to mitigate them for India and elsewhere.

Keywords: climate change risk; climate change impacts; drivers for climate change mitigation; mitigation actions; business organisations.

Reference to this paper should be made as follows: Potdar, A. and Unnikrishnan, S. (2021) 'Management of climate change risks in Indian organisations: a proposed framework', *Int. J. Environment and Sustainable Development*, Vol. 20, No. 1, pp.1–28.

Biographical notes: Aditee Potdar is currently pursuing her PhD at the National Institute of Industrial Engineering (NITIE), Mumbai, India. She holds a Master in Environmental Science from University of Mumbai, India. She has successfully completed her Post Graduate Diploma in Environmental Law from National Law School of India University, Bangalore, India. Prior to joining PhD, she worked as an Environmental Analyst at an environmental laboratory. Further, she also worked at the Centre for Environmental Studies at NITIE as a Research Associate. She has about ten publications in peer-reviewed journals till date.

Seema Unnikrishnan received her PhD from National Institute of Industrial Engineering (NITIE), Mumbai, in the area of Hazardous Waste Management. She completed her Post Graduate Diploma in Environmental Law from Madurai Kamaraj University, India. She is currently working as a Professor in NITIE, Mumbai. Before joining NITIE, she worked with the Central Pollution Control Board for three years. She has several research publications in the field of environmental management. Her areas of research interest are climate change, hazardous waste management, cleaner production, and disaster prevention and management.

Copyright © 2021 Inderscience Enterprises Ltd.

1 Introduction

The necessity to integrate economic, social, and environmental aspects in the development process surfaced due to the wasteful, reckless, and unjust patterns of development, which, if continued, could lead to the destruction of the biophysical environment in the near future (Du Pisani, 2006). There is an urgent need to switch to environmental sustainability because the environment, which is an important life-support system, is deteriorating at a faster pace than expected (Goodland, 1995; IPCC, 2014). To achieve sustainability, reducing and stabilising the load on the environment are essential, which can be executed by decreasing the effects of overpopulation, modifying the consumption patterns, or investment in technology (Hart, 1997; Shwom and Lorenzen, 2012; Thuku et al., 2013; Coccia, 2014). Given the holistic nature of sustainable development, economic, social, and environmental challenges ought to be dealt with jointly and/or simultaneously (Bocken et al., 2014).

Climate change has emerged as the leading sustainability issue of the current century (Renukappa et al., 2013; Owusu and Asumadu-Sarkodie, 2016). In a developing country, sustainability and climate change link environmental matters with social equity and the economic problem such as poverty. According to the recent literature, it is factual that climate change is associated with a large number of other environmental and socioeconomic issues, including deforestation, desertification, rural electrification, resource availability (e.g., water), biodiversity, income generation capacity, security, and health (Pinkse and Kolk, 2012).

Businesses, which are future economic engines, must largely shoulder the responsibility of and be accountable for safeguarding a sustainable world (Hart, 1997). Environmental sustainability has turned out to be a significant concern for businesses, as their actions are associated with global environmental concerns (Park and Kremer, 2017). They act as a central player in addressing these problems because they have easy access to resources, knowledge, technology, and expertise, and they possess wider vision, global reach, and the drive to achieve sustainability. Businesses have a future sustainability vision, which stresses the evolution of future products and services and the new proficiencies that would be required to fulfil this vision (Hart, 1997; Hou et al., 2019).

One of the global sustainability issues that have gradually gained the interest of the business community in the early 21st century is climate change. Along with the business community, a range of stakeholders (investors, suppliers, competitors, non-governmental organisations (NGOs), customers, etc.) has begun to notice the potentially serious impacts and the need to initiate action on climate change (Renukappa et al., 2013). Climate change could entirely alter the current competitive environment by presenting new risks and opportunities to business organisations (Lee, 2012; Elijido-Ten, 2017), and firms can carve out a niche for themselves by responding innovatively to climate change policy through innovations in technology, developing capabilities, and socio-technical innovations (Pinkse and Kolk, 2010; Su and Moaniba, 2017).

With the increasing concurrence of scientists on the potential impacts of climate change, business organisations are under tremendous pressure from various stakeholders to reduce their greenhouse gas (GHG) emissions from different life stages of their products and services. The pressure on business organisations is varied across sectors (Dunn, 2002; EIRIS, 2009). As the single largest contributors for increasing the GHG emissions (Baumert et al., 2005), industries play an essential role in the ‘stabilisation of

GHG concentration in the atmosphere,' which is the goal of the United Nations Framework Convention on Climate Change (United Nations, 1992).

The restriction on GHG emissions from industrial activities would form a significant action of an organisation's corporate responsibility agenda (Hendrichs and Busch, 2012). The recent initiatives undertaken by the organisations are emission reduction activities; improvements in products and processes; alliance and engagement with other organisations, gain expertise; and exploration of emission trading (Kolk and Pinkse, 2004) and measurement of footprint across the supply chain, and production, operations and consumption pattern (Ridoutt et al., 2016). To survive in a carbon-constrained environment, many organisations have started to prepare themselves to avoid the extreme impacts of climate change (Jeswani et al., 2008; Zhou and Wen, 2019). The appreciation in demand for low-carbon technologies has given an impetus to firms to take more action on climate change (Hoffman, 2005; Purdy et al., 2011; Zhou and Wen, 2019).

Given the growing evidence of a scientific agreement on the anthropogenic influence on climate change, business organisations have to confront several climate change-related challenges, such as risks, costs, benefits, and opportunities, which require measurement and assessment (Liu, 2012). The risks emerging from climate change – *viz.* regulatory risks, litigation risks, reputation risks, and physical risks – motivate organisations to come up with innovations through which they can gain an advantage both for growth and lessening climatic impacts (Nikolaou et al., 2015). The corporate response to climate change mitigation varies from the reactive approach to the proactive approach. Several corporations focus on managing the risks and legal compliances and thereby prefer to implement a reactive approach. In contrast, other firms undertake voluntary actions leading to a proactive perspective. In addition, many other firms tend to adopt a 'wait-and-see' stance (Elijido-Ten, 2017). By the application of specific climate change strategies to reduce carbon emissions, an opportunity for competitive advantage is offered to organisations to grow further with green innovation (Hendrichs and Busch, 2012).

1.1 Impact of climate change on Indian organisations

India is currently at a crossroads in its developmental path. It is both a major GHG emitter and one of the most vulnerable countries in the world to projected climate change (JGCRI et al., 2009). India's CO_2 emission level rose from 1.06 billion tonnes in 2000 to 1.97 billion tonnes in 2012, making it the third-largest emitter country in the world followed by China and the USA (Soni and Bhanawat, 2015). India contributed 6.24% of CO_2 emissions worldwide in 2016 (Statista, 2018). Transition economies like India face the challenge of developing a green economy that answers the call for sustainable and inclusive development without forgoing the optimal rate of growth (Giz et al., 2012; Ray, 2013). India has shifted from its earlier position of negating the role of developing countries in climate change to one of the more proactive steps of announcing voluntary emission reduction targets, in line with its growing role in the global economic order. However, the shift has been slow (Das, 2012).

In the last decade, India's dual role as a victim of climate change as well as a major polluter created momentum in the industrial sector. The economic liberalisation of the 1990s saw changes in the top Indian organisations in the form of sustainable development policies (Ray, 2013). Climate change is one of the environmental issues that has increasingly attracted corporate attention in recent years in India; a range of stakeholders, including governments, started paying more attention to the potentially negative

consequences of climatic effect. India became increasingly aware of the need to take action for climate change (Prasad and Sri, 2008). Indian organisations prioritised inventorying and reducing their GHG emissions, even in the absence of government regulation (Pulver, 2012). Indian organisations have also realised the value of adopting environment-friendly processes and business practices, which is expected to ultimately lead to the introduction of more efficient processes.

The impact of climate change is global; the problem is long-term, and the impact is substantially irreversible. However, it is interesting to note that despite being a significant perpetrator of the phenomenon, business organisations are also bearing the brunt of climate change. These organisations face major uncertainties about the magnitude and timing of climate change risks they are likely to face (Lash and Wellington, 2007). Thus, it is important to determine the various climate change risks and understand how they affect the organisations from short-run to long-run.

The literature primarily focuses on the identification of climate change risks that are central to business organisations and the strategies they devise to combat climate change. Most of the literature is from developed countries. Hence, this study emerges as the one of the first report from a developing country like India, aiming to advance the literature on significant climate change risks and the actions business organisations should undertake to lessen the climatic impact. Moreover, this study contributes to the literature by adopting an empirical approach to climate change risk management framework, which has hitherto been used in a limited manner in the literature. The study also probes into how the organisations analyse and evaluate these risks and implement actions to manage them.

