

STRANDED ASSETS

PROGRAMME



SMITH SCHOOL OF ENTERPRISE
AND THE ENVIRONMENT



Financial Dynamics of the Environment: Risks, Impacts, and Barriers to Resilience

Working Paper for the UNEP Inquiry

July 2014



Inquiry: Design of a
Sustainable Financial System

About the Inquiry

The Inquiry into the Design of a Sustainable Financial System has been initiated by the United Nations Environment Programme (UNEP) to advance design options that would deliver a step change in the financial system's effectiveness in mobilizing capital towards a green and inclusive economy.

Established in January 2014, it will publish its final report in the second half of 2015. More information on the Inquiry can be found here: <http://www.unep.org/greeneconomy/financialinquiry>

Contact:

Mahenau Agha, Director of Outreach
mahenau.gha@unep.org

About the Stranded Assets Programme

Stranded assets are assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities and they can be caused by a variety of risks. Increasingly risk factors related to the environment are stranding assets and this trend is accelerating, potentially representing a discontinuity able to profoundly alter asset values across a wide range of sectors.

Yet environment-related risks that could strand assets are poorly understood and regularly mispriced, resulting in an over-exposure to such risks throughout our financial and economic systems. Some of these risk factors include:

- Environmental challenges (e.g. climate change, natural capital degradation)
- Changing resource landscapes (e.g. shale gas abundance, phosphate scarcity)
- New government regulations (e.g. carbon pricing, air pollution regulation)
- Falling clean technology costs (e.g. solar PV, onshore wind, electric vehicles)
- Evolving social norms (e.g. fossil fuel divestment campaign) and consumer behaviour (e.g. certification schemes)
- Litigation (e.g. carbon liability) and changing statutory interpretations (e.g. fiduciary duty, disclosure requirements)

The Stranded Assets Programme at the University of Oxford's Smith School of Enterprise and the Environment was established in 2012 to understand these risks in different sectors and systemically. We research the materiality of environment-related risks over time, how different risks might be interrelated and the potential impacts of stranded assets on investors, businesses, regulators and policymakers. We also work with partners to develop strategies to manage the consequences of environment-related risks and stranded assets.

The Programme is currently supported by grants from: The Ashden Trust, Aviva Investors, Craigmore Sustainables, European Climate Foundation, Generation Foundation, Growald Family Fund, HSBC Holdings plc, The Luc Hoffmann Institute, The Rothschild Foundation, The Woodchester Trust and WWF-UK. Our research partners include: Standard & Poor's, Carbon Disclosure Project, TruCost, Ceres, Carbon Tracker Initiative, Asset Owners Disclosure Project, 2° Investing Initiative, Global Footprint Network and RISKERGY.

About the Authors

Ben Caldecott is a Programme Director at the Smith School, where he founded and directs the Stranded Assets Programme. Ben is concurrently an Adviser to The Prince of Wales's International Sustainability Unit. He has

authored and edited a wide range of publications and is an experienced media commentator and public speaker. He is also a regular peer reviewer and has a number of board and advisory panel appointments, including with the Green Alliance, Carbon Tracker Initiative, Natural Capital Declaration and the University of Oxford's Socially Responsible Investment Review Committee.

Jeremy McDaniels is a Visiting Research Associate in the Smith School's Stranded Assets Programme and a Senior Consultant at ESP Consulting. Jeremy was previously a Research Assistant at the Smith School and prior to that graduated from Oxford's MSc in Environmental Change and Management (Distinction). He holds a BA from the University of British Columbia and has worked in consulting, strategic planning, international development and academic research, and has published on a range of environmental issues.

Acknowledgements

The authors would like to thank the UNEP Inquiry into the Design of a Sustainable Financial System for commissioning this Working Paper and particularly Nick Robins, Simon Zadek, and Maya Forstater. We would also like to gratefully acknowledge the experts we interviewed throughout the research process and the peer reviewers who provided invaluable advice and feedback. Christopher Kaminker from the Organisation for Economic Co-operation and Development (OECD) led the external review process and his support has been invaluable throughout.

Working Paper Series

This Working Paper is intended to stimulate discussion within the research community and among users of research. The views expressed in this paper represent those of the author(s) and do not necessarily represent those of the host institutions or funders.

University of Oxford Disclaimer

The Chancellor, Masters and Scholars of the University of Oxford make no representations and provide no warranties in relation to any aspect of this publication, including regarding the advisability of investing in any particular company or investment fund or other vehicle. While we have obtained information believed to be reliable, neither the University, nor any of its employees, students or appointees, shall be liable for any claims or losses of any nature in connection with information contained in this document, including but not limited to, lost profits or punitive or consequential damages.

United Nations Environment Programme Disclaimer

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the United Nations Environment Programme concerning the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of its frontiers or boundaries. Moreover, the views expressed do not necessarily represent the decision or the stated policy of the United Nations Environment Programme, nor does citing of trade names or commercial processes constitute endorsement.

Table of Contents

About the Inquiry	2
About the Stranded Assets Programme	2
About the Authors	2
Acknowledgements	3
Working Paper Series	3
University of Oxford Disclaimer	3
United Nations Environment Programme Disclaimer	3

Executive Summary	6
--------------------------	----------

Introduction	8
---------------------	----------

Part I: Why the financial sector should care about the environment and environment-related risks	8
---	----------

<i>Key findings</i>	8
1. Environment-related risks and natural capital	9
1.1 <i>Understanding natural capital</i>	9
1.2 <i>Environment-related risks</i>	10
1.3 <i>Valuing and accounting for natural capital</i>	11
2. Potential impacts on the financial system	14
2.1 <i>Understanding natural capital impacts across scales</i>	14
2.2 <i>Impact pathways and potential financial implications</i>	15
2.3 <i>Institutional perspectives on risk and materiality</i>	17
2.4 <i>Key issues and barriers</i>	20
3. Current response mechanisms and implications for financial stability	22
3.1 <i>Private sector responses</i>	22
3.2 <i>Public policy responses</i>	23

Part II: Structural barriers that could prevent the financial system from managing environment-related risks	26
---	-----------

<i>Key Findings</i>	26
4. Policies and Regulations	27
4.1 <i>Policy and regulation favouring the fossil fuel economy</i>	27
4.2 <i>No mandated ESG integration or disclosure</i>	28
4.3 <i>Risk-based funding regulations</i>	29
4.4 <i>Liquidity requirements</i>	29
4.5 <i>The debate over the implications of Basel III</i>	30
4.6 <i>The uncertainty around deployment, application and calibration of Solvency II</i>	33
4.7 <i>Accounting regulations</i>	34
4.8 <i>Quarterly reporting cycle and intra-day reporting requirements</i>	35
4.9 <i>Fiduciary duty and modern portfolio theory</i>	35
4.10 <i>Investment restrictions</i>	36
4.11 <i>Financial, investment and competition policies with unintended consequences</i>	37

4.12 <i>A lack of instruments and vehicles</i>	37
5. Overview of stakeholder responses	38
5.1 <i>Financial regulations and investor practices</i>	38
5.2 <i>New business models</i>	39
5.3 <i>ESG reporting and disclosure</i>	40
5.4 <i>Active ownership</i>	41
5.5 <i>Short termism in financial markets</i>	43
Conclusion	43
References	45

Executive Summary

This Working Paper was commissioned by the UNEP Inquiry into the Design of a Sustainable Finance System (“the Inquiry”) to feed into its process of analysis and knowledge dissemination. This Working Paper has attempted to do three things: first, summarise the underlying logic for why the financial sector should care about the state of the environment and environment-related risks; second, review the main structural barriers that could prevent the financial system from managing such issues; and third, identify the main researchers and organisations undertaking work on these topics internationally. The aspiration being that this document should be a useful initial reference guide to those concerned with both how environment-related risks could affect the financial sector and what financial institutions can do to manage such risks.

We have attempted to provide, within a limited amount of time, a broad and balanced overview of these issues. We cannot claim that this review is exhaustive, but we hope that it makes a meaningful contribution to the process of identifying, consolidating and presenting the best work being done on these topics. Based on our review we have found the following:

- The available literature has focused predominantly on OECD countries and comparatively little research exists for emerging economies and developing countries. This is unfortunate and should be an area of great significance for future research.
- It is clear that financial institutions hold divergent perspectives on the materiality of environment-related risks to current and future value. Natural capital underpins the health of global economic and financial systems, however, these contributions remain largely unpriced within the economy and are largely absent from the balance sheets of financial institutions, and metrics quantifying economic growth.
- Environmental change, natural capital depletion and degradation could potentially pose systemic risks to financial stability; however, the processes through which this may happen are currently unclear and may be remote. Though we find little evidence to suggest that environment-related risks currently pose a systemic risk to the financial system beyond large-scale natural catastrophe events, there is growing evidence that these risks are becoming increasingly material and will figure significantly in financial valuation in coming years.
- Public policy responses to environment-related risks also have the potential to impact the financial system and financial stability. These include through monetary and fiscal policy responses to environment-related risks in commodity markets, environmentally-motivated trade policy (including export restrictions), as well as more direct environmental control policies.
- Due to their spread of investments and activities across sectors and geographies, the indirect exposure of financial institutions to natural capital risks may have equally costly impacts on balance sheets and system function than those firms with clear direct linkages to natural capital value.
- Accounting for environment-related risk in the financial sector involves a range of uncertainties and variables which can make assessment complex. At a higher level, key metrics used in valuing economic growth (such as GDP) are not very useful in illustrating economic costs of drastic environmental change. Addressing these issues is a priority for informed financial sector decision-making.
- The phenomenon of short-termism in financial markets undermines the ability to invest and manage risk with due consideration for environmental-related risks. It is driven in part by the practices and regulations that govern financial institutions. These include short-term benchmarks for performance measurement, risk management, reporting and compensation along with other factors such as

decreasing CEO tenure, but also in the realm of financial regulation with the application of mark-to-market accounting practices, liquidity requirements, and insufficiently granular risk-based calibration and modelling.

- A number of major financial and investment policies unrelated to facilitating a transition to an environmentally resilient economy, are widely accused of being structured in ways that have unintended consequences on the ability of the financial sector to participate in this economic transition. These include Solvency II, Basel III, EU unbundling regulation and certain accounting regulations and standards. At the same time, sparse empirical evidence exists to support some of these claims, possibly because it is difficult to model the impacts of regulations which are under development and in varying stages of implementation, or to distinguish between transitional and permanent effects, as well as the type of market or region that may be affected.
- The lack of a mandate for companies to integrate ESG factors in decision-making, undertake materiality assessments or disclose environment-related risks hinders both consistent understanding of the issues and the ability to mitigate risks.
- The interpretation of fiduciary duty has evolved significantly over time and must continue to evolve to adjust to changing social and economic realities. Fiduciary duty is often cited as an obstacle to incorporating ESG factors into the investment process. The argument that ESG-inclusive investing is inconsistent with fiduciary duty is based on the premise that including ESG factors in investment decision-making would compromise returns to achieve extraneous social or environmental objectives.
- In recent years, major analytical research efforts have been aimed at quantifying and describing the nature of some of these above-mentioned issues and proposing solutions, from short-termism in financial markets to drivers of and responses to asset stranding. As more data and research become available and as the environmental sustainability agenda becomes integrated with the broader long-term investment agenda, potential for meaningful and catalytic change exists.