2 Climate change risks

A literature review on various facets of climate change management has been provided by Potdar et al. (2019). Their study delves into different climate change risks and how they affect various business organisations. Business risks presented by climate change are unavoidable, as climate change has a global impact and is a long-term challenge, and the impairment caused is broadly irreparable. During an organisational risk assessment, overlooking the fiscal and competitive climate change concerns could lead to the formulation of an erroneous risk profile (Lash and Wellington, 2007). The research by climate scientists anticipates serious effects on the supply chain and assets of business organisations due to the build-up of pollution from fossil fuel in the atmosphere and oceans (Ceres, 2010). Climate change risks posed to companies vary and depend on several factors, such as the fuel used for production, the energy source and the extent of its use, the geographic location of production facilities, technological innovations companies are ready to undertake, product mix, capability of risk management, and entrepreneurial risk companies are ready to take. Regardless of these differences, companies cannot deny the pressure from climate change (Pattberg, 2012). Lash and Wellington (2007) proposed several climate change risks that could affect business organisations, such as regulatory risk, supply chain risk, litigation risk, competitive risk, reputational risk, and physical risk. The risks are listed in detail below.

a *Regulatory risk* – for business organisations, the risk from regulations is certainly a discernible impact area. It might appear in the manner of regulating emissions from

the production processes or from the products themselves (Lash and Wellington, 2007). Many sectors face regulatory risk from the higher costs of fossil fuels and the lesser need for energy-intensive products (Wellington and Sauer, 2005; Ceres, 2010). Regulatory risks are mainly associated with the types of mitigation strategies that firms have undertaken to comply with the requirements of existing environmental legislation (Blyth et al., 2007). The regulation to manage GHGs might pose additional costs and mandated compliance for some firms, while regulation is not directly concern for other firms. Most firms would benefit from the emergence of a new market, which would increase fuel prices and/or changes in consumer demand (Ceres, 2010). Business organisations prefer a national policy for climate change instead of each state bringing in its regulations. Business organisations that initiate an assessment of the impact of future regulations are far-sighted in managing the regulatory risk and have an advantage over their adversaries (Lash and Wellington, 2007). Elijido-Ten (2017) shows that among other climate change-associated risks, only regulatory risk is extensively recognised and is negatively associated with sustainability performance.

b *Supply chain ris*k– the emissions from the supplier is included in Scope 3 of the GHG Protocol. As the business organisations anticipate climate change regulations, it is necessary for them to measure, evaluate, and manage the emissions coming from their suppliers. Moreover, the executives should assess and maintain the number of suppliers operating at different levels of the organisation. In addition, executives must be watchful that the climate change risks affecting their organisations might affect their suppliers as well (Lash and Wellington, 2007).

c *Product and technology risk* – to stay in the competitive world of climate change, business organisations are required to be prepared and introduce novel climate-friendly products. In such cases, organisations that can spot the market opportunities for innovative climate products perform better (Lash and Wellington, 2007).

d *Litigation risk* – litigation risks may result in heavy fines paid by firms due to an inability or reluctance to comply with the requirements of climate change public policy and directly affect the economic performance of the firms (Nikolaou et al., 2015). An organisation working in the sector of high carbon emissions (*viz.,* oil and gas, electric utilities, manufacturing of automobiles) is exposed to a greater risk of litigation. An organisation that does not tackle the climate change issue effectively may present new challenges for the top management as a form of a lawsuit from stakeholders (Lash and Wellington, 2007).

e *Competitive risk* – firms have to deal with considerable risk from competitors, as the variations in technology, costs, and demand pattern interrupt the sectors and supply chains entirely (Jones and Levy, 2007), and the central proficiencies become outdated (Kolk et al., 2008). A changing physical environment and anticipation of climate change regulations could lead to the creation of a new competitive environment, through increased costs of fuel and energy and heightened competition for diminishing resources such as water, which could further lead to an increase in costs (Ceres, 2010).

f *Financial risk* – Esty (2007) states that financial institutions are beginning to recognise the cost and risk implications presented by climate change as the economic losses due to natural disasters accumulate and need to be incorporated into the core financial operations. Rating agencies, working for large investment funds, are screening firms for their environmental and sustainability factors, and they exclude poor performers.

g *Reputational risk* – business organisations face a greater risk of damage to reputation from any climate change risk if the brand name is closely associated with damage from climate change or if there happens to be alleged mismanagement of the risk environment due to climate change (Ceres, 2010). Firms can face backlash from public opinion due to the sale and use of processes, products, or practices having a negative climate impact. The prospect of such criticism is specifically greater in markets that are environmentally sensitive or in sectors where brand loyalty is of significant value. Similar to other climate change risks, firms can incorporate practices that are beneficial for the earth and use a platform to turn reputational risk into an opportunity (Lash and Wellington, 2007).

h *Physical risk* – a changing climate poses a direct risk to individuals. Physical risk is a mainstream climate change problem and affects the maximum number of individuals and firms. Frequent extreme events like floods, hurricanes, and winter storms are likely to pose a serious physical risk (Ceres, 2010).

Depending on the sector and the frequency of the physical risks, a series of consequences for operations and production processes has been identified by Nikolaou et al. (2015), including an irregular supply of raw materials (supply chain risks), the relocation of the business units, and interruptions to transportation. The sectors that are predominantly exposed to climate change are agriculture, fisheries, forestry, insurance, real estate, and tourism, as they largely depend on the elements of the physical and ecological environment. Other sectors such as oil and gas are also affected by the physical risk, as they are located in vulnerable areas and pay high insurance premiums for such locations (Lash and Wellington, 2007; Kolk et al., 2008). Electricity supply companies, when challenged by climate change, modified their operational and strategic practices and incorporated the challenge of physical risk (Okereke et al., 2012).

Apart from directly affecting business organisations, climate change poses indirect risks as well. The indirect risks could be related to the availability of resources and could be probable regulatory risks due to a cap on emissions, regulatory obligations from insurance companies, or requirements of building codes (Shulman, 2012). The banking sector could be affected by the lack of relevant information; for instance, the land is often used as collateral against loans, and the land may be devalued due to the polluting activities of businesses (Thompson and Cowton, 2004). Similarly, a banking sector that focuses exclusively on lending to the agriculture sector might have greater exposure to climate change risks because extreme weather events that might weaken the borrowers' ability to pay back the loan (Demertzidis et al., 2015).

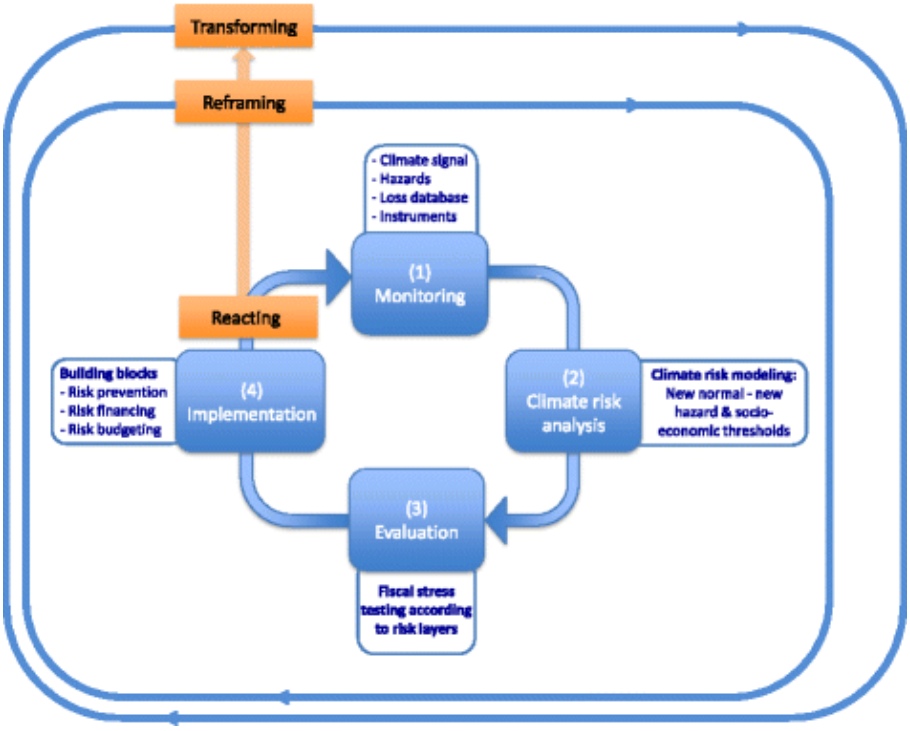
Apart from the risks stated, a few authors have highlighted how climate change risks are impacting business organisations and the ways they are tackling them. Wittneben and Kiyar (2009) discuss how businesses can reduce their carbon footprint and anticipate changes in the physical and political environment related to climate change. Their study is valuable to managers who are expected not only to reduce emissions from operations

but also to gain awareness of the physical, political, and social risks stemming from the impacts of climate change. A new methodological framework relying on the benchmarking-scoring systems and Global Reporting Initiative (GRI) guidelines was proposed by Demertzidis et al. (2015). The framework operationalises and quantifies an array of business climate change risks to provide more comprehensive and tangible information on non-traditional risks, and it is applied to various Greek businesses that are certified by the Environmental Management and Audit Scheme (EMAS). Nikolaou et al. (2015) identified how physical, regulatory, reputational, and litigation risks affect day-to-day business operations by developing a dynamic model to investigate the evolutionary trends of the relationships among climate change risks, financial performance, and the operational processes of firms.

2.1 Framework for climate change risk management

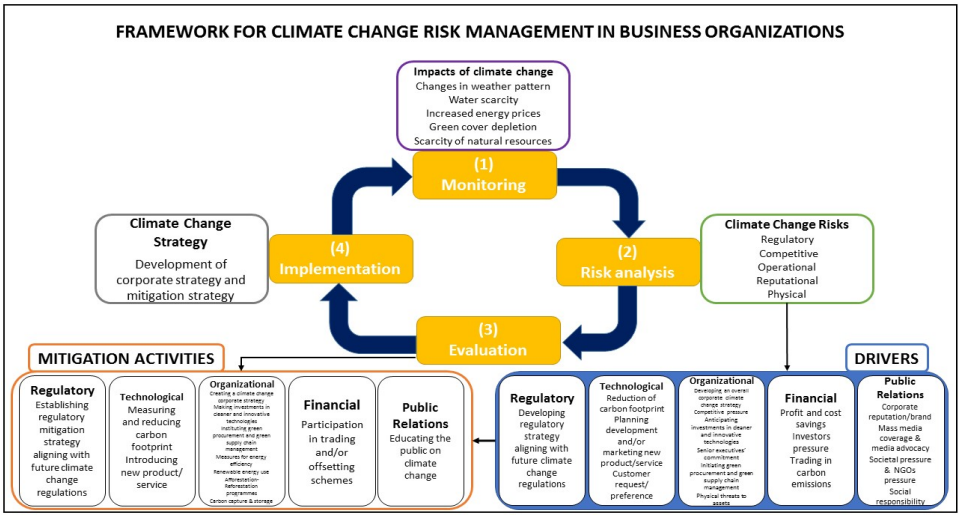
The proposed framework in this study for the management of climate change risk in business organisations is built upon the existing climate risk management framework as proposed by Schinko et al. (2017) shown in Figure 1. Schinko et al. (2017) developed and applied a methodological approach to climate risk management in the decision context of sovereign risk (flooding) in Austria; they tested the usefulness of climate risk management, and based on these insights, they informed applications in other decision contexts.

Figure 1 Existing climate risk management framework (see online version for colours)



Source: Schinko et al. (2017)

Figure 2 Proposed climate risk management framework (see online version for colours)



The proposed framework in Figure 2 consists of four steps and is based on the concept of continual improvement, as suggested in the ISO 14001:2015 standard. The first step is monitoring of the impacts of climate change that affect the organisation, which includes changes in the weather pattern, water scarcity, increased energy prices, green cover depletion, and scarcity of natural resources. Monitoring the impacts would lead to the analysis of certain risks; they pose as the second step of the framework. Certain risks may affect an organisation extensively, while other organisations may be affected narrowly. Also, the risks could vary depending on the sector and location of the organisation/facility. The analysis of the risks will help to identify drivers, which the organisations can undertake to mitigate climate change. This step is in line with the study of Lash and Wellington (2007), which offers a guide for firms to create a strategy that will help in managing the risks (step 2) and pursue the opportunities offered (step 3). The drivers identified will be evaluated by the organisations to form a tangible mitigation action to be implemented in their facilities. This forms the third step of the framework supported by Kolk and Pinkse (2004) and Okereke (2007). Using the empirical information from the largest multinational companies worldwide, Kolk and Pinkse (2004) examined the market responses, focusing on the drivers (threats and opportunities) and the actions being taken by companies (step 3). Okereke (2007) explored climate response activities (step 3) of FTSE 100 companies in terms of motivations, drivers, and barriers to carbon management. The final step in the framework is the identification of mitigation actions, which could implement and lead to the development and formation of strategies to apply them. This step is consistent with the studies by Cadez and Czerny (2016) and de Abreu et al. (2017). Cadez and Czerny (2016) appraised the relationships between carbon reduction practices (step 3) and their underlying strategies (step 4). Abreu et al. (2017) proposed a conceptual model for the development of corporate climate change strategy, which reflects the dynamic influence of climate change risks (step 2) and stakeholder pressure (drivers for climate change risk management) (step 3) on the adopted carbon management practices. These steps will benefit an organisation by being a low-carbon firm, enhancing corporate reputation, achieving regulatory compliance, and gaining the

trust of the stakeholders. The effects of climate change are experienced differently at different levels of the firm. Thus, it is important for business organisations to continuously monitor, analyse, evaluate the climate change risks, and implement strategies to mitigate these risks, leading to sustainable development in the true sense.

3 Methodology

A questionnaire was designed to identify the climate change risks affecting Indian business organisations followed by a survey (Sekaran, 2003). The target population for this study is business organisations and their units across India from the diverse manufacturing sector and, specifically, the manufacturing sectors that are energy intensive. The sampling procedure used for the study is mainly random sampling. In some cases, snowball sampling technique was adopted.

A stepwise and detailed process was adopted for the development of the survey instrument (questionnaire) that measure the constructs linked to the identification of climate change risks. Those constructs include impacts of climate change affecting the organisations, drivers that the organisations could consider to mitigate climatic risks, and the mitigation actions that could be undertaken by the organisations. The items under those constructs are highlighted in Table 1. In addition, questionnaires on similar topics were referred duly (Kolk and Pinkse, 2004, 2007; Lash and Wellington, 2007; McKinsey Quarterly, 2007; Okereke, 2007; Kolk et al., 2008), and a few general questions from those questionnaires were included to elicit a better response. A pool of 39 items for all constructs considered in the proposed framework was developed through the literature. Those 39 items were evaluated for face validity and content validity.

A construct was operationalised by selecting its measurement scale items and scale type. A literature search aids for individual constructs and scale identification from the previous studies (Hair et al., 2010). All the constructs were structured by referring to the literature and are operationalised using a Likert scale. The questionnaire in this study is designed based on a seven-point Likert scale ranging from 1 (extremely low) to 7 (extremely high), which provides a more accurate measure of a participant's true evaluation (Finstad, 2010). Earlier empirical research in the same field has also developed questionnaires using a five-point Likert scale (Sprengel and Busch, 2011) and a seven-point Likert scale (Cadez and Czerny, 2016).

Likert scale						
1	*2*	*3*	*4*	*5*	*6*	*7*
Extremely low	Very low	Low	Medium	High	Very high	Extremely high

At the end of the questionnaire, a section to understand the background information of the respondent was added. This section included the respondent's demographic information, such as name of the organisation, location of the organisation, sector in which it operates, name of the respondent, designation, email address, and contact number. However, the sharing of these details was voluntary. The questionnaire was supplemented with a cover letter that stated the purpose of conducting the study and made a declaration that the responses would only be used for academic and research purposes.

Table 1 Elements of the questionnaire

Elements	*No. of variables*	*Code*	*Variable*	*Reference*
Impacts of climate change affecting the unit	5	CICC 1	Erratic changes in weather pattern	Kolk and Pinkse (2007), Prasad and Sri (2008) and Dombrowski and Ernst (2014)
		CICC 2	Water scarcity	NRDC (2010)
		CICC 3	Energy consumption and demand	Akhmat et al. (2014)
		CICC 4	Decrease in green cover	Gosling et al. (2011)
		CICC 5	Scarcity of natural resources	Evans (2010)
Risks that may be associated with the firm and to what extent	5	CCR 1	Regulatory risk	Lash and Wellington (2007), Kolk et al. (2008), CERES (2010) and Okereke et al. (2012)
		CCR 2	Competitive risk	Jones and Levy (2007), Kolk et al. (2008) and Sullivan (2010)
		CCR 3	Operational risk	Lash and Wellington (2007)
		CCR 4	Reputational risk	Lash and Wellington (2007), Kolk et al. (2008), Knox-Hayes and Levy (2011), Okereke et al. (2012) and Wright et al. (2012)
		CCR 5	Physical risk	Kolk and Pinkse (2004), Lash and Wellington (2007) and Hendrichs and Busch (2012)

Table 1 Elements of the questionnaire (continued)

Elements	*No. of variables*	*Code*	*Variable*	*Reference*
Assessing the importance of the drivers in response to climate change	17	DRCC 1	Corporate reputation, brands	Hoffman (2005) and McKinsey Quarterly (2007)
		DRCC 2	Reduction of carbon footprint	McKinsey Quarterly (2007)
		DRCC 3	Developing an overall corporate climate change strategy (looking at future physical impacts of climate change)	McKinsey Quarterly (2007)
		DRCC 4	Profit and cost savings	Hoffman (2006), Okereke (2007) and Slawinski et al. (2014)
		DRCC 5	Planning development and/or marketing of new products/services through technological innovations	Kolk and Levy (2001), Dunn (2002), Kolk and Pinkse (2004, 2007), McKinsey Quarterly (2007), Okereke (2007) and Wittneben and Kiyar (2009)
		DRCC 6	Customer request or preference	McKinsey Quarterly (2007)
		DRCC 7	Investors pressure	Okereke (2007)
		DRCC 8	Competitive pressure	
		DRCC 9	Anticipating investments in innovative and cleaner technologies to mitigate the impacts of climate change	Dunn (2002), McKinsey Quarterly (2007) Okereke (2007) and Slawinski et al. (2014)
		DRCC 10	Senior executives' commitment	Okereke et al. (2012)
		DRCC 11	Trading in carbon emissions	Dunn (2002), Kolk and Pinkse (2004), McKinsey Quarterly (2007) and Pulver (2007)
		DRCC 12	Initiating procurement, supply chain management changes (by introducing innovative green procurement and green supply chain management)	Kolk and Pinkse (2005, 2007) and Sullivan (2010)
		DRCC 13	Mass media coverage and media advocacy	McKinsey Quarterly (2007)
		DRCC 14	Physical threats to assets (e.g. – disasters)	Lash and Wellington (2007)
		DRCC 15	Developing regulatory strategy aligning with future climate change regulations	Kolk and Pinkse (2004), Hoffman (2006) and McKinsey Quarterly (2007)
		DRCC 16	Societal pressure and pressure from NGOs	Hoffman (2006) and Knox-Hayes and Levy (2011)
		DRCC 17	Social responsibility	Hoffman (2006)

Table 1 Elements of the questionnaire (continued)