Introduction

This Working Paper was commissioned by the UNEP Inquiry into the Design of a Sustainable Finance System (“the Inquiry”) to feed into its process of analysis and knowledge dissemination. The paper is intended to support three outcomes. First, to provide an overview of why the financial sector should care about the state of the environment and environment-related risks. Secondly, to summarise the main structural barriers that could prevent the financial system from managing such issues. Thirdly, to provide an up-to-date literature review of the work key researchers and organisations are undertaking on these topics internationally.

We have attempted to provide, within a limited amount of time, a broad and balanced overview of these issues. We cannot claim that this review is exhaustive, but we hope that it makes a meaningful contribution to the process of identifying, consolidating and presenting the best work being done on these topics. It should also be a useful reference guide to those concerned with how environment-related risks could affect the financial sector and what financial institutions can do to manage such risks. The authors and the Inquiry both welcome feedback and comments on this and related work, so as to improve future iterations.

Part I: Why the financial sector should care about the environment and environment-related risks

This section provides a summary and evaluation of leading work on the ways in which the state of the environment may impinge on the value and stability of financial assets, institutions and systems. We discuss recent thinking around environment-related risks, and particularly the degradation of natural capital (air, climate, soils, water), and how this has affected or could affect financial value and stability. This is examined at both the micro (firm-level) and the macroeconomic level, for example through impacts on growth, inflation, trade, and markets. Finally, this section outlines specific examples from the literature where responses to environment-related risks and natural capital degradation could affect financial value and stability.

Key findings

- Natural capital underpins the health of global economic and financial systems, however, these contributions remain largely unpriced within the economy and are largely absent from the balance sheets of financial institutions, and metrics quantifying economic growth.
- Based on a review of the available evidence, we conclude that environmental change, natural capital depletion and degradation could potentially pose systemic risks to financial stability; however, the processes through which this may happen are currently unclear and may be remote.
- Insight on the potential pathways for environment-related risks to impact on the financial system can be gleaned from recent research and debates around carbon risk, resource-reliant economies, and international trade.
- Financial stakeholders hold divergent perspectives on the materiality of environment-related risks to current and future value.
- Accounting for environment-related risk in the financial sector involves a range of uncertainties and variables which can make assessment complex. At a higher level, key metrics used in valuing economic growth (such as GDP) may not be very useful in illustrating economic costs of drastic environmental change. Addressing these issues is a priority for informed financial sector decision-making.
- We find little evidence to suggest that environment-related risks currently pose a systemic risk to the financial system beyond large-scale natural catastrophe events, but there is growing evidence that these risks are becoming increasingly material and will figure greatly in financial valuation in coming years.

- Public policy responses to environment-related risks have the potential to impact the financial system and financial stability. These include monetary and fiscal policy responses to environment-related risks in commodity markets, environmentally-motivated trade policy (including export restrictions), as well as more direct environmental control policies.
- Due to their spread of investments and activities across sectors and geographies, the indirect exposure of financial institutions to natural capital risks may have equally costly impacts on balance sheets and system function than those firms with clear direct linkages to natural capital value.
- Financial policymaking and regulation need to strongly consider natural capital, in terms of interactions with environmental, climate, energy, and industrial policies. Managers and regulators should engage in thinking about financial sector sustainability and resilience – in terms of both its impacts and system vulnerabilities, and the potential unintended consequences of policies designed to improve sector health.

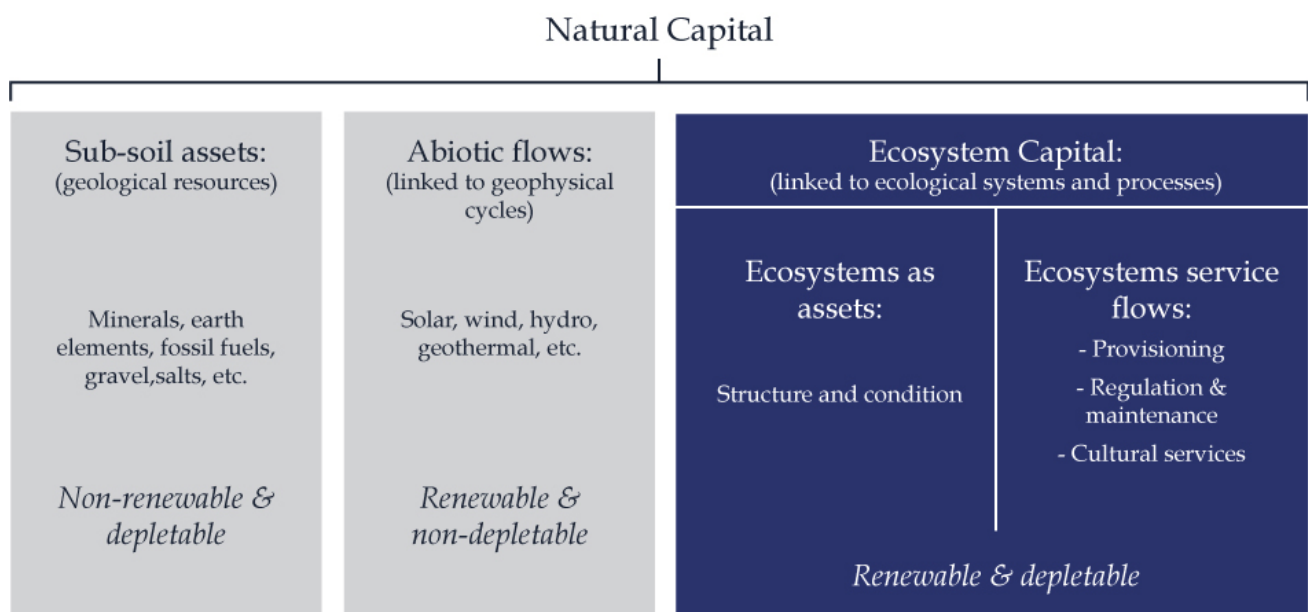
1. Environment-related risks and natural capital

1.1 Understanding natural capital

Natural capital is the totality of renewable and non-renewable resources (stocks) and ecosystems services (flows) that nature provides to society, which ensures human health, prosperity and economic growth. The value of natural capital to human wellbeing lies in the benefits it can provide. There are ongoing efforts to develop robust measures of the value of ecosystem services and the underlying natural capital that sustains them, including freshwater, oceans, surface and sub-surface terrestrial resources, habitats, and air (NCC, 2014).

There are different frameworks for understanding the relationships between assets, stocks and flows. An overview of the European Commission's Mapping and Assessment of Ecosystems and their Services (MAES) framework is provided in Figure 1, which differentiates stocks and flows in terms of being renewable and depletable. We employ this framework to understand the role of natural capital within the economy and its implications for the financial system. Species loss and ecological overshoot, where resources are used more quickly than they are regenerated, can breach thresholds and lead to limited access to some renewable resources (Barnosky et al, 2012).

Figure 1: Elements of Natural Capital



Source: European Commission, 2013

The concept of natural capital stems from a considerable theoretical body of literature aimed at pricing the environment (Gomez-Baggethun et al., 2010; Gomez-Baggethun and De Groot, 2010). Economists have approached environmental resource management problems from a variety of perspectives, including the pricing of environmental externalities and the monetisation of non-market environmental goods and services, meeting with more or less success in translating environmental values into economic frameworks for decision-making. While it is beyond the scope of this paper to review all antecedent concepts and developments motivating a shift to valuing natural capital, a few key points should be made:

- Despite significant concern regarding the resilience of environmental systems and limits to growth (Club of Rome, 1972), the global macroeconomy has so far proved extremely resilient to environmental shocks.
- While technological innovations in production and consumption have improved natural resource efficiency (resulting in relative decoupling), most economies have not experienced absolute decoupling of natural capital impact and GDP growth (Fischer-Kowalski and Swilling, 2011; Hepburn and Bowen, 2012).
- Rapid environmental change has inspired a significant amount of institutional attention aimed at the valuation of global natural capital stocks (MEA, 2005; TEEB, 2008, 2010; TEEB for Business, 2013).
- Policies aimed at fostering green growth and sustainable development rely heavily upon the integration of natural capital into frameworks and accounting to inform decision-making, yet many of these process have only recently been initiated (Russi and ten Brink, 2013).

Natural capital underpins global economic and financial system health. However, natural capital inputs and services remain largely unpriced within the economy and are largely absent within the accounting processes governing firm value, the balance sheets of financial institutions, and metrics quantifying economic growth. Here, we conduct a brief overview of the current state-of-the-art in valuing and accounting for natural capital to develop a foundation for our conceptual analysis undertaken in Sections 2 and 3.

1.2 Environment-related risks

Natural capital degradation is just one of a broader set of risks, which include the policy, technology and societal responses to environmental issues. Broadly considered, these risks can have a significant impact on asset values today, and these impacts could increase in significance over time (Caldecott et al., 2013). They are a key group of risks that can create 'stranded assets', which are assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities (Ibid.). Caldecott et al. (2013) note that there are potential correlations and connections between each set of risks – though the extent of these interdependencies is yet to be determined and is an important area for future research.

Figure 2: Typology of environment-related risks

SET	SUBSET
Environmental change	Climate change; natural capital depletion and degradation; biodiversity loss and decreasing species richness; air, land, and water contamination; habitat loss; and freshwater availability.
Resource landscapes	Price and availability of different resources such as oil, gas, coal and other minerals and metals. E.g. shale gas revolution, phosphate availability, and rare earth metals.

Government regulations	Carbon pricing (via taxes and trading schemes); subsidy regimes (e.g. for fossil fuels and renewables); air pollution regulation; voluntary and compulsory disclosure requirements; changing liability regimes and stricter license conditions for operation; the 'carbon bubble' and international climate policy.
Technological change	Falling clean technology costs (e.g. solar PV, onshore wind); disruptive technologies; GMO; and electric vehicles
Social norms and consumer behaviour	Fossil fuel divestment campaign; product labelling and certification schemes; and changing consumer preferences.
Litigation and statutory interpretations	Carbon liability; litigation; damages; and changes in the way existing laws are applied or interpreted.

Source: Based on Caldecott et al., 2013

There are many examples of assets affected by environment-related risks, either separately or from a combination of risks being present simultaneously (Caldecott et al., 2014). Evidence from different domains, such as the insurance sector (Munich Re, 2014) and studies on specific risks such as the emergence of climate regulation (Nachmany et al., 2014), suggest that these risks are growing in significance and the speed at which they are emerging is accelerating.