Elements	*No. of variables*	*Code*	*Variable*	*Reference*
Climate change mitigation activities in terms of the likelihood of implementing them	12	MACC 1	Measuring and reducing the carbon footprint	McKinsey Quarterly (2007)
		MACC 2	Creating a climate change corporate strategy (looking at future physical impacts of climate change)	
		MACC 3	Introducing new products/services through technological innovations	Kolk and Levy (2001), Dunn (2002), Kolk and Pinkse (2004, 2007), McKinsey Quarterly (2007), Okereke (2007) and Wittneben and Kiyar (2009)
		MACC 4	Making investments in cleaner and innovative technologies to mitigate the impacts of climate change	Dunn (2002), McKinsey Quarterly (2007), Okereke (2007) and Slawinski et al. (2014)
		MACC 5	Instituting green procurement and green supply chain management	Kolk and Pinkse (2005, 2007) and Sullivan (2010)
		MACC 6	Establishing regulatory mitigation strategy aligning with future climate change regulations	Kolk and Pinkse (2004), Hoffman (2005) and McKinsey Quarterly (2007)
		MACC 7	Participation in internal or external emission trading and/or offsetting schemes	Dunn (2002), Kolk and Pinkse (2004), Okereke (2007), Pulver (2007) and Knox-Hayes and Levy (2011)
		MACC 8	Measures for energy efficiency	Dunn (2002), Kolk and Pinkse (2005), Hoffman (2006), McKinsey Quarterly (2007), Wittneben and Kiyar (2009) and Slawinski et al. (2014)
		MACC 9	Renewable energy use	Kolk and Pinkse (2007), Okereke (2007), Pulver (2007), Wittneben and Kiyar (2009), Akashi et al. (2012), Slawinski and Bansal (2012) and Slawinski et al. (2014)
		MACC 10	Afforestation-reforestation programmes	Trabucco et al. (2008)
		MACC 11	Carbon capture and storage	Okereke (2007), Pulver (2007), Kolk and Pinkse (2010) and Akashi et al. (2012),
		MACC 12	Educating the public on climate change	Okereke (2007)

To ensure the content validity of the survey instrument (i.e., questionnaire), a two-step process was adopted. A pilot study was conducted using a draft questionnaire developed and administered to 33 business organisations. The respondents were requested to provide feedback on the questionnaire design, the phrasing of the constructs, and whether each item fell under the accurate construct. Modifications were made to the questionnaire according to the feedback received, and certain constructs were rephrased to obtain precise responses. The modified questionnaire was further sent to seven subject experts to upgrade further. These subject experts included international and national academicians with expertise in the climate change area, an industry body, and an environmental think-tank. The guidance from subject experts helped in framing concise and unambiguous constructs that could elicit an appropriate response from the respondent. It also ensured capturing all variables related to a particular construct. The business organisations and subject experts were also requested to assess the pool of items for each construct for clarity, conciseness, consistency, and simplicity. A total of 33 responses collected for the pilot study from business organisations were not utilised further.

Questionnaires were either personally administered, sent through the mail, or electronically administered. An online version of the questionnaire was designed for easy facilitation and response of business organisations across India. The data collection phase was spread from May 2014 to November 2016. A few industrial associations were contacted to acquire information on business organisations. The respondents were contacted via phone and email for their interest to participate in the survey. Upon their acceptance, the researcher promptly made visits to the organisation if it was located in the vicinity. These visits to the nearby locations were made in November 2014 and April 2015. Many respondents chose to respond online. The researcher personally visited business organisations in a few states (Gujarat, Maharashtra, Goa, Odisha, and Punjab) across India from May 2016 to November 2016. The response rate for a personally administered questionnaire was 100%, while the response rate for the questionnaires forwarded through mail or electronically administered was 18%. The data obtained were checked for inconsistencies and incompleteness, and then entered into a spreadsheet. A total of 257 organisations participated in the study through different modes which were tabulated and subjected to statistical analysis. The responses helped the researcher to obtain a representative sample from diverse manufacturing sectors (Dana and Dana, 2005).

The data collected on different constructs were evaluated by assessing their average; logical reasoning was also employed to ascertain which items could strongly affect the organisations. In order to check if the relationship among climate change risks, drivers for climate change risk management, and mitigation activities for climate change risk management is significant, regression analysis was performed. Following the usual rule in statistics, the threshold limit value for considering a parameter statistically significant was set at 0.05, which allowed stating that a given parameter was statistically significant with a confidence level of 95%.

4 Results and discussion

A sector-wise distribution of organisations from different manufacturing sectors is depicted in Figure 3. The study was comprised of manufacturing organisations from a

wide variety of sectors. The sample was comprised of about 40% organisations from chemical/pharmaceutical and allied sectors, 26.85% from oil and gas and petrochemical sectors, 9.34% from engineering and allied sectors, and 6.61% from automobile and allied sectors.

Figure 3 Sector-wise distribution of organisations (see online version for colours)

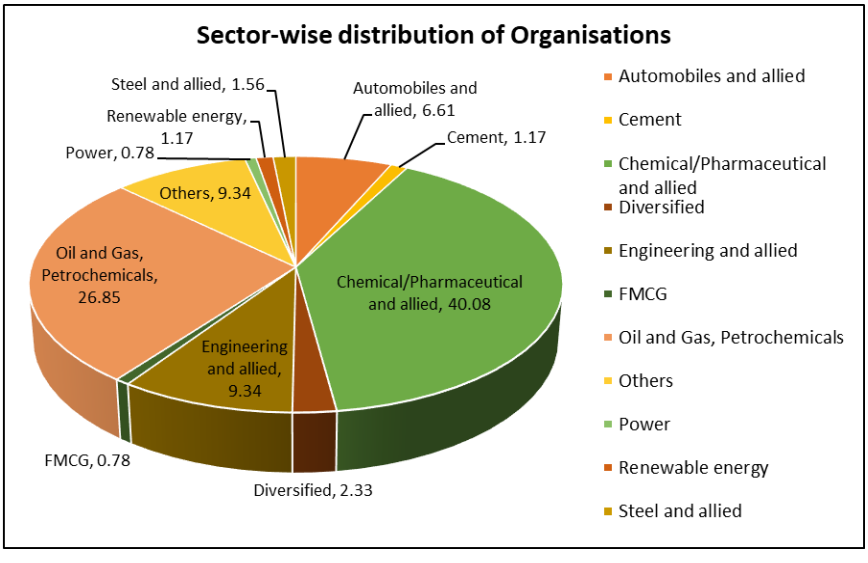
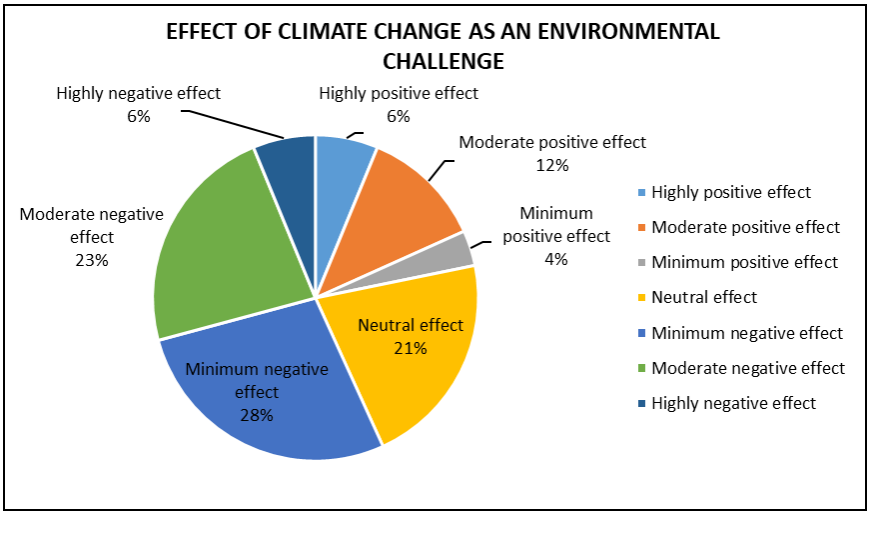


Figure 4 Perception of climate change as an environmental challenge (see online version for colours)



A question was posed to the organisations on how they perceived climate change as the next environmental challenge. Their responses are depicted in Figure 4. 51% of the organisations opined that there was a minimal or moderately negative effect on their functioning due to climatic change. Climate change appeared to have a neutral effect on

21% of the organisations. 12% of the organisations admitted to having a moderately positive effect of climate change. Highly negative and highly positive climate change effects were experienced by 6% of the respondents each. A minimum positive effect was reported by 4% of the organisations.

The effect of climate change on organisations was found to depend on the sector in which they operate. Sectors like oil and gas, automobiles, and electricity are exposed to greater climate change risks (Kolk and Levy, 2001; Levy and Kolk, 2002; van den Hove et al., 2002; Pulver, 2007; Frondel et al., 2011; Nierop, 2014; Kouloumpis et al., 2015; De Stefano et al., 2016). Since only manufacturing organisations are considered in the study, these industries are exposed to at least some climate change risks. This explains why more than half of the respondents discoursed that climate change caused a minimum negative effect. Some sectors like engineering and sectors where production takes place under controlled conditions (food processing or active pharmaceutical ingredient manufacturing) experience very little or no impact of external climate on their overall operations. Hence, these were considered as the climate change neutral organisations. Organisations in the sectors where sun drying plays a role tend to have a positive effect in the case of increased heat.

Bleda and Shackley (2008) reported that many companies had recognised the significance of adapting to the adverse impacts of climate change and make the best use of the opportunity presented by climate change. Though some proactive companies have integrated climate change management in their strategic decision-making, most do not remain restricted to compliances and perform a bit more than merely abiding by the regulations. This is in line with the current findings where more than half of the organisations realised that climate change is actively harming them. Building on 11 case studies in the electricity sector, the study by Busch (2012) addressed the exposure and adaptation to climate change-related disruptions of operational processes, supply chain, and product distribution aspects. The intensification of disruptions caused by global climate change requires organisations to start adapting to them immediately. The impact of climate change is experienced by organisations was found in one way or another. Climate change impacts through weather pattern changes, causing water scarcity, increased energy prices through increased consumption and demand, and depletion of green cover, among other impacts. The impact of climate change at different levels is presented in Table 2.

Table 2 Impacts of climate change on organisations

Impact of climate change	*Mean (on a scale of 7)*
Changes in weather pattern	4.14
Water scarcity	4.65
Increased energy prices	4.70
Green cover depletion	3.40
Scarcity of natural resources	4.53

From the responding organisations, the highest impact of climate change was observed for increased energy prices. The organisations are taking steps to move towards cleaner fuels like liquefied natural gas (LNG), which increased the cost of their operations. Energy is mandatory for the operations, and sourcing clean fuel is becoming a requirement from governmental bodies. NewsRx (2012) states that higher water

temperatures and reduced river flow in Europe and the USA in recent years have resulted in reduced production or even temporary shutdown of several thermoelectric power plants, resulting in increased electricity prices and rising concerns about future energy security in a changing climate. King and Gulledge (2014) report that climate change may have a secondary effect, which could aggravate the instability of society and interrupt energy systems, apart from influencing energy supply and/or systems directly or affecting energy security through the outcome of climate-related policies. Ridoutt et al. (2016) highlight that climate change has the potential to impact energy prices as businesses in the energy sector respond to government policies and seek to constrain high emission sources of energy and to commercialise new energy technologies. Thus, NewsRx (2012), King and Gulledge (2014), and Ridoutt et al. (2016) stress the increase in energy prices as an impact of climate change, bolstering our finding. They also brought up concerns about future energy security.

Closely following the increased energy prices, another impact of climate change experienced by organisations is water scarcity. Water crises have been consistently featured among the top-ranked global risks for the past seven editions of The Global Risks Report (WEF, 2017). Water scarcity is a concern in many parts of the world and has the potential to intensify under climate change. Water scarcity represents a physical risk to irrigation-dependent agricultural production systems as well as the operation of food processing facilities. Water scarcity has the potential to completely disrupt value chains under extreme circumstances (Ridoutt et al., 2016). It has been highlighted by Egan (2009) for Australia, and by King and Gulledge (2014) and Bhat (2015) for more than 100 countries. Egan (2009) reports that water scarcity has become a critical community concern in Australia in recent years after years of protracted drought, so water management is a particularly important sustainability management practice for this nation. There would be a reduction in the capacity of hydroelectricity generation in a few nations that are exploring low-carbon and other sources of energy (King and Gulledge, 2014). Bhat (2015) studied more than 55,000 firms in more than 100 countries. The author concluded that although water is required by most of the firms (belonging to any size and sector), one in four firms experiences insufficient water supply.

Ridoutt et al. (2016) state that water scarcity might heighten societal concern and increase reputational and/or market access risks/opportunities. Water scarcity also has the potential for increased water pricing, which is a financial risk, especially to operations using large volumes of water. Water is important for all processes, and the shortage of rainfall in recent years in India must have led the organisations to give prominence to this impact of climate change. Organisations from the distilleries sector shared that drought-like conditions in their areas led to limited water supply, ultimately causing them to shut down their operations for two days a week, leading to financial losses. Hence, from the studies cited and the current findings, it can be presumed that water scarcity is a global problem affecting most nations, including India.

Climate change leading to the depletion of green cover has been rated as the lowest impact of climate change. This could be because a majority of the sampled organisations were not directly dependent on forests for their raw materials (with the exception of the pulp and paper industry) and would not be affecting the green cover directly; moreover, the organisations were unlikely to be operating in biodiversity-rich areas.

The climate change risks posed to business organisations have been adequately discussed in Section 2. The risks specifically affecting Indian organisations are examined in this study and are presented in Table 3.

Table 3 Climate change risks affecting business organisations

Climate change risk	*Mean (on a scale of 7)*
Regulatory	3.80
Competitive	4.37
Operational	4.20
Reputational	4.17
Physical	4.00

As per this survey, Indian organisations were found to consider competitive risk due to climate change as significant. With an increase in climate change awareness, organisations are modifying themselves to be sustainable. Kolk et al. (2008) state that organisations are forgoing their core competencies and venturing into new areas of development. To establish a firm foothold in the changing market, organisations have to invest in modifying their technologies, introducing new products, and enhancing their skill-sets to win the trust of their stakeholders. As Indian organisations are going global, they have to compete with the elite, world-standard business organisations and establish themselves as credible competitors. Comparatively, the regulatory pressure on Indian business organisations to reduce their carbon footprint is less, which could be the reason why organisations rated regulatory risk as low. In India, only the coal industries and the energy-intensive organisations from eight sectors (thermal power, iron and steel, cement, aluminium, fertiliser, paper and pulp, textile, and chlor-alkali) are subject to regulatory pressure through Clean Environment Cess and a Perform-Achieve-Trade (PAT) scheme, respectively.

India, as a developing nation, is more likely to act on climate change when the government issues new climate change norms restricting carbon emissions through various mechanisms. In the study by Abreu et al. (2017), physical risk had the highest mean, followed by regulatory risk and technological risk. Physical risk was recognised by more than half (52.6%) of the sampled firms in the study by Elijido-Ten (2017). Since physical risk received the highest mean in the studies by Abreu et al. (2017) and Elijido-Ten (2017), it is in contrast with the present study. Since here the mean was lower, it can be interpreted that the respondents were theoretically aware of the physical risks associated with climate change. However, not having experienced these risks, they were unsure of the exact impact.

The literature has listed numerous drivers that would propel organisations to act on climate change, some of which are listed in Table 4.

Among these, the respondents discoursed that the 'commitment of senior executives' was a prime driver to ensure positive action on climate change. Climate change challenges posed to an organisation are known fairly well at all hierarchical levels, but the initial action has to commence from the senior executive level. The commitment of these executives acts as a major driving force for all stakeholders. The top management would be entirely responsible for any shortcoming resulting in financial losses, tarnished reputation, etc. Hence, their commitment to upcoming challenges like climate change is of the utmost importance. Kolk and Pinkse (2005) and Hoffman (2005) note that a growing threat of regulation and the desire to promote climate-related market changes for competitive advantage were two of the most important issues driving business response to climate change. Unnikrishnan and Hegde (2006) also highlight the commitment of top

management as a major driver in their study on the adoption of cleaner technologies. Kumarasiri and Gunasekarage (2017) report that decision makers are threat-biased and are more likely to take immediate actions when climate change issues are viewed as threats as opposed to new prospects. The financial pressure exerted by regulations and the reputational pressure among extended stakeholders were visible as the main factors that forced companies to take actions on climate change issues. The studies by Hoffman (2005), Kolk and Pinkse (2005), Unnikrishnan and Hegde (2006), and Kumarasiri and Gunasekarage (2017) stress the importance of senior executives' commitment, which is an important finding of this study as well. Other driving factors – *viz.* corporate climate change strategy (which includes corporate emission reduction targets and regulatory compliance) and cost savings, whose mean is fairly close to that of the 'commitment of senior executives' – can be verified with the findings of Jeswani et al. (2008).

Table 4 Drivers for climate change risk management

Driver	*Mean (on a scale of 7)*
Corporate reputation, brands	5.04
Reduction of carbon footprint	4.59
Developing an overall corporate climate change strategy	4.84
Profit and cost savings	4.90
Planning development and/or marketing of new products/services	5.12
Customer request or preference	5.13
Investors pressure	3.34
Competitive pressure	4.31
Anticipating investments in cleaner and innovative technologies	5.20
Senior executives' commitment	5.56
Trading in carbon emissions	3.80
Initiating green procurement and green supply chain management	4.80
Mass media coverage and media advocacy	4.26
Physical threats to assets	3.78
Developing regulatory strategy aligning with future climate change regulations	4.80
Societal pressure and pressure from NGOs	2.93
Social responsibility	5.49

Societal pressure and pressure from NGOs are the drivers' those are the least affecting norms that affect organisations. Though climate change presents several risks at different platforms, organisations, society, and NGOs are yet to fully realise them. The energy-intensive organisations are already under regulatory pressure, and thus feel the pressure from society and NGOs to a lesser extent. Singh et al. (2016) state that sustainability-conscious movements or campaigns on critical environmental issues or challenges must be addressed by NGOs and other social institutions to create green responsiveness.

To translate the climate change drivers into accomplishments, organisations have to undertake several actions to mitigate the effects of climate change, as depicted in Table 5.

Table 5 Mitigation activities for climate change risk management

Mitigation activities	*Mean (on a scale of 7)*
Measuring and reducing the carbon footprint	4.78
Creating a climate change corporate strategy	4.95
Introducing new products/services	5.12
Making investments in cleaner and innovative technologies	5.33
Instituting green procurement and green supply chain management	4.90
Establishing regulatory mitigation strategy aligning with future climate change regulations	4.92
Participation in emission trading and/or offsetting schemes	3.85
Measures for energy efficiency	5.70
Renewable energy use	5.18
Afforestation-reforestation programmes	5.26
Carbon capture and storage	2.77
Educating the public on climate change	4.96

The simplest and least intensive action that an organisation could undertake for mitigating the effects of climate change is energy efficiency. The efficient use of energy and supplies that are reliable, affordable, and less-polluting are widely acknowledged as important, and even indispensable components of sustainable development (Panwar et al., 2013). In line with the current study, Renukappa et al. (2013) and Sugiyama et al. (2014) report that the most often implemented strategies to reduce CO_2 include energy-saving initiatives, fuel switching, and eco-friendly transportation initiatives. In a study conducted by Renukappa et al. (2013), 64% of interviewees noted that their organisations had implemented energy-saving initiatives as a part of their broader climate change strategy. Rehman and Shrivastava (2013) classify the conservation of energy as a sustainable strategy, which helps in green manufacturing. Morrow et al. (2014) analysed 22 and 25 energy efficiency measures applicable to India's cement and iron and steel industries, respectively. For the cement industry from 2010 to 2030, the authors predicted 82 Mt CO_2 emission reductions from electricity savings and 97 Mt CO_2 emission reductions from fuel savings. For the steel industry from 2010 to 2030, the authors predicted 65 Mt CO_2 emission reductions from electricity savings and 67 Mt CO_2 emission reductions from fuel savings. Dasgupta and Roy (2015) report that the historical trend of technological progress in India is expected to help industries not only reduce their energy cost shares but also achieve enhanced energy efficiency. The widespread adoption of energy efficiency by organisations is evident from the studies of Cadez and Czerny (2016) and Fernando and Hor (2017). From the studies of Renukappa et al. (2013), Morrow et al. (2014), Dasgupta and Roy (2015), Cadez and Czerny (2016), and Fernando and Hor (2017), it can be inferred that energy efficiency is the simplest measure implemented to mitigate carbon emissions. Certain measures for energy efficiency are undertaken by almost all organisations in the sample, thereby rating it as the top mitigation activity. Many industries are in the process of undertaking an energy audit as well.