1.3 Valuing and accounting for natural capital

Natural capital accounting is the process of calculating the total of natural stocks and associated flows in a given geographic, sectoral, or business context, by applying monetary values to them. There are many different techniques that may be applied and definitions, standards, and methodological approaches vary. Prices and values of some natural capital goods may be derived from market prices for products (such as timber or fish), while others may be derived from the value of marketable natural capital assets (such as agricultural land). Environmental externalities without appropriate market prices may be represented by 'effective' or 'shadow' prices based upon estimates of effective costs to the economy (Price, Thornton and Nelson, 2007). Other un-priced externalities – often those relating to the public goods values of ecosystem services, such as provisioning services (e.g. of freshwater) and cultural services (e.g. of spiritual, recreational, and aesthetic value) – require more complex assumptions upon which prices are developed (Farber, Costanza and Wilson, 2002; Curtis, 2004). In these cases, often where important cultural or other non-monetary values are associated with ecosystem service provision, non-market valuation techniques (including attribute utility weighting) may be employed to derive proxy values for changes in the value of a particular ecosystem service (Prato, 1999; Mazzanti, 2002; Hajkowicz, 2006).

Estimates of the costs of natural capital degradation and negative environmental externalities to the economy are high. Recent estimates have suggested costs of up to USD 7.3 trillion annually in primary production and processing across the economy in 2009 (TEEB for Business Coalition, 2013). National-level studies have suggested costs relevant to significant portions of GDP in emerging economies such as China and India, with estimates of 2.2% of 2007 GDP and 2.6-8.8% of 2009 GDP respectively (Knight, Robins and Chan, 2013).

While the valuation of natural capital is not a new concept (Ahmad, Serafy and Lutz, 1989; Hartwick, 1990; UN-STATS, 1993; Jansson, 1994; Costanza et al., 1998, Wackernagel and Rees, 1997; Wackernagel et al., 1999; Costanza et al., 2014), there has been increasing progress towards the integration of natural capital values into public and private accounting in recent years. This is especially relevant in the context of national accounting at national, regional, and international levels.

1.3.1 Public sector approaches: government

There have been a number of actions taken multilaterally and nationally towards the implementation of natural capital accounting into decision-making. Some of these initiatives have built upon previous work in accounting for sustainability (Lamberton, 2005). Approaches in this sphere are myriad (Singh et al., 2009), including the use of broad or selected sets indicators for green growth (Mitchell, 2006; Stiglitz, Sen and Fattoussi, 2008; OECD, 2011); the use of composite indices (Parris and Kates, 2003; Boringher and Jochem, 2007); or the development of alternative macroeconomic indicators such as Green GDP values (Boyd, 2007; Boyd and Banzhaf, 2007). Within broader sustainability accounting frameworks, approaches which ascribe specific values to positive and negative changes in stocks and flows of capital assets and services can be understood as natural capital accounting; we focus on these exclusively. Recent notable actions are summarised in Table 1.

1.3.2 Private sector approaches: firms

There are a growing number of firms that acknowledge the importance of natural capital in terms of profit and loss, as well as operational and market risks. While the diffusion of this work is still at an early stage, there are notable examples in terms of supply chain assessment and disclosure:

- Kering has been pioneering work on comprehensive and integrated natural capital accounting across sections of its supply chain, including work on environmental profit and loss accounting to assess the costs of various natural capital inputs into production processes.
- Long-term partnership between Dow Chemical and the Nature Conservancy to value natural capital within investment strategy and decision-making (Dow, 2013).
- Increasing use of shadow prices for carbon emissions (CDP, 2013) and water (Greenbiz, 2014; CDP, 2014).

Beyond the disclosures of specific firms, a number of coalitions, organisations and associations have been initiated in order to enhance the ability of businesses to undertake natural capital accounting. In recent years there appears to have been a shift towards communicating and orchestrating corporate sustainability leadership through the lens of natural capital. The Natural Capital Coalition (formerly TEEB for Business) is developing a Natural Capital Protocol to provide a standardised approach to natural capital accounting and valuation for companies. The Natural Capital Declaration plans to develop a finance sector supplement to the Protocol, to provide guidance for financial institutions on accounting and valuation of natural capital impacts and dependencies at a portfolio level. The launch of new rankings indices – including the Natural Capital Leaders Index (Trucost, 2014) – aim to identify leaders in this area, while assessments such as the annual State of Green Business Report (Greenbiz, 2014) aim to identify specific advances in natural capital valuation and accounting. In addition to these developments, some new measurement and accounting frameworks have recently been unveiled, although there are only a few (principally integrated reporting frameworks) which directly focus on natural capital (Table 2). On the whole, while the vocabulary of natural capital is being integrated with great enthusiasm by private sector actors, progress towards meaningful and tangible integration of the concept across corporate sectors has only recently begun.

Table 1: Natural capital valuation within international and national regulatory frameworks

Initiative	Date	Geography	Lead Agency	Key aims/Actions
Strategic Plan for Biological Diversity 2011-2020	2010	CBD signatory countries	Convention on Biological Diversity	- Countries committed to the integration of biodiversity values into national and local development and poverty reduction strategies and planning processes, and the incorporation of such values into national accounting (Aichi Target 2); - Related accounting commitments present in forthcoming National Biodiversity Strategies and Action Plans.
Wealth Accounting and the Valuation of Ecosystem Services	2010	Eight partner countries	UNEP, UNDP, UN-STATS, NGOs, research institutions	- Promotes the development of environmental economic accounting according to the guidelines provided by the System of Environmental-Economic Accounting (SEEA) - Launched at the tenth meeting of the Conference to the Parties of the Convention on Biological Diversity - Core Implementing Partners include Botswana, Colombia, Costa Rica, Guatemala, Indonesia, Madagascar, Philippines, and Rwanda
EU Biodiversity Strategy to 2020	2011	EU Member States	European Commission	- Mandates EU Member States to map, assess, and examine ecosystems and their services by 2014, assess economic values, and support integration of these values into accounting by 2020 - Aims to halt the loss of EU biodiversity and the degradation of ecosystem services by 2020
Gaborone Declaration	2012	Sub-Saharan Africa	Country partners, UN organisations	- Set of principles and development goals that aim to integrate natural capital into the centre of development planning, including national accounting and corporate planning - Ten African states: Botswana, Gabon, Ghana, Kenya, Liberia, Mozambique, Namibia, Rwanda, South Africa, Tanzania
EU Reg. 691/2011 Rio+20 Communiqué	2012	EU Member States	European Commission	- Requirement for Member States to develop various environmental-economic accounts: a) GHG/pollutant emission accounts; b) accounts on environmental taxes; c) material flow accounts
GLOBE Natural Capital Initiative	2012	Developing countries	Global Legislators Organization (GLOBE)	- Promoting the understanding and implementation of the Natural Capital concept by national governments and across government departments - Establishment of an international process for national legislators to support the development and implementation of natural capital accounting - Link with WAVES partnership countries: Botswana, Costa Rica, Colombia, the Philippines, Peru, Georgia, Germany, UK
EC Strategy on Green Infrastructure	2013	EU Member States	European Commission	- Promoting deployment of 'green infrastructure': the network of natural land and water that lies within/between urban areas - Development in the EU in urban and rural areas; linked to EU 2020 Biodiversity Strategy
UK Natural Capital Committee	2012	UK	UK	- Develop metrics and a register for natural assets, piloting natural capital accounts with businesses as part of its work to create the first national natural capital accounts by 2020 - 1st report: Outlining evidence supporting natural capital - 2nd report: UK needs a 25-year 'landscape-scale' plan to take better account of natural capital value

Table 2: Frameworks for managing and understanding environment-related risks in corporate sectors

	Frameworks	Initiator	Year published	Why established?	Main environmental topic(s)	Core concept(s)
Measurement frameworks	Guide to corporate ecosystem valuation	WBCSD	2011	To improve corporate decision-making through valuing ecosystem services	Biodiversity and ecosystem services	Ecosystem values
	GHG Protocol (Corporate Standard)	WBCSD & WRI	2001	To develop internationally accepted greenhouse gas (GHG) accounting and reporting standards for business and to promote their broad adoption. The GHG Protocol	Greenhouse gas emissions	Climate Change
	Water Protocol	WBCSD	2012	To identify under what method fits best under which particular circumstances	Water	
	Manual for the preparers and users of eco-efficiency indicators	UNCTAD ISAR	2004	To give guidance on how to define, recognise, measure and disclose environmental and financial information as specified within the traditional accounting and reporting frameworks; to complement and support existing reporting guidelines (e.g. the UN Sustainability Reporting Guidelines developed by the Global Reporting Initiative (GRI)).	Water, energy, greenhouse gas, global warming, ozone depletion, waste	Eco-efficiency
	IR Framework	IIRC	2013	To incorporate the wide range of factors, both financial and non-financial, that determine the long-term value of a company	Natural capital	Integrated thinking, long-term value creation
Reporting frameworks	Sustainability reporting guidelines	GRI	2013	To make sustainability reporting standard practice by providing guidance and support	Materials, energy, water, biodiversity, emissions, waste	Stakeholder inclusiveness, sustainability context, materiality, completeness
	Carbon Disclosure Project	CDP	2010	To drive GHG emissions reduction and sustainable water use by organisations	Greenhouse gas emissions and water	Climate change, water use, supply chain
	Climate change reporting framework	CDSB	2010	To respond to the demand for a global reporting model that ensures fair and transparent markets and inspires confidence in reporting	Greenhouse gas emissions	Climate Change
	Sustainability Disclosure Framework	SASB	2015	To develop standards for 89 industries in 10 sectors suitable for use in providing decision-useful information in the SEC Forms 10-K and 20-F	Sector and industry specific	Materiality

Source: Kamp-Roelands, 2013

2. Potential impacts on the financial system

It is increasingly apparent that the continued degradation of natural capital resources will likely pose risks to asset values. These impacts may have potential implications for the financial system. However, such outcomes are contingent upon a range of variables, all of which contain a range of uncertainty regarding the magnitude, timing, and scope of impacts. This section assesses the hypothesis that natural capital degradation could affect financial stability. We set out potential pathways for this to happen, assess different perspectives on the materiality of these issues, and outline remaining issues and uncertainties.

2.1 Understanding natural capital impacts across scales

Natural capital degradation and rapid environmental change pose risks that are likely to have impacts across scales, sectors, geographies and timeframes. We outline recent thinking on how this could impact stability at different scales, expanding from the micro (firm and sector level) to the macroeconomic (country level), and finally at the system level.