The mitigation activity that had the least likelihood of implementation in the sampled organisations was carbon capture and storage. This technology is relatively new as well

as expensive. Moreover, few organisations were aware of it. Further research must be directed at making this technology available and affordable.

Figure 5 View of climate change impact in the organisation (see online version for colours)

The respondents were queried on how the impact of climate change was viewed in their organisations. Their responses are presented in Figure 5. The respondents gave a mixed view of the impact of climate change in their organisations. It was found that 28.79% of them believed that climate change presents mostly risks but limited opportunities to their organisations. Additionally, 25.68% of the respondents believed that an equal balance of risk and opportunities. 16.73% believed that climate change presents mostly opportunities, along with limited risks in the organisations. Moreover, 11.28% of respondents considered climate change only as a risk, while 0.39% of respondents considered climate change only as an opportunity. Finally, 17.2% of organisations either believed that climate change had no impact or they were unsure how climate change was to be viewed within their organisation. Although climate change presents both risks and opportunities, the view that an individual or organisation holds about the phenomenon depends on several factors, such as climate change risks posed to the organisation, senior executives' commitment, actions undertaken in the past years, employee involvement and market pressure.

Table 6 Descriptive statistics

Variables	*Minimum*	*Maximum*	*Mean*	*Standard deviation*
Climate change risks	5	35	20.48	7.56
Drivers for climate change risk management	17	119	77.78	20.03
Mitigation activities for climate change risk management	12	84	57.64	14.63

Further, regression analysis was performed to investigate if there exists a significant relationship amongst climate change risks, drivers for climate change risk management, and mitigation activities for climate change risk management. Climate change risks and drivers for climate change risk management are considered as independent variables, and

mitigation activities for climate change risk management is considered as a dependent variable. The descriptive statistics of the variables are presented in Table 6. The result of regression analysis is presented in Table 7.

For climate change risks, the minimum value obtained is 5, while the maximum value is 35. The mean is 20.48, and the standard deviation value obtained is 7.56. It can be concluded that most of the responses are clustered around the mean. The minimum and maximum values obtained for drivers for climate change risk management are 17 and 119, respectively. The mean value is 77.78, and the standard deviation is 20.03. The responses for drivers for climate change risk management are clustered slightly greater than the mean value. For mitigation activities for climate change risk management, the minimum value obtained is 12, and the maximum value obtained is 84. The values for mean and standard deviation are 57.64 and 14.63, respectively. The responses are clustered slightly above the mean value for mitigation activities for climate change risk management.

Table 7 Regression analysis

	R^2	*Std. error of the estimate*	*F*	*Sig.*	*Unstandardised coefficients*		*Standardised coefficients*	*t*	*Sig.*
					B	*Std. error*	β		
	.737	7.544	356.295	.000[a]					
Constant					10.378	1.937		5.358	.000
DRCC					.661	.027	.905	24.535	.000
CCR					–.202	.071	–.104	–2.824	.005

Notes: [a]Predictors: (constant), CCR, DRCC.
Dependent variable: CCMA.

The 'R square' column in Table 7 represents the R^2 value (also called the coefficient of determination), which is the proportion of variance in the dependent variable that can be explained by the independent variables. The value of R^2 is found at 0.737.

It can be inferred based on the significance of the F-value, as presented in Table 7, that the independent variables (climate change risks, drivers for climate change risk management) are statistically significant ($p < 0.05$) in predicting the dependent variable (mitigation activities for climate change risk management), and the overall regression model is a good fit of the data.

The B values signify the relationship between the dependent variable and each of the independent variables. As the drivers for climate change risk management increase, the mitigation activities also increase. On the other hand, the B values signify an inverse relationship between climate change risks and mitigation activities for climate change risk management.

This study found DRCC, $t(257) = 24.535$, $p<0.05$, and CCR, $t(257) = –2.824$, $p < 0.05$, are significant predictors of CCMA. It can be concluded from the t value that drivers for climate change risk management have more impact than climate change risks on mitigation activities for climate change risk management.

Multicollinearity was assessed using tolerance and variation inflation factor (VIF) as indicators. Since the VIF is 1.314, which is significantly below the threshold level of 10 as suggested by Hair et al. (2010), and the tolerance level is 0.761which is greater than

0.1; thus it can be concluded that there is no overlapping of variance among the proposed factors and no redundancy.

Thus, based on the study findings, a significant relationship exists between climate change risks and drivers, and climate change risks and mitigation actions for climate risk management. It is crucial that business organisations start adopting measures even when smaller effects of climate change are experienced and constantly monitor the impacts of climate change affecting the organisation.

Okereke (2007) explored the climate response activities of FTSE 100 companies in terms of motivations, drivers, and barriers to carbon management. The drivers stated in the study of Okereke (2007) are included in the present study as well. Thus, the significant relationship between the independent variable (drivers for climate change risk management) and dependent variable (mitigation activities for climate change risk management) is strengthened.

Weinhofer and Busch (2013) found clear evidence for different measures seeking to identify and assess climate change risks, thus establishing a relationship between mitigation activities for climate change risk management and climate change risks. The results of the study further illustrate that responding to climate change risks, firms should undertake measures to be achieved at least one of the objectives of risk response e.g., risk identification, risk assessment, and risk response.

This study strongly highlights the climate change risks, drivers, and mitigation actions affecting Indian business organisations and can be potentially replicated in another country to understand the climate change-related factors those are significant for the business organisations. Since this study focuses on the manufacturing sector and mitigation actions alone, thus future studies can be carried out to understand the climate change adaptation responses, and within all sectors in the economy. Additionally, the outcome of the study is purely on the perception view. Further studies would work on innovations by developing new technologies and low-carbon products from which firms can gain a competitive advantage on low carbon development, and mitigation costs incurred by the firms to determine the expenditure on climate-proofing operations.

5 Conclusions

An impairing effect of climate change is experienced strongly by Indian business organisations. It is necessary that organisations realise the effect of climate change promptly, and start adapting to it. The business organisations should analyse the climate change impact affecting them directly and indirectly, and initiate actions accordingly. To understand better the impacts of climate change in the Indian organisations, this study focuses on four steps (monitoring, analysis, evaluation, and implementation) along with top management commitment as a key driver to guide organisations to address the climate change challenge. It is found from the findings that apart from the commitment of the top management, organisations are required to undertake a few actions (e.g., energy efficiency) that are not the only pro-environment but also provide economic incentives. Besides, organisations can view opportunities in mitigating climate change. Government organisations should also issue strict regulations that tackle carbon emissions efficiently. There do exist schemes to mitigate climate change, such as the Renewable Energy Certificate mechanism, PAT scheme, and Clean Environment Cess. These schemes provide a win-win situation for the government and industries, and there is plenty of

scope for business organisations to evaluate, analyse, and act on the climate change challenge. Finally, semi-governmental or quasi-governmental bodies should create awareness programmes for business organisations to describe how to develop sustainability.

References

Abreu, M.C.S., Freitas, A.R.P. and Rebouças, S.M.D.P. (2017) 'Conceptual model for corporate climate change strategy development: Empirical evidence from the energy sector', *Journal of Cleaner Production*, Vol. 165, pp.382–392.

Akashi, O., Hijioka, Y., Masui, T., Hanaoka, T. and Kainuma, M. (2012) 'GHG emission scenarios in Asia and the world: The key technologies for significant reduction', *Energy Economics*, Vol. 34, No. 3, pp.S346–S358.

Akhmat, G., Zaman, K., Shukui, T. and Sajjad, F. (2014) 'Does energy consumption contribute to climate change? Evidence from major regions of the world', *Renewable and Sustainable Energy Reviews*, Vol. 36, pp.123–134.

Baumert, K., Herzog, T. and Pershing, J. (2005) *Navigating the Numbers: Greenhouse Gas Data and International Climate Policy* [online] http://pdf.wri.org/navigating_numbers.pdf (accessed 20 September 2016).

Bhat, V.N. (2015) 'Water and its effect on business productivity: a cross-country analysis', *Water Resources Management*, Vol. 29, No. 11, pp.4007–4020.

Bleda, M. and Shackley, S. (2008) 'The dynamics of belief in climate change and its risks in business organisations', *Ecological Economics*, Vol. 66, Nos. 2–3, pp.517–532.

Blyth, W., Bradley, R., Bunn, D., Clarke, C., Wilson, T. and Yang, M. (2007) 'Investment risks under uncertain climate change policy', *Energy Policy*, Vol. 35, No. 11, pp.5766–5773.

Bocken, N.M.P., Short, S.W., Rana, P. and Evans, S. (2014) 'A literature and practice review to develop sustainable business model archetypes', *Journal of Cleaner Production*, Vol. 65, No. 15, pp.42–56.

Busch, T. (2012) 'Organizational adaptation to disruptions in the natural environment: the case of climate change', *Scandinavian Journal of Management*, Vol. 27, No. 4, pp.389–404.

Cadez, S. and Czerny, A. (2016) 'Climate change mitigation strategies in carbon-intensive firms', *Journal of Cleaner Production*, Vol. 112, Part 5, pp.4132–4143.

Coalition for Environmentally Responsible Economies (CERES) (2010) *Climate Change Risk Perception and Management: A Survey of Risk Managers* [online] http://www.ceres.org/resources/reports/risk-manager-survey/view (accessed 4 October 2013).