2.1.1 Microeconomic and macroeconomic dimensions

Continued degradation of natural capital is likely to lead to declining access to environmental resource inputs for economic processes, which may introduce increased price volatility and a range of new business constraints at the firm level. The World Trade Organization (2010) has warned that even renewable resources (e.g. fish, forests and water) can be exhausted if they are mismanaged, and that trade may contribute to the exhaustion of resources by accelerating their depletion. Uneven distribution of resources can cause trade friction and disputes over access and usage rights. Recent research and analysis has suggested that natural capital depletion and degradation (Knight, Robins and Chan, 2013; NCC, 2014; TEEB for Business Coalition, 2013) may affect economic value at the firm level through several channels, including:

- **Scarcity of priced and un-priced resources for products:** The most basic impacts on business value are likely to originate from changing commodity prices, as evidenced by the recent rises in commodity prices.
- **Scarcity of priced and un-priced inputs for business operations:** disruptions of natural capital flows, such as water scarcity, may have wide ranging effects on key sectors, such as thermal electricity generation, mining and oil & gas (WRI, 2013; Ceres, 2014).
- **Demand suppression:** Resource scarcity and variability in ecosystem service flows may affect demand for specific products or product classes. This may be motivated by changing social norms, procurement standards, regulatory actions, or technological innovation (Citi, 2013).
- **Increased risk of punitive trade measures:** border carbon tax adjustments or environmental standards that bias against outputs that negatively impact natural capital could affect trade flows and export competitiveness. Multilateral trade rules are a key component of cooperation on environmental protection and national policies to manage scarce resources (WTO, 2010).
- **Impacts to non-market ecosystem values:** Impacts related to various intangible ecosystem service values – including cultural, recreational, or reputational value – may have negative implications for the value of dependent sectors, for example, tourism and real estate (Ekins et al., 2003).

Interactions between natural capital flows, population growth, and economic transition (via urbanisation, development, and resource decoupling) can affect natural capital stocks (Knight, Robins, and Chan, 2013), but this can occur in non-linear ways. Beyond these risks, stochastic extreme events that impact natural capital (such as natural disasters) may exacerbate existing vulnerabilities, including:

- **Reduced primary environmental productivity:** for example, loss of pollinators within agricultural areas/economies is likely to affect a range of sectors as well as human and social capital, leading to negative impacts in terms of sectoral GVA and total GDP growth.
- **Increased social-environmental health costs across the economy:** reduced environmental quality will reduce lifespans and increase healthcare burdens, resulting in higher costs, lower productivity, and increasing socio-economic inequality.
- **Increasing cost of reinvestment in natural capital:** damages may affect distribution of capital spending across the economy, potentially negatively affecting socio-economic development outcomes if actions are taken at the expense of social spending.

2.2 Impact pathways and potential financial implications

Environment-related risks, and natural capital degradation specifically, could have a diverse range of impacts on the financial system. Here we set out three potential, high-level scenarios based on recent events and relevant literature:

- **Bottom-up contagion**
- **Capital flight**

- **Hazard globalisation**

2.2.1 Bottom-up contagion: cascading risks posed by stranded assets and firm-level losses

There is a rapid devaluation of assets as a result of previously mispriced environment-related risks being repriced and this is of sufficient size, scale, and rapidity that it affects financial stability. It begins in a specific sector where mispricing is obvious and disproportionately large, and then after repricing occurs this spreads to other sectors and jurisdictions.

The Carbon Tracker Initiative (2013; 2014) has put forward a version of this scenario where a 'carbon bubble' bursts when 'unburnable' fossil fuel reserves lose value precipitously due to climate policy, destabilising the financial system. Though a significant number of stakeholders disagree on whether or not systemic risk is currently (or could potentially be) posed by carbon within the economy (see Caldecott, McDaniels and Dericks, 2014), analysis of this debate yields useful insights for how other drivers may have an impact on financial stability.

The key motivating factor in a bottom-up scenario could either stem from physical impacts (such as natural capital disruptions), or strong and comprehensive regulatory policy in response to a specific natural capital challenge, such as water scarcity or air quality. A hypothetical example of China implementing strong national controls on water use by coal-fired industry could have ripple effects across global coal markets, leading to potentially considerable losses in major coal exporting countries (see Caldecott, Tilbury and Ma, 2013). Coal consumption reduction targets introduced in 2013 to tackle air quality problems in China could reduce coal use by 350 million tonnes by 2017 (Greenpeace, 2014).

2.2.2 Capital flight: Natural capital revenues, investment, and credit

Degradation of natural capital stands as an especially significant macroeconomic risk to income, growth and stability in resource-reliant economies. Analysis of such risks has mainly focused on the potential 'resource curse' faced by resource-rich economies (Ross, 1999; Auty, 2001, 2007; Van der Ploeg, 2011), but a broader range of development outcomes and risks may be posed beyond risks based on depletion of natural resources. If a country or region experiences significant degradation of natural capital stocks and flows, capital may rapidly flow from this area as investors reallocate current and planned investments, divest from assets, or firms reorient operations to new nodes of production with adequate resources or reliable flows.

Building on the theory of capital flight from political risk (Van Wijnbergen, 1985; Dooley, 1988; Alesina, and Tabellini, 1989), negative capital flows could be motivated by either natural capital degradation or increasing option value on future natural capital stocks in different geographies. In countries heavily reliant on a select number of resource industries predicated on natural capital stocks and flows such a capital flight could have serious macroeconomic consequences, affecting inflation and international competitiveness. This may be especially significant for those relying upon non-renewable natural capital assets vs. renewable assets, which produce rents less associated with depletions of public capital stock (Bhattacharyya and Collier, 2014).

Under a scenario of serious natural capital degradation across the economy, outflows of invested capital could significantly harm exchange rates, triggering fiscal policy responses. Such a situation would likely be compounded in those countries with little internal investment, high domestic deficits, and negative trade balances. This could also affect countries that have pursued significant inward investment as a hedge against volatility (Collier et al., 2009), as reorienting invested capital elsewhere may prove difficult as a flood of public and private capital enters global markets.

Potential causes of a natural capital degradation event of this scale could result from events such floods, earthquakes, or species-based epidemics (like the North American mountain pine beetle infestation). However, more gradual resource-based risks – such as increasing population pressure and higher per capita consumption – may present more detrimental underlying constraints if not managed.

2.2.3 Hazard globalisation: Natural capital and global trade

Natural capital degradation could affect financial stability through trade flows and global supply chain interactions. The globalisation of key commodity supply chains and increasing financialisation of commodity markets (Henderson, Pearson, and Wang, 2012; Cheng and Xiong, 2013) have increased exposure to climatic shocks affecting production in remote geographic areas. This process of 'hazard globalisation' (Sternberg, 2013) represents a new dimension of environmental risk transfer through which natural capital degradation could affect regional social, economic and political volatility, which in turn may have implications for global financial stability.

Natural capital degradation may influence global markets and trade flows through either price-based shifts or regulatory actions. Such processes have been cited as evidence of the complex relationships between climate change and trade that have motivated significant regional social and political unrest in recent years, including the Arab Spring. Insights from research on the climate-related dimensions of the Arab Spring are useful in examining how different dimensions of natural capital risks could be transmitted globally through the international trading system.

While the product of many different antecedent socio-economic and political conditions, an important driver of the Arab Spring was significant increases in the price of basic commodities. In countries such as Egypt, where approximately 38% of household income is spent on food (FAO, 2006), price-based drivers of food insecurity proved especially significant. Global wheat prices doubled from 2010 to 2011 in response to supply shortages brought on by shifting weather patterns. Sternberg (2013:7) notes that: 'Climate factors curtailed wheat production in Russia (down 32.7 percent) and Ukraine (down 19.3 percent) due to drought, heat waves, and fires, while cold and rainy weather in Canada (down 13.7 percent) and excessive rain in Australia (down 8.7 percent) resulted in reduced global wheat supply and major price increases.' Climatic disruptions inspired countries such as Russia to implement export restrictions on wheat, significantly curtailing supplies traded on global exchanges (Welton, 2011). In order to mitigate the impacts of its own 2010 drought the Chinese government began purchasing wheat from global markets which greatly exacerbated this shortage. As the cross-border wheat trade represents 6-18% of total global wheat production (Sternberg, 2013), aggressive demand increases sharply affect major wheat importers – with Egypt being the largest (Lampietti et al., 2010; Index Mundi, 2013).

2.3 Institutional perspectives on risk and materiality

In this section we review some of the different institutional, organisational, and private sector perspectives on the materiality of environment-related risks, particularly natural capital risk, identified and discussed in the previous sections. We recognise that the following discussion is not exhaustive, but we aim to address key points of interest in relation to the pathways discussed in Section 2.2.

Institutional perspectives on the materiality of environment-related risks to financial stability have changed over the course of the last decade. Work on the role of environment and climate risks in fiduciary duty and the materiality of environmental, social and governance (ESG) risks to enterprise increased after 2004, following the publication of UNEP Freshfields I and II reports (Clements-Hunt, 2012). A PRI/UNEP FI report (2010) demonstrated that it is in the financial interest of fund beneficiaries that large diversified institutional investors such as pension funds, mutual funds and insurance companies address the environmental impacts of investments to reduce exposure to externalities, and recommended that they seek policy and regulatory solutions to address externalities. Since 2010 there has been an increasing recognition of both the scope (in terms of breadth of risks considered) and potential scale of natural capital risk materiality to value, growth, and financial stability. Here we assess various areas in terms of specific natural capital issues, including carbon, water, biodiversity, and soil risk, while briefly discussing cross-cutting risks such as natural disasters.

2.3.1 Carbon risk

From the late 1980s and accelerating rapidly from 2000, individuals and organisations working on climate change issues began to acknowledge the possibility that climate change policy and regulation could negatively influence the value or profitability of fossil fuel companies to the point that they could become impaired (Krause et al., 1989; IPCC, 2001). With the concept of a global ‘carbon budget’ (Krause et al., 1989) – the 1 trillion tonnes of cumulative atmospheric CO₂ emissions allowable for 2 degrees of global warming – there was a way to determine when too much was enough. When the amount of fossil fuels combusted, plus the amount of carbon accounted for in reserves yet to be burned exceeded the carbon budget, either the climate or the value of fossil fuel reserves would have to give – this is the ‘unburnable carbon’ or ‘carbon bubble’ concept cited earlier.

Research on stranded electricity assets has also noted the counter-intuitive outcomes of market and policy drivers stemming from carbon risk, distributed generation, market reform, and climate policies (IEA, 2013; Caldecott & McDaniels, 2014; Greenpeace, 2014). A particularly striking example is EU thermal power generation, where new high-efficiency gas-fired power plants have been rendered uneconomic in comparison to cheaper coal-fired generation due to the combined effects of merit order displacement by renewable energy, weak carbon prices, and cheap coal displaced by the US shale boom (Caldecott & McDaniels, 2014). While the potential for systemic financial risks originating from losses on gas plants may be negligible, the experience of utilities illustrates how rapid and unanticipated impacts of policy and technology shifts may have material impacts in other sectors and regulatory contexts.

Financial stakeholders have responded to carbon risk materiality in different ways. There is a general trend of increasing recognition that can be seen across public institutions, major environmental institutional investor groups, and global organisations. On the whole, proactive responses to carbon risk management remain the exception rather than the rule. Many private sector firms and equity analysts flatly reject the materiality of carbon risk, or greatly downplay exposure to known risks.

Notable recent developments include the UK House of Commons Environmental Audit Committee (2014) citing a need for the assessment and management of carbon asset risk within a recent parliamentary submission, as well as recent analysis by international organisations including the IEA (2013), IPCC (2013), World Economic Forum (2014), and others. Some institutional investor coalitions have undertaken work to stress test portfolios for carbon asset risk (Ceres, 2013). In the private sector, many global banks – including HSBC (2014), Citi (2013a, 2013b), and others – have conducted research on the potential for demand constraints on fossil fuel assets value across various global majors. In a recent study, HSBC (Knight, Robins and Chan, 2013) suggested that carbon risk and water risks are the greatest natural capital issues facing business over the short term. Such findings were echoed in other recent assessments, including the WEF 2014 global risk report – three of the top ten global risks were environmentally-based, with water crises being cited in the top three (WEF, 2014). In 2013, Bloomberg launched a tool for investor clients to stress test company valuations against different carbon constraint scenarios and this is being improved and updated (Caldecott and Elders, 2013).

2.3.2 Water risk, biodiversity loss, and terrestrial environmental quality

Recent research on potential stranded assets arising from environment-related risks has expanded the scope of this debate beyond climate policy risk. One important area for this research is current and potential risks brought on by water scarcity, and the processes by which changing weather patterns, water availability, and water quality may have significant impacts on asset value across the economy. Much of this research has focused on potential impacts on thermal electricity generation and related coal infrastructure in developing countries (WRI, 2013a; Pearson, 2012), while other aspects have focused on potential implications for unconventional fossil fuel extraction (WRI 2013b).

There has been increasing research on the implications of biodiversity loss to business value, and the materiality of biodiversity risks to financial systems (Dempsey, 2013). In response to the recognition of biodiversity’s importance to long-term value, various assessment tools and accounting metrics have been developed to

quantify and manage these risks (Hill et al., 2011). In recent years biodiversity loss has been integrated into natural capital accounting frameworks, and stakeholders appear to be taking a wider view of the potential materiality of risk associated with biodiversity loss. In addition, governments appear to be taking an increased interest in terrestrial resources, principally soil quality, as a foundational element of natural capital and ecosystem quality (NCC, 2014; House of Commons, 2014).

2.3.3 Cross-cutting risks: natural disasters

At the macro scale, institutional investors are increasingly recognising the potential materiality of macroeconomic risks posed by climate-related natural disasters. Much of this work addresses the macroeconomic costs of catastrophic events, as opposed to the creeping risks posed by continued degradation of capital stock, flows, and pollution sinks. Significant environmental events impacting natural capital have grasped the attention of the financial sector because of the large-scale losses they can inflict on firms, governments, and society. The macroeconomic impacts of such events have been of greatest interest to the insurance industry, and are becoming of increasing interest to institutions involved in project finance, corporate finance, and investment.

Empirical research on the macroeconomic impacts of natural disasters has grown significantly in the last decade (Pelling et al., 2002; Okuyama, 2007; Raschky, 2008; Hallegatte and Przyluski, 2010; Cavallo and Noy, 2009; Cavallo et al., 2013). It is generally accepted that such events have negative macroeconomic costs, with some impacts at global scales; in a meta-analysis of 22 studies Lazzaroni and van Bergeijk (2013) find that the majority of multi-nation and multi-event studies examining natural disasters suggest negative macroeconomic value implications. However, it should be noted that delineating the costs of disaster impacts across scales is challenging. There may be overlap and uncertainty in the attribution of direct costs (market losses with observable prices), indirect costs (such as interrupted flows of goods and services), and secondary costs (long-term macroeconomic performance over time) that may be linked to a disaster event (Hallegatte and Przyluski, 2010).

Natural disasters have increased both in frequency and in magnitude of direct and indirect losses over the last several decades (Munich RE, 2014). Despite these increases there remains a dearth of research on the financial implications of disasters beyond the insurance sector. While direct losses from disasters and their immediate costs to the financial institutions may be clearer to assess (for example, the costs of a second hurricane Sandy to US and global public equities due to disruption of markets), the long-term impacts and the distribution of these impacts across the sector remains unclear.

2.3.4 Materiality and institutional standards

The first step to understanding the various ways ESG factors may impact corporate value – both positively and negatively – is a materiality assessment at the firm level, which can then facilitate more efficient resource allocation. Recent responses by financial stakeholders suggest that natural capital is becoming increasingly material, though from a low base. Perceptions of materiality are, however, uneven across the financial sector. A 2012 survey of accountancy professionals, conducted by the professional body ACCA found that 49% of those that responded identified natural capital as a material issue, with implications for operational, regulatory, reputational and financial risks (ACCA, 2012), however, response rates within the survey were unusually low. Key issues identified through the same survey included the limited insights provided by current natural capital disclosures; the lack of standardised business cases for accounting, and the lack of market signals for natural capital and biodiversity values.

Recent analysis suggests that institutional definitions and perceptions of materiality – in terms of disclosure codes, accounting frameworks, and other standards – may be broadening through changes at the ‘boundaries’ of materiality assessments (ACCA, 2013). Criteria affecting scope (in terms of the ESG issues considered), stakeholders (in terms of actors to be included when assessing materiality of risk), and timeframes vary depending on interpretations of materiality employed by an organisation or a firm (AccountAbility, 2013).

Valuing and judging materiality is therefore a complex and varied space; indeed, definitions of materiality (Table 3) vary widely across bodies and geographies.

Table 3: Materiality Definitions

Body	Definition of Materiality
IASB & FASB	Information is material if omitting it or misstating it could influence decisions that users make on the basis of financial information about a specific reporting entity.
IFAC/ IAASB	Misstatements, including omissions, are considered to be material if they, individually or in the aggregate, could reasonably be expected to influence relevant decisions of intended users taken on the basis of the subject matter information. The practitioner's consideration of materiality is a matter of professional judgment, and is affected by the practitioner's perception of the common information needs of intended users as a group.
FRC	Misstatements, including omissions, are considered to be material if they, individually or in the aggregate, could reasonably be expected to influence the economic decisions of users taken on the basis of the financial statements.
SEC	Information is material if 'there is a substantial likelihood that a reasonable shareholder would consider it important' in making an investment decision. To fulfil the materiality requirement, there must be a substantial likelihood that a fact 'would have been viewed by the reasonable investor as having significantly altered the "total mix" of information made available.' A matter is 'material' if there is a substantial likelihood that a reasonable person would consider it important.
GRI 3.1	Materiality for sustainability reporting is not limited only to those sustainability topics that have a significant financial impact on the organisation. Determining materiality for a sustainability report also includes considering economic, environmental, and social impacts that cross a threshold in affecting the ability to meet the needs of the present without compromising the needs of future generations.
GRI G4	Organisations are faced with a wide range of topics on which they could report. Relevant topics are those that may reasonably be considered important for reflecting the organisation's economic, environmental and social impacts, or influencing the decisions of stakeholders and, therefore, potentially merit inclusion in the report. Materiality is the threshold at which aspects become sufficiently important that they should be reported.
IIRC	A matter is material if, in the view of senior management and those charged with governance, it is of such relevance and importance that it could substantively influence the assessments of the primary intended report users with regard to the organisation's ability to create value over the short, medium and long term. In determining whether or not a matter is material, senior management and those charged with governance should consider whether the matter substantively affects, or has the potential to substantively affect, the organisation's strategy, its business model, or one or more of the capitals it uses or affects.

Source: Adapted from ACCA, 2013

Perceptions of materiality (in both scope and scale) remain highly varied across the financial system. While many standards define, and in some cases make it mandatory for companies to report on key ESG performance indicators declared to be 'material', there is little evidence that investors view this information as material to their decision-making. This is due to a range of barriers (many of which are discussed in the following section), but can best be encapsulated in the notion of inertia and incremental action that has plagued the integration of new risks into the financial system (Woods, 2009). One dimension of this inertia is that the actions and behaviour of different stakeholders – including those who could be considered climate- or sustainability-minded – appear to be contingent on the behaviour and actions of others. In this context, the tension between the financial sector, financial regulators, civil society, and private firms appears to be having a significant drag effect on real action. This has been identified in a number of recent papers, including reviews of climate change disclosure (Ceres, 2014), carbon risk accounting (ACCA, 2013b), and systemic risk (Caldecott, McDaniels and Dericks, 2014).

2.4 Key issues and barriers

2.4.1 Quantifying natural capital

Natural capital accounting involves both epistemological and ontological uncertainties regarding the quantification and measurement of the stocks and flows of capital assets and services. A key dimension of

uncertainty inherent in the assessment of stocks and flows is the estimation of appropriate threshold and limit values for what may define a sustainable use rate of a specific resource base or flow (NCC, 2014). Assigning values to these thresholds is a complex and inherently subjective process, and a lack of standardisation across approaches may inhibit the validity of comparisons across contexts. Similarly, the choice of a discount rate is necessary to calculate scope of benefits accruing to economic owners, but there is little consensus on appropriate discount rates for different types of assets (Khan and Greene, 2013) and the choice of a higher or lower rate will significantly affect natural capital values over time.

Such uncertainties and subjective choices affect policymakers, business, and financial institutions. For instance, prices set for natural capital assets may often be significantly divorced from current prices within markets, making natural capital values too remote to be useful beyond theoretical applications. For example, in the TEEB top 100 Natural Capital externalities report (TEEB for Business Coalition, 2013) carbon emissions are valued at USD 120/t – a far cry from current prices within the EU ETS. Similar disjunctions between the 70-plus types of capital assets and flows priced within this assessment may increase the complexity of integrating this type of analysis into business decision-making around natural capital risk management.

2.4.2 Models and metrics

It is becoming increasingly clear that alternatives to classical economic approaches are required to understand environment-related risks. A key issue is that economic models for assessing the long-term costs of climate change do not include the impacts of economic volatility caused by environmental change, and the costs of this volatility to firms, households, and governments (Stern, 2013). By omitting or underestimating key environmental factors including tipping points and feedback loops in climatic and biophysical geographic systems, economists risk underestimating the fat tail downside costs of climate change and natural capital degradation.

2.4.3 Quantifying potential risk posed to the financial system

GDP may have limited utility for measuring impacts on the financial system. The global financial crisis is a good example: it is largely agreed that the GDP impacts of the financial crisis have proven to be comparatively small and there is a disparity between these values with the long-run impacts of the crisis. This is exemplified in a number of recent analyses of the real impacts of the financial crisis, which focus on the implications of ‘economic trauma’ on the US macroeconomy, which have estimated the ‘real’ aggregate long-term cost of the crisis at USD 6-14 trillion at 2012 values (Atkinson, Luttrell, and Rosenblum, 2013). Losses of economic output from reductions in living standards attributed to the crisis (including human capital losses from skills atrophy and psychological damage) are likely to have significant long-term impacts that are not adequately (or accurately) reflected in GDP-only metrics.