Coccia, M. (2014) 'Driving forces of technological change: the relation between population growth and technological innovation: analysis of the optimal interaction across countries', *Technological Forecasting and Social Change*, Vol. 82, pp.52–65.

Dana, L-P. and Dana, T.E. (2005) 'Expanding the scope of methodologies used in entrepreneurship research', *International Journal of Entrepreneurship and Small Business*, Vol. 2, No. 1, pp.79–88.

Das, T. (2012) 'Climate change and the private sector', in Dubash, N.K. (Ed.): *Handbook of Climate Change in India: Development, Politics and Governance*, pp.246–253, Oxford University Press, New Delhi.

Dasgupta, S. and Roy, H. (2015) 'Understanding technological progress and input price as drivers of energy demand in manufacturing industries in India', *Energy Policy*, Vol. 83, pp.1–13.

De Stefano, M.C., Montes-Sancho, M.J. and Busch, T. (2016) 'A natural resource-based view of climate change: innovation challenges in the automobile industry', *Journal of Cleaner Production*, Vol. 139, pp.1436–1448.

Demertzidis, N., Tsalis, T.A., Loupa, G. and Nikolaou, I.E. (2015) 'A benchmarking framework to evaluate business climate change risks: a practical tool suitable for investors decision-making process', *Climate Risk Management*, Vol. 10, pp.95–105.

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, GRI Focal Point India and Arbitrage Research Institute (2012) *Sustainability Reporting Practices and Trends in India*, [online] http://www.giz.de/en/downloads/giz-2012-sustainable-reporting-india-en.pdf (accessed 18 August 2015).

Dombrowski, U. and Ernst, S. (2014) 'Effects of climate change on factory life cycle', *Procedia CIRP*, Vol. 15, pp.337–342.

Du Pisani, J.A. (2006) 'Sustainable development-historical roots of the concept', *Environmental Sciences*, Vol. 3 No. 2, pp.83–96.

Dunn, S. (2002) 'Down to business on climate change: an overview of corporate strategies', *Greener Management International*, Autumn, Vol. 39, pp.27–41.

Egan, M. (2009) 'Sydney water sector change and industrial water management', *Journal of Accounting & Organizational Change*, Vol. 5, No.2, pp.277–293.

Elijido-Ten, E.O. (2017) 'Does recognition of climate change related risks and opportunities determine sustainability performance?', *Journal of Cleaner Production*, Vol. 141, pp.956–966.

Esty, D.C. (2007) 'What stakeholders demand', *Harvard Business Review*, October, pp.30–34.

Ethical Investment Research Service (EIRIS) (2009) 'The role of consumers and corporations in tackling climate change', *OECD Conference on Corporate Responsibility* [online] https://www.oecd.org/daf/inv/corporateresponsibility/43357880.pdf (accessed 8 September 2019).

Evans, A. (2010) *Resource Scarcity, Climate Change and the Risk of Violent Conflict. Background Paper*, World Development Report 2011 [online] ipccwg2.gov/njlite_download2.php?id=10351 (accessed 21 July 2014).

Fernando, Y. and Hor, W. L. (2017) 'Impacts of energy management practices on energy efficiency and carbon emissions reduction: A survey of Malaysian manufacturing firms', *Resources, Conservation and Recycling*, Vol. 126, pp.62–73.

Finstad, K. (2010) 'Response interpolation and scale sensitivity: evidence against 5-point scales', *Journal of Usability Studies*, Vol. 5, No. 3, pp.104–110.

Frondel, M., Schmidt, C.M. and Vance, C. (2011) 'A regression on climate policy: the European Commission's legislation to reduce CO_2 emissions from automobiles', *Transportation Research Part A: Policy and Practice*, Vol. 45, No. 10, pp.1043–1051.

Goodland, R. (1995) 'The concept of environmental sustainability', *Annual Review of Ecology and Systematics*, Vol. 26, pp.1–24.

Gosling, S.N., Arnell, N.W. and Lowe, J.A. (2011) 'The implications of climate policy for avoided impacts on water scarcity', *Procedia Environmental Sciences*, Vol. 64, pp.112–121.

Hair, J., Black, W., Babin, B. and Anderson, R. (2010) *Multivariate Data Analysis*, 6th ed., Prentice Hall, Upper Saddle River, New Jersey.

Hart, S.L. (1997) 'Beyond greening: strategies for a sustainable world', *Harvard Business Review*, January-February, pp.66–76.

Hendrichs, H. and Busch, T. (2012) 'Carbon management as a strategic challenge for SMEs', *Greenhouse Gas Measurement and Management*, Vol. 2, No. 1, pp.61–72.

Hoffman, A. (2006) *Getting Ahead of the Curve: Corporate Strategies that Address Climate Change*, [online] http://www.c2es.org/docUploads/PEW_CorpStrategies.pdf (accessed 19 July 2014).

Hoffman, A.J. (2005) 'Climate change strategy: the business logic behind voluntary greenhouse gas reductions', *California Management Review*, Vol. 47 No. 3, pp.21–46.

Hou, G., Wang, Y. and Xin, B. (2019) 'A coordinated strategy for sustainable supply chain management with product sustainability, environmental effect and social reputation', *Journal of Cleaner Production*, Vol. 228, pp.1143–1156.

Intergovernmental Panel on Climate Change (IPCC) (2014) *Climate Change 2014: Synthesis Report*, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K. and Meyer, L.A. (eds.)], IPCC, Geneva, Switzerland, 151pp [online] https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_AR5_FINAL_full_wcover.pdf (accessed 8 September 2019).

Jeswani, H.K., Wehrmeyer, W. and Mulugetta, Y. (2008) 'How warm is the corporate response to climate change? Evidence from Pakistan and the UK', *Business Strategy and the Environment*, Vol. 17, No. 1, pp.46–60.

Joint Global Change Research Institute (JGCRI), Battelle Memorial Institute (BMI) and Pacific Northwest Division (2009*) India: The Impact of Climate Change to 2030*, A Commissioned Research Report. National Intelligence Council [online] https://www.dni.gov/files/documents/climate2030_india.pdf (accessed 27 February 2018).

Jones, C.A. and Levy, D.L. (2007) 'North American Business strategies towards climate change', *European Management Journal*, Vol. 25, No. 6, pp.428–440.

King, M.D. and Gulledge, J. (2014) 'Climate change and energy security: an analysis of policy research', *Climatic Change*, Vol. 123, No. 1, pp.57–68.

Knox-Hayes, J. and Levy, D.L. (2011) 'The politics of carbon governance as climate governance', *Strategic Organization*, Vol. 9, No. 1, pp.91–99.

Kolk, A. and Levy, D. (2001) 'Winds of change: corporate strategy, climate change and oil multinationals', *European Management Journal*, Vol. 19, No. 5, pp.501–509.

Kolk, A. and Pinkse, J. (2004) 'Market strategies for climate change', *European Management Journal*, Vol. 22, No. 3, pp.304–314.

Kolk, A. and Pinkse, J. (2005) 'Business response to climate change: identifying emergent strategies', *California Management Review*, Vol. 47, No. 3, pp.6–20.

Kolk, A. and Pinkse, J. (2007) 'Multinationals' political activities on climate change', *Business & Society*, Vol. 46, No. 2, pp.201–228.

Kolk, A. and Pinkse, J. (2010) 'Business and climate change: key strategic and policy challenges', *Amsterdam Law Forum*, Vol. 2, No. 2, pp.41–50.

Kolk, A., Levy, D. and Pinkse, J. (2008) 'Corporate responses in an emerging climate regime: the institutionalization and commensuration of carbon disclosure', *European Accounting Review*, Vol. 17, No. 4, pp.719–745.

Kouloumpis, V., Stamford, L. and Azapagic, A. (2015) 'Decarbonising electricity supply: is climate change mitigation going to be carried out at the expense of other environmental impacts?'. *Sustainable Production and Consumption*, Vol. 1, pp.1–21.

Kumarasiri, J. and Gunasekarage, A. (2017) 'Risk regulation, community pressure and the use of management accounting in managing climate change risk: Australian evidence', *The British Accounting Review*, Vol. 49, No. 1, pp.25–38.

Lash, J. and Wellington, F. (2007) 'Competitive advantage on a warming planet', *Harvard Business Review*, March, pp.95–102.

Lee, S-Y. (2012) 'Corporate carbon strategies in responding to climate change', *Business Strategy and the Environment*, Vol. 21, No. 1, pp.33–48.

Levy, D.L. and Kolk, A. (2002) 'Strategic responses to global climate change: conflicting pressures on multinationals in the oil industry', *Business and Politics*, Vol. 4, No. 3, pp.275–300.

Liu, Y. (2012) 'An empirical research of awareness, behavior and barriers to enact carbon management of industrial firms in China', *Science of Total Environment*, Vol. 425, pp.1–8.

McKinsey Quarterly (2007) *How Companies Think about Climate Change: A McKinsey Global Survey* [online] http://www.nyu.edu/intercep/lapietra/ClimateChangeAttitudes.pdf (accessed 17 April 2014).

Morrow III, W.R., Hasanbeigi, A., Sathaye, J. and Xu, T. (2014) 'Assessment of energy efficiency improvement and CO2 emission reduction potentials in India's cement and iron & steel industries', *Journal of Cleaner Production*, Vol. 65, pp.131–141.

Natural Resources Defense Council (NRDC) (2010) *Climate Change, Water, and Risk: Current Water Demands Are Not Sustainable* [online] http://www.nrdc.org/globalwarming/watersustainability/files/WaterRisk.pdf (accessed 19 August 2014).

NewsRx (2012) *Climate Change; US and European Energy Supplies Vulnerable to Climate Change – Nature Climate Change*, Global Warming Focus [online] http://search.proquest.com/business/docview/1020081609/47364BD96BF5401EPQ/15?accountid=49672 (accessed on 29 November 2016).