As GDP has been widely acknowledged to mask losses in other important types of economic capital, losses in natural capital may be similarly hidden or downplayed. As many significant natural disasters have been illustrated to have similar broad-based impacts to the financial crisis (including impacts on human and natural capital), it may be the case that a pure GDP-based measure is not the most appropriate tool to value impacts on the financial sector. While current approaches to valuing natural capital are strongly related to GDP due to its dominance as a growth metric, it may be necessary to employ a suite of tailored metrics that are able to accurately reflect the current and future economic costs of natural capital degradation.

3. Current response mechanisms and implications for financial stability

3.1 *Private sector responses*

3.1.1 *Response mechanisms*

i) Stress testing, disclosure, and integrated reporting

Financial stakeholders are implementing a range of responses to environment-related risks, but most fall into what can be understood as very preliminary risk assessments. There is a standard progression of ‘assessment/transparency/management’ that can be seen in the responses of financial stakeholders, with many only taking initial steps towards proactively managing environment-related risks. Key mechanisms in this space include stress testing, risk analysis, risk disclosure, and integrated reporting. There are a significant number of new industry bodies providing guidance in this area, including standards boards, councils, and various coalitions between industry, regulators, and international organisations. While it is beyond the scope of this report to review each of these in detail, we can make a number of general observations:

- Established financial sector standard-setters (such as IASB and FASB) are taking steps towards requiring greater transparency of environmental impacts, as well as specific actions on water, biodiversity, and other natural capital risks. In addition, these standards are implementing actions to assess various climate-related exposures, including carbon footprint accountability/exposure, and exposure to sea level rise.
- The wide range of standards and guidance bodies (including the GRI, WBCSD, SASB, CDSB, ISAR, CDP, AODP, and others) have begun to implement new frameworks to improve the rigour and utility of sustainability, climate, and natural capital disclosure outputs. Some of these bodies are also beginning to target other important parts of the investment chain, including asset owners (AODP, 2013; PRI Reporting Framework).
- Recent developments in established reporting systems and channels (such as climate risk within the SEC) suggest that uptake is a potentially long and slow process, which has little impact in the short run (Ceres, 2014).
- Beyond specific firms or financial stakeholder groups actions on natural capital may be implemented through exchanges, as illustrated by the preliminary progress towards carbon reporting requirements for stock exchanges. Some of the recent work in this area is being coordinated by the UN’s Sustainable Stock Exchange Initiative (SSE, 2014).
- Future macro-prudential regulations remain an uncertainty. Currently it is unclear how environment-related risks may be explicitly addressed (if at all) in such regulations, but analysts have suggested that a potential ‘Basel IV’ could result in ‘tougher requirements on the leverage ratio, risk-weighted assets and stress testing’ (KPMG, 2014). As climate change is likely to affect underlying asset bases of banks (to the degree that they lend to clients in environmentally vulnerable/high risk industries) there may be implications for asset risk weighting, potentially leading to higher capital requirements for assets with greater levels of exposure to environment-related risks.

iii) Financial aspects of environmental risk management

Corporations may implement mechanisms to improve environmental performance in advance of environment-related risks becoming material. Large financial institutions may be exposed to reputational risks to corporate clients who may be engaged in operations with significant adverse natural capital impacts. Recently some EU banks have also implemented a number of actions to directly respond to natural catastrophe events (NCEs) at the retail banking level, such as flooding. Different types of ‘repayment holidays’ on loans such as residential mortgages have been implemented as a goodwill action to customers impacted by extreme weather, including RBS, Santander and HSBC’s recent actions in response to major floods in the UK in 2014. If the implementation

of such repayment hiatuses becomes accepted practice, an increasing amount of high-cost NCEs may impact the service of interest commitments and repayments of specific types of loans.

iv) Securitisation of environmental risk

Many insurers, reinsurers, and other financial stakeholders are undertaking efforts to reduce environment-related risk exposure through the issuance of financial securities. The use of catastrophe bonds ('cat bonds') and other insurance-linked securities (ILS) are becoming increasingly prevalent in transferring environment-related risks to capital markets, often via indexed approaches to valuing damages from NCEs. Cat bonds are a private sector mechanism that are related to a wider group of public and private disaster risk financing mechanisms, which are outlined in Table 4. The IPCC's recent AR5 WG2 report supports catastrophe bonds and risk securitisation as a key tool for the diversification of climate-related disaster risk across capital markets. New instruments that may operate as capital market risk transfer mechanisms include weather derivatives and hybrid products linking parametric climate-based and capital market loss triggers, acting as a hedge against a 'double hit' from direct disaster losses and losses incurred within asset management portfolios and capital markets (IPCC, 2014). Changes in the dynamics of these markets call attention to the potential for systemic risks arising across the financial system in response to increased exposure to NCE damages.

Table 4: Non-traditional disaster risk financing mechanisms

Mechanism	Financing issue	Description	Stakeholders	Example
Catastrophe bonds	Need for insurers to transfer catastrophe-related underwriting risk to capital markets in order to de-risk portfolios	ILS (often fully collateralised) whereby investor receives return premium when specified NCE (often measured via indices) does not occur; when NCEs occur investors sacrifice interest premium	Private insurers and reinsurers, institutional investors	Wide range of catastrophe bond issuances (refer to Artemis, 2014)
National insurance programmes/pools	Reluctance of private insurers to offer insurance for high-risk and high cost NCEs, due to covariant dynamics affecting solvency	Insurance pool based on mandatory private capital contributions designed to reduce public fiscal exposure to disaster events; often guaranteed by government/donors	National governments	Turkish Catastrophe Insurance Pool (Gurneko, 2004)
Contingent credit	Inability to secure access to credit at appropriate rates in period of fiscal illiquidity following disaster events	Credit access agreement whereby governments pay a premium for a call option on a guaranteed loan at a predetermined rate, contingent on a disaster or some other defined event occurring	National governments, IFIs, MDBs	Colombia contingent credit agreement with the World Bank (Cummins and Mahul, 2008)
International insurance pools	Regional standards for disaster risk insurance pricing may be subject to fluctuations that effectively de-link premiums with recorded damages	International insurance risk sharing facility which allows governments to pay into a pool in order to access immediate liquidity at a lower cost than private insurance within capital markets	National governments	Caribbean Catastrophe Risk Insurance Facility; Pacific Catastrophe Risk Assessment Financing Initiative
Alternative mechanisms	Various	Index-based micro-insurance Public sector risk transfer Insurance of international donors	Various	Various

Source: Adapted from Linnerooth-Bayer and Hochrainer-Stigler (2014)

3.2 Public policy responses

There has been a wide range of research on the micro and macro implications of various public policy responses to climate change, environment-related risks, and natural disasters. However, this work has not been focused on the financial system. Here we focus specifically on recent research and analysis pertinent to finance, banking, insurance and investment in order to derive specific implications for the financial system. In this context we

recognise that the following discussion is not exhaustive, and we do not concentrate on well-understood fiscal policy responses such as carbon pricing.

3.2.1 Monetary policy responses

To date there is little evidence suggesting that governments implement monetary policy actions explicitly in response to degradation of non-market or unpriced natural capital stocks and flows, such as water or ecosystem services. Governments may implement monetary policy actions in response to changes in the value of natural capital stocks (i.e. discoveries or depletion of resource wealth), losses of natural capital (i.e. natural catastrophe events), and changes in the value of market goods and services predicated upon natural capital stocks and flows (i.e. price volatility within international commodity markets).

Much of the analysis in this area relates to the management of natural resource extraction rents, including energy resource discoveries (Wills, 2013) and the management of long-term resource depletion (Leigh and Olters, 2006; Collier et al., 2010; Van der Ploeg and Venables, 2011; Cologni and Manera, 2013). Instead of expanding on this discussion, here we focus recent findings from analysis of monetary policy responses to i) natural catastrophe events and ii) commodity price volatility. We concentrate on these areas of research as these processes may serve as partial proxies for impacts of natural capital degradation and resource scarcity, as outlined in Section 2.2.

i) Monetary policy responses to natural catastrophe events

Natural catastrophe events have major direct and indirect costs at the macroeconomic level (Hallegatte and Przyluski, 2010) and within different sectors across the economy (Loayza et al., 2012). These costs may constitute significant issues for public finance and debt, as NCEs impacts necessitate increased government spending concurrent with a decrease in fiscal revenues (Melecky and Raddatz, 2014). Monetary responses to NCEs are often aimed at stimulating the economy in advance of a long-term economic slowdown; for example the Thai central bank reduced interest rates from 3.5 to 3.25% in anticipation of significant output declines from flood damage in 2011 (Yuvejwattana, 2011). Governments implement monetary responses to NCEs in order to stabilise the economy and mitigate losses from environmental damage, but there has been less focus on the use of such instruments to manage interrupted flows of natural capital to the economy.

Beyond monetary policy there is an increasing volume of analysis of broader macroeconomic and fiscal policy responses to NCEs and physical climate impacts, with studies examining the fiscal impacts of Hurricane Sandy (Mantell et al., 2013), Caribbean hurricanes (Ouattara and Strobl, 2013), floods (Cunado and Ferreira, 2014), and other catastrophes. Many different fiscal policy tools and combinations of responses to NCEs have been implemented, with varying effects on macroeconomic growth and financial stability. While these lessons are pertinent to implications for financial stability stemming from responses to natural capital degradation, many dimensions of such policies relate to broader macroeconomic issues and are thus hard to disaggregate as specific actions with environmental objectives.

ii) Monetary policy responses to commodity market volatility

Governments may introduce monetary policy responses to commodity market volatility based upon either changes in the value of export-based capital inflows or exposure of domestic consumers to significant shifts in the CPI, leading to inflation. Changes in values of exports of primary natural commodities (such as oil, agricultural products, or other natural resources) can significantly affect capital inflows. Inflationary impacts from increased prices for exports can be exacerbated by pro-cyclicality of bank lending, increasing risk of systemic negative consequences during major price downturns (Masson, 2014). For example, oil-based capital inflows and loose monetary policy in Nigeria led to a severe credit-based financial crisis. Following a cumulative real growth in private sector credit of 235% over 2006–08, the fall in oil prices stemming from the 2008 financial crisis led to a rapid increase in non-performing loans, bank failures, and eventual monetary policy actions by the Central Bank of Nigeria (Masson, 2014).

Increasing commodity prices may influence similar tendencies in inflation, resulting in monetary policy issues. New research on relationships between commodity prices and dynamics of monetary policy instruments across countries is useful to examine what indirect policy responses natural capital degradation may elicit through commodity markets (beyond export inflows). Ano-Sujithan et al. (2013) find an implicit inverse relationship between commodity prices and short-term interest rates for a set of heterogeneous countries, noting that high commodity prices and price shocks can influence short-term interest rate decreases. Drawing on this finding, it could be argued that increasing frequency and magnitude of commodity price shocks stemming from natural capital risk factors could indirectly motivate monetary policy responses. Increased volatility transmission across different commodity markets, e.g. between oil and agricultural products (Du et al., 2011; Creti et al, 2013; Nazlioglu et al., 2013) may also increase potential risks posed by price shocks. To the degree that monetary policy responds disproportionately to commodity market price volatility, or that such commodity market volatility obfuscates or distracts from other important indicators used within monetary policy, responses could result in sub-optimal policy outcomes in terms of the size, timing, and direction of the given interest rate response.

Such policy responses – while not directly responding to natural capital degradation or other environment-related risks – illustrate the potential pathways by which natural capital losses may have complex implications for financial stability through both markets and regulatory architecture. It should be noted, however, that increased volatility in commodity prices would likely entice a combination of monetary and fiscal policy responses to manage it, and that the potential for sub-optimal monetary policy responses to affect financial stability is contingent on a number of other macroeconomic variables (including trade deficits and national debt). Similarly, different monetary and fiscal policy responses to natural capital degradation and environment-related risk are likely to impact on growth and inflation expectations in similar ways to other policies without environmental imperatives – and may not represent new or unique stability risks. On the whole, the appropriateness of different monetary or fiscal responses (or combinations of responses) will depend upon both the scale and speed of the economic impacts of a disaster event and the rate of implementation and rate of expected impacts from a given policy prescription (HSBC, 2014).

Beyond monetary policy, governments may also implement a range of fiscal controls in response to commodity market volatility. Some of these tools are part of complex fiscal instruments, the impacts of which may be difficult to disaggregate. We discuss specific fiscal actions in the following section, focusing on identifiable climate and environment policies which merit individual examination.

3.2.3 Other policy responses

There are a range of policy drivers (including conservation, trade, industrial, and social policies) that have the potential to increasingly affect the relationship between natural capital degradation and the financial sector.

i) Policies to conserve/sustain natural capital, including investment

It is becoming increasingly accepted that well-designed policies to support natural capital resilience and conservation are considered positive for long-run economic competitiveness, as they help to drive resource productivity (HSBC 2014). Regulatory and legislative responses to mitigate, abate, or manage natural capital degradation and other environment-related risks comprise a significant body of response measures, including:

- Conservation policy
- Protected areas and knock-on effects (collateral actions)
- Investments in ecosystem restoration and rehabilitation
- Investments in natural infrastructure
- Investments in ecosystem resilience

ii) Trade policies, industrial policies, and social policies

Impacts on financial stability may arise from national-level regulations and policies that affect business competitiveness and trade. The most important of such actions include production restrictions, import restrictions, and export restrictions implemented to control, abate, or maintain natural capital (such as key environmental resources). As these policies may often be directly designed to affect trade flows, they may have ripple effects across the economy that pose sector-wide or potentially systemic financial risks.

A recent area of research that may prove relevant to natural capital is green industrial policies, and the role of the government in facilitating industrial competitiveness through a green economy lens (Hallegatte et al., 2013). While not directly related to financial stability, the implementation of green industrial policies could significantly affect brown industry if provisions are not adequate to avoid significant stranded asset issues, as outlined previously.

Finally, policies in response to significant social or civil society concern could also have financial implications. Examples of this can be seen in the recent campaign to divest from fossil fuels in the US and the EU (Ansar et al., 2013), as well as public protest in response to air pollution in China. As social norms around natural capital may change rapidly if human health and human environmental quality are negatively affected, governments are likely to respond rapidly (and potentially unpredictably) to social issues with policies that may significantly affect financial markets.

Part II: Structural barriers that could prevent the financial system from managing environment-related risks

This section provides an overview of the structural barriers that could be preventing the financial system from managing environment-related risks and harnessing some of the financial opportunities associated with the transition to a more environmentally sustainable global economy. It reviews a body of literature, which has increased in depth since the onset of the global financial crisis, on short-termism in financial markets and financial regulatory barriers standing in the way of long-term investment, and in recent years has also started to focus on long-term investment in green infrastructure and environmental sustainability. Drawing on the literature review, it outlines barriers arising from financial market and investor practices and norms and looks at impacts on risk and return. It then examines policies and regulations through the same risk/return framework. Following this, it provides an outline of current and potential regulatory, firm and investor responses to these barriers.

Key Findings

The review identifies the following issues as areas of convergence in the academic, policy and financial literatures:

- The phenomenon of short-termism in financial markets undermines the ability to invest and manage risk with due consideration for environmental-related risk factors. It is driven in part by the practices and regulations that govern financial institutions. These include short-term benchmarks for performance measurement, risk management, reporting and compensation along with other factors such as decreasing CEO tenure, but also in the realm of financial regulation with the application of mark-to-market accounting practices, liquidity requirements, and insufficiently granular risk-based calibration and modelling.

- A number of major financial and investment policies, which have been implemented or are under development with the purpose of addressing policy objectives unrelated to facilitating a transition to a low carbon and environmentally resilient economy, are widely accused of being structured in ways that have unintended consequences on the ability of the financial sector to participate in this economic transition. These include, inter alia, Solvency II, Basel III, EU unbundling regulation and certain accounting regulations and standards. At the same time, sparse empirical evidence exists to support some of these claims, possibly because it is difficult to model the impacts of regulations which are under development and in varying stages of implementation, or to distinguish between transitional and permanent effects, as well as the type of market or region that may be affected.
- The lack of a mandate for companies to integrate ESG factors in decision-making, undertake materiality assessments or disclose environment-related risks hinders both consistent understanding of the issues and the ability to mitigate risks.
- Fiduciary duty and is often cited as an obstacle to incorporating ESG factors into the investment process. The argument that ESG-inclusive investing is inconsistent with fiduciary duty is based on the premise that including ESG factors in investment decision-making would compromise returns to achieve extraneous social or environmental objectives. This perspective is frequently argued as missing the mark on both the nature and goals of 'sustainable investing'. It is argued that the interpretation of fiduciary duty has evolved significantly over time and must continue to evolve to adjust to changing social and economic realities.
- In the wake of the global financial crisis, as new financial reform is being pursued this has the potential to have a positive impact on the transition to a low carbon economy, but in practice there are few instances where environmental sustainability issues have been integrated or even discussed in this context. Efforts are underway by governments (an estimated 40 countries and 20 sub-national jurisdictions) to lay the foundations of 'investment grade policy settings' with a price on carbon, but in other major investment destination countries there is inertia, or even worse from the perspective of interested investors: progress is being undone through the dismantling of carbon pricing mechanisms or retroactive change to support mechanisms for renewable energy.
- In recent years, major analytical research efforts have been aimed at quantifying and describing the nature of some of these above-mentioned issues and proposing solutions, from short-termism in financial markets to drivers of and responses to asset stranding. As more data and research become available and as the environmental sustainability agenda becomes more integrated with the broader long-term investment agenda, potential for meaningful and catalytic change exists.
- Finally, to date, the majority of the literature in this area has focused predominantly on OECD countries and comparatively little research exists for emerging economies and developing countries. This is an area identified as having great significance for future research.

4. Policies and Regulations

4.1 Policy and regulation favouring the fossil fuel economy

Globally, there are national fiscal policies that distort the risk/return calculus for green investments and tilt the playing field in favour of the fossil fuel economy. These include a lack of coherent carbon pricing that directly or indirectly encourages the production or use of fossil fuels. In OECD countries, such support often takes the form of reductions in or exemptions from indirect taxes, such as value-added taxes or excise duties. As a result of the continued existence of those support mechanisms, governments often end up having a policy package that explicitly and implicitly puts a price on carbon on the one hand, but also subsidises fossil-fuel production and use on the other. This policy mix is clearly not coherent and can significantly undermine the effectiveness of overall climate policies (OECD, 2013).

The OECD has identified over 550 individual support mechanisms that directly or indirectly encourage the production or consumption of fossil fuels across OECD countries (OECD, 2013o). The overall value of support

measures for fossil fuel consumption and production support identified in the OECD inventory is estimated to be between USD 55 and USD 90 billion a year for the period 2005-11. In addition, the IEA estimates the value of fossil fuel consumption support mechanisms in developing and emerging economies to be USD 544 billion (IEA, 2013). Such measures are often introduced in response to concerns over competitiveness or the distributional impacts of energy prices. However, they undermine the policies that seek to reduce countries' dependence on fossil fuels and impede the transition towards zero-carbon solutions, providing incentives to increase emissions of greenhouse gases instead. Moreover, support is often poorly targeted and thus inefficient in achieving its intended aims, as well as being very costly in terms of forgone revenue or budgetary outlays.

The OECD *Policy Guidance for Investment in Clean Energy Infrastructure* (OECD 2013) goes into greater depth on investment policy elements and describes aspects of investment policy frameworks in OECD and emerging and developing countries that alter the risk/return profile of green investments. These include:

- Instances where investment policy principles such as non-discrimination of foreign versus domestic investors, intellectual property rights, transparency and contract enforcement are not aligned with clean energy investments;
- Competition policy that obstructs investment in clean energy such as tilted playing fields between independent power producers (IPPs) and state-owned enterprises (SOEs), wholesale electricity markets that do not accommodate increases in renewable energy generation, and restriction of access of multiple actors to engage in electricity generation as well as transmission/distribution;
- Financial market policy that is inadequate to channel green finance e.g. underdeveloped domestic financial markets and access to long-term finance;
- Energy market design that features restrictions on foreign and domestic private investment in renewable energy, opaque and complex procurement processes for renewable energy projects, a lack of long-term PPAs for independent producers of renewable energy, and weak legal protection of renewable energy investors.

4.2 No mandated ESG integration or disclosure

The Investor Network on Climate Risk (2013) describes how ESG materiality assessments are not mandatory anywhere. A materiality assessment is the critical first step to understanding the various ways ESG factors may impact corporate value – both positively and negatively – and will facilitate more efficient allocation of resources to manage risks and take advantage of growth or other opportunities. Without these mandatory assessments, critical ESG issues are not discussed in annual financial statements. INCR calls for a movement 'from optional to a space where it is considered part of the fundamental reporting expectations'. INCR suggests that buy- and sell-side analysts would pay more attention to the risks and opportunities presented by ESG issues.

Financial and ESG data are often reported to investors using different timeframes and/or reporting cycles and INCR underlines that it is important that both sets of disclosures be aligned to avoid confusion and inaccurate analysis. INCR stresses that aligning reporting timeframes is an essential element to moving forward with the integration of financial and ESG information and the integration of sustainability into both business and investor decision-making.

The World Economic Forum (2013) argues that laws governing the disclosure of risks by publicly quoted companies generally do not require the identification of risks relating to climate, extreme weather, water or environment; yet these can be as material as other types of risks that must be disclosed, such as legal disputes or forthcoming legislation.

Della Croce, Stewart and Yermo (2011) argue that while there has been much interest in 'responsible investment' in recent years by pension funds and other institutional investors, most are far from fully and comprehensively integrating ESG factors in their investment strategies. Some regulators have introduced requirements for institutional investors to disclose whether ESG risks are considered in the investment strategy, but no regulator

has gone as far as actively requiring their integration in risk management strategies. Similarly, credit rating agencies are only slowly waking up to the importance of these risks for companies' financial health.