Nierop, S.C.A. (2014) 'Envisioning resilient electrical infrastructure: a policy framework for incorporating future climate change into electricity sector planning', *Environmental Science & Policy*, Vol. 40, pp.78–84.

Nikolaou, I., Evangelinos, K. and Filho, W.L. (2015) 'A system dynamic approach for exploring the effects of climate change risks on firms' economic performance', *Journal of Cleaner Production*, Vol. 103, pp.499–506.

Okereke, C. (2007) 'An exploration of motivations, drivers and barriers to carbon management: The UK FTSE 100', *European Management Journal*, Vol. 25, No. 6, pp.475–486.

Okereke, C., Wittneben, B. and Bowen, F. (2012) 'Climate change: challenging business, transforming politics', *Business & Society*, Vol. 51, No. 1, pp.7–30.

Owusu, P.A. and Asumadu-Sarkodie, S. (2016) 'A review of renewable energy sources, sustainability issues and climate change mitigation', *Cogent Engineering*, Vol. 3, No. 1, pp.1–14.

Panwar, N.L., Reddy, V.S. and Ranjan, K.R. (2013) 'Sustainable development with renewable energy resources: a review', *World Review of Science, Technology and Sustainable Development*, Vol. 10, No. 4, pp.163–184.

Park, K. and Kremer, G.E.O. (2017) 'Text mining-based categorization and user perspective analysis of environmental sustainability indicators for manufacturing and service systems', *Ecological Indicators*, Vol. 72, pp.803–820.

Pattberg, P. (2012) 'How climate change became a business risk: analyzing nonstate agency in global climate politics', *Environment and Planning C: Politics and Space*, Vol. 30, No. 4, pp.613–626.

Pinkse, J. and Kolk, A. (2010) 'Challenges and trade-offs in corporate innovation for climate change', *Business Strategy and the Environment*, Vol. 19, No. 4, pp.261–272.

Pinkse, J. and Kolk, A. (2012) 'Addressing the climate change – sustainable development nexus: the role of multistakeholder partnerships', *Business & Society*, Vol. 51, No. 1, pp.176–210.

Potdar, A., Unnikrishnan, S. and Singh, A. (2019) 'A framework for climate change management in organisations: a case for India', *World Review of Entrepreneurship, Management and Sustainable Development*, Vol. 15, No. 3, pp.303–334.

Prasad, M.S.V. and Sri, B.S. (2008) 'Corporate response to climate change: what do stakeholders expect?', *Australasian Accounting, Business and Finance Journal*, Vol. 2, No. 3, pp.63–75.

Pulver, S. (2007) 'Making sense of corporate environmentalism: an environmental contestation approach to analyzing the causes and consequences of the climate change policy split in the oil industry', *Organization & Environment*, Vol. 20, No. 1, pp.44–83.

Pulver, S. (2012) 'Corporate responses to climate change in India', in Dubash, N.K. (Ed.): *Handbook of Climate Change and India: Development, Politics and Governance*, pp.254–265, Oxford University Press, New Delhi.

Purdy, M., Davarzani, L. and Peppes, A. (2011) 'New waves of growth in the developed world', *Thunderbird International Business Review*, Vol. 53, No. 2, pp.173–188.

Ray, S. (2013) 'A model of business response to climate change – an Indian perspective', *Vilakshan XIMB Journal*, Vol. 10, No. 2, pp.113–124.

Rehman, M.A.A. and Shrivastava, R.L. (2013) 'Green manufacturing (GM): past, present and future (a state of art review)', *World Review of Science, Technology and Sustainable Development*, Vol. 10, Nos. 1/2/3, pp.17–55.

Renukappa, S., Akintoye, A., Egbu, C. and Goulding, J. (2013) 'Carbon emission reduction strategies in the UK industrial sectors: an empirical study', *International Journal of Climate Change Strategies and Management*, Vol. 5, No. 3, pp.304–323.

Ridoutt, B., Sanguansri, P., Bonney, L., Crimp, S., Lewis, G. and Lim-Camacho, L. (2016) 'Climate change adaptation strategy in the food industry - insights from product carbon and water footprints', *Climate*, Vol. 4, No. 2, p.26.

Schinko, T., Mechler, R. and Hochrainer-Stigler, S. (2017) 'A methodological framework to operationalize climate risk management: managing sovereign climate-related extreme event risk in Austria', *Mitigation and Adaptation Strategies for Global Change*, Vol. 22, No. 7, pp.1063–1086.

Sekaran, U. (2003) *Research Methods for Business. A Skill-Building Approach*, 4th ed., John Wiley & Sons, USA.

Shulman, I. (2012) *Analysis of California, Washington, and New York Insurer Climate Risk Surveys for the 2011 Reporting Year*, Columbia Law School, Center for Climate Change Law, [online] http://web.law.columbia.edu/sites/default/files/microsites/climatechange/files/Publications/Students/Climate%20Risk%20Surveys%20Final%20Aug%202012.pdf (accessed 30 September 2016).

Shwom, R. and Lorenzen, J.A. (2012) 'Changing household consumption to address climate change: social scientific insights and challenges', *Wiley Interdisciplinary Reviews Climate Change*, Vol. 3, No. 5, pp.379–395.

Singh, M.P., Chakraborty, A. and Roy, M. (2016) 'The link among innovation drivers, green innovation and business performance: empirical evidence from a developing economy', *World Review of Science, Technology and Sustainable Development*, Vol. 12, No. 4, pp.316–334.

Slawinski, N. and Bansal, P. (2012) 'A matter of time: the temporal perspectives of organizational responses to climate change', *Organization Studies*, Vol. 33, No. 11, pp.1537–1563.

Slawinski, N., Pinkse, J., Busch, T. and Banerjee, S.B. (2014) *The Role of Short-Termism and Uncertainty in Organizational Inaction on Climate Change: A Multilevel Framework* [online] http://hal.grenoble-em.com/hal-00961226/document (accessed 20 March 2014).

Soni, M. and Bhanawat, S.S. (2015) 'Strategies adopted by indian corporate sectors to mitigate the carbon risk: an analysis', *The IUP Journal of Accounting Research & Audit Practices*, Vol. 14, No. 2, pp.43–52.

Sprengel, D.C. and Busch, T. (2011) 'Stakeholder engagement and environmental strategy – the case of climate change', *Business Strategy and the Environment*, Vol. 20, No. 6, pp.351–364.

Statista (2018) *Largest Producers of CO_2 Emissions Worldwide in 2016, Based on their Share of Global CO_2 Emissions* [online] https://www.statista.com/statistics/271748/the-largest-emitters-of-co2-in-the-world/ (accessed 3 March 2018).

Su, H-N. and Moaniba, I.M. (2017) 'Does innovation respond to climate change? Empirical evidence from patents and greenhouse gas emissions', *Technological Forecasting and Social Change*, Vol. 122, pp.49–62.

Sugiyama, M., Akashi, O., Wada, K., Kanudia, A., Li, J. and Weyant, J. (2014) 'Energy efficiency potentials for global climate change mitigation', *Climatic Change*, Vol. 123, Nos. 3–4, pp.397–411.

Sullivan, R. (2010) 'An assessment of the climate change policies and performance of large European companies', *Climate Policy*, Vol. 10, No. 1, pp.38–50.

Thompson, P. and Cowton, C.J. (2004) 'Bringing the environment into bank lending: implications for environmental reporting', *The British Accounting Review*, Vol. 36, No. 2, pp.197–218.

Thuku, G.K., Paul, G. and Almadi, O. (2013) 'The impact of population change on economic growth in Kenya', *International Journal of Economics and Management Sciences*, Vol. 2, No. 6, pp.43–60.

Trabucco, A., Zomer, R.J., Bossio, D.A., van Straaten, O. and Verchot, L.V. (2008) 'Climate change mitigation through afforestation/reforestation: a global analysis of hydrologic impacts with four case studies', *Agriculture, Ecosystems & Environment*, Vol. 126, Nos. 1–2, pp.81–97.

United Nations (1992) *United Nations Framework Convention on Climate Change* [online] http://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf (accessed 20 September 2016).

Unnikrishnan, S. and Hegde, D.S. (2006) 'An analysis of cleaner production and its impact on health hazards in the workplace', *Environment International*, Vol. 32, No. 1, pp.87–94.

van den Hove, S., Le Menestrel, M. and de Bettignies, H.C. (2002) 'The oil industry and climate change: strategies and ethical dilemmas', *Climate Policy*, Vol. 2, No. 1, pp.3–18.

Weinhofer, G. and Busch, T. (2013) 'Corporate strategies for managing climate risks', *Business Strategy and the Environment*, Vol. 22, No. 2, pp.121–144.

Wellington, F. and Sauer, A. (2005) *Framing Climate Risk in Portfolio Management*, World Resources Institute, Washington, DC [online] http://pdf.wri.org/framing_climate_risk_uncertainty.pdf (accessed 10 November 2016).

Wittneben, B.B.F. and Kiyar, D. (2009) 'Climate change basics for managers', *Management Decision*, Vol. 47, No. 7, pp.1122–1132.

World Economic Forum (WEF) (2017) *The Global Risks Report 2017*, 12th ed. [online] https://www.mmc.com/content/dam/mmc-web/Global-Risk-Center/Files/the-global-risks-report-2017.pdf (accessed 5 March 2018).

Wright, C., Nyberg, D. and Grant, D. (2012) ''Hippies on the third floor': climate change, narrative identity and the micro-politics of corporate environmentalism', *Organization Studies*, Vol. 33, No. 11, pp.1451–1475.

Zhou, P. and Wen, W. (2019) 'Carbon-constrained firm decisions: From business strategies to operations modeling', *European Journal of Operational Research*, doi: 10.1016/j.ejor.2019.02.050.