Regulators should also consider the integration of long-term investment risk factors (in particular, environment-related risks) in institutional investors' risk management strategies, as recommended in the OECD Guidelines for Pension Funds Risk Management and LTI principles (G20/OECD 2013).

IFC (2013) argues that there is a wide range of inconsistent terminology used both by investors and their initiatives to define green investments, including sustainability-themed, ESG-targeted, climate-sensitive, or climate-related investments and green allocations. This demonstrates the lack of a consistent understanding of the issues.

4.3 Risk-based funding regulations

Regulations sometimes exacerbate the focus on short-term performance at the expense of long-term investment in the green economy, especially when assets and liabilities are valued referencing market prices. The OECD suggests that this is the case where quantitative, risk-based funding regulations are used in combination with mark-to-market valuations for pension fund balance sheets in countries such as Denmark, Finland and the Netherlands (Della Croce et al., 2011). The Financial Stability Board (2013c) has suggested that more granular and detailed analysis of the risk profile of long-term projects of the infrastructure type should be reflected in the regulatory framework, to improve the targeting of financial regulation to such risks.

On the one hand, the measures have been associated with investors matching assets and liabilities more closely, and moving to lower-risk, fixed-term assets (e.g. sovereign bonds) which provide a long-term return that better matches the expected cash flows of the insurance contract or pension liability. On the other hand, to the extent that the regulations use short horizons for assessing solvency or apply different methods of fair valuation to the assets and liabilities, thereby creating excessive volatility in financial statements, they may promote myopic behaviour and impinge on the ability of those investors to participate in certain long-term asset classes (Severinson and Yermo, 2012).

The standard-setters are continuing to work on this issue, both in the context of the development of these standards and as part of the wider reassessment of the conceptual framework for financial reporting. However, it is important to note that other financial market developments – such as the increasing use of short-term benchmarks for performance measurement, risk management, reporting and compensation – may also have contributed to an excessive focus on short-term returns (Severinson and Yermo, 2012).

4.4 Liquidity requirements

Particularly since the 2008 financial crisis, regulators, rating agencies, and investors have been heavily focused on the liquidity of investment portfolios. This focus has taken different forms depending on the jurisdiction and the nature of the institution, but is prevalent globally. While the focus on liquidity is certainly understandable, a swing of the pendulum in the other direction may lead institutions to leave potential returns on the table and to pass on investment opportunities that may generate significant benefits such as green infrastructure (Climate Policy Initiative, 2013). Rather than shunning illiquid investments altogether, careful analysis of the acceptable illiquidity risks and proper accounting of options to hedge this risk could encourage more investment. Furthermore, several policy mechanisms could reduce the cost of illiquidity by offering liquidity reserves to back up these investments or by enabling clearing houses that could improve the liquidity of these project investments (Climate Policy Initiative, 2013).

The FSB has highlighted that experts attending its roundtables questioned the calibration of risk-based capital requirements for long-term investment finance – in their view there has been inadequate attention paid to

research indicating lower default rates on project loans than on corporate debt of the same maturity (including for green infrastructure). Moreover, the weight and sensitivity of capital charges to duration risk was too high in their view. And they also questioned whether there was excess focus on market spread movements (reflecting interim value changes) rather than on exposure to actual defaults (Financial Stability Board, 2013c).

Standard & Poor's (2014) echoes these questions in a report entitled *Low Default Rates and High Recoveries for Infrastructure Projects*. S&P argues that default and recovery statistics indicate that the creditworthiness of infrastructure projects is strong, and expected to continue. They state (2014:14) that since the 'first rated project default in 1998, the average annual default rate for all project finance debt rated is just 1.5% – below the 1.8% default rate for corporate issuers in the same period'. On top of its stronger resistance to default, project finance debt also delivers a better rate of recovery when defaults do happen. The average recovery rate across S&P's rated project finance portfolio is about 75% – with most lenders receiving close to 100%, and very few getting shut out entirely. This reflects the specific characteristics of project debt, which typically benefits from strong collateral, with lenders enjoying first-priority security. In many cases, strong collateral in tandem with certain contractual features enables projects that default to continue as going concerns, thereby ensuring cash flow and bolstering recovery prospects. Either way, S&P states that it is clear that post-default recoveries for project finance are considerably stronger than the average of about 45% among corporate borrowers (Standard & Poor's, 2014).

4.5 The debate over the implications of Basel III

Basel¹ III is a comprehensive set of policy measures designed to strengthen the regulation, supervision and risk management of the banking sector in response to the financial crisis. The Basel III framework builds on and enhances the regulatory framework set out under Basel II and Basel 2.5. Basel III has been flagged by many institutions and authors as having problematic implications for the transition to a green economy (Spencer and Stevenson, 2013; Lowder, 2012; Narbel, 2013; Alexander, 2014; G20/OECD 2012; Ceres, 2014; BNEF, 2013) on the risk and return sides of the equation.

It has been accused of causing banks to curtail lending to infrastructure projects, including renewable energy projects. Specifically, implementation of the new bank liquidity requirements² is alleged to be responsible for reducing loan tenors, increasing interest rates, and ultimately driving up the cost of financing for clean energy (Spencer and Stevenson, 2013; Lowder, 2012; Narbel, 2013).

The main objective of the reforms is to improve the banking sector's ability to absorb shocks arising from financial and economic stress, thus reducing the risk of spillover from the financial sector to the real economy. The key elements of Basel III are: (1) the strengthening of the regulatory capital framework by raising the quantity and quality of the capital base, enhancing risk coverage, supplementing the risk-based capital requirement with a leverage ratio backstop, and promoting the conservation of capital and reducing procyclicality via additional capital buffers; and (2) the introduction of two minimum global liquidity standards (Financial Stability Board, 2013b; Basel Committee on Banking Supervision, 2014). Such requirements are intended to ensure that banks always have sufficient liquid assets³ on hand to enable them to withstand periods of market stress (i.e. a run on the bank).

¹ The Basel Committee on Banking Supervision consists of senior representatives of bank supervisory authorities and central banks from Argentina, Australia, Belgium, Brazil, Canada, China, France, Germany, Hong Kong SAR, India, Indonesia, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Russia, Saudi Arabia, Singapore, South Africa, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The committee's governing body is the Group of Central Bank Governors and Heads of Supervision, which comprises central bank governors and (non-central bank) heads of supervision from member countries. The committee usually meets at the Bank for International Settlements (BIS) in Basel, Switzerland, where its permanent secretariat is located.

² Basel Committee on Banking Supervision, 'Basel III: The Liquidity Coverage Ratio and liquidity risk monitoring tools'; Bank for International Settlements, January 2013, <http://www.bis.org/publ/bcbst238.pdf>

³ Liquid assets can be sold (hence converted into cash) quickly and easily without the seller being forced to accept major reductions in price.

The regulations in question are still being defined, and their implementation will be phased in over the coming decade. Significant changes have recently been made to a key measure of the regulations, the Liquidity Coverage Ratio (LCR). The EU transposition of Basel III, Capital Requirements Directive (CRD) IV, is still under negotiation. New regulations are under consideration at the national and EU level, such as those concerning the ring-fencing of retail banking and procedures for unwinding insolvent banks while limiting public involvement (Basel Committee on Banking Supervision, 2014). Further, some measures and some regulatory impacts, such as cost and availability of bank credit, have been the subject of detailed quantitative assessment. Other impacts, for example on securitisation or the tenor of bank credit, have been subject to more qualitative assessment.

Basel III and CRD IV aim to increase the stability and liquidity of bank funding, and improve the temporal matching of assets and funding sources. The two central measures are the LCR and the Net Stable Funding Ratio (NSFR). The LCR aims to ensure that banks have a sufficient stock of high quality, liquid resources to cover their funding needs during a 30-day period of funding stress. The NSFR requires banks to fund longer-term assets with stable funding of at least a one-year maturity.

The phase-in of the LCR begins in 2015 and should be fully implemented by 2019, the NSFR by 2018. Spencer and Stevenson (2013) argue that the LCR in particular will, 'induce a capital reallocation to highly liquid assets eligible for compliance (especially sovereign and central bank bonds, cash, and some highly rated corporate bonds). In order to comply with the NSFR, banks will make use of longer-term and hence in principle higher cost funding. This in turn will create incentives for a decrease in asset tenors in order to reduce the cost of regulatory funding requirements under the NSFR. Banks will become more sensitive to temporal mismatches between assets and funding, and hence more reluctant to hold long-term assets.' (Spencer and Stevenson, 2013: 8).

Ceres (2014) argues that loans to renewable energy and other infrastructure projects do not help banks to meet their LCR thresholds. To make room for additional holdings of assets that do count toward LCR thresholds, banks are selling off project finance loans and reducing the supply of capital for renewable energy developers. The NSFR requires banks to fund a greater proportion of their illiquid, long-term assets – such as loans to renewable energy projects – with longer-term sources of funding such as Eurobonds and customer deposits. Since longer-term funds are more expensive, however, Ceres (2014) argues that this requirement is causing banks to charge higher interest rates for long-term loans, increasing debt costs for renewable energy projects; and/or shorten loan durations (for example, making five to ten-year loans instead of ten to 15-year loans). Shorter loan tenors introduce risk such as whether a project will be able to refinance when its initial loan expires. Since cash flows from a project will be used to repay debt before giving any returns to equity investors, uncertainty about the cost of debt over a project's lifetime creates greater risk for equity investors (who typically fund at least 20% of renewable energy projects). This added risk increases the required return for equity capital, thus further increasing the overall financing cost for renewable energy projects.

Specifically, project finance loans at 15 years or more maturity constitute the primary source of capital for high and low carbon energy infrastructure, while bank lending provides nearly 90% of the project finance credit for low-carbon infrastructure projects (Alexander, 2014). Under Basel II's standardised approach, long-term project loans at 15 years or more were given the same risk-weighting as shorter-term loans under ten years. In contrast, under Basel III's standardised approach, bank credit for long-term project finance lending (15 years or more maturity) is given a higher risk-weighting than equivalent loans over a shorter term, thereby attracting a higher capital charge. Spencer and Stevenson (2013:9) argue that this will increase refinancing risks for low-carbon borrowers. They also state that the NSFR will 'create incentives to move low-carbon assets off balance sheet through the sale of project finance loan books or the securitisation of low-carbon loans'. Finally, contingent credit obligations, such as letters of credit and revolving credit facilities, are treated unfavourably under both the LCR and NSFR, which may have an impact on the provision of construction finance that is important for low carbon infrastructure development (Spencer and Stevenson, 2013).

Though implementation of Basel III is just beginning (and will stretch from 2013-19), its impacts on lending to renewable energy projects are described by Ceres (2014) as already becoming clear, especially for European

banks⁴, which are the dominant lenders to renewable energy projects. To rectify an expected shortfall in long-term liquidity under Basel III of EUR 2.3 trillion, European banks are said to have unloaded over USD 11 billion in project finance loans (often at discount prices) to US and Japanese banks in 2012. Tenors on project finance loans are also reported to have shrunk from ten to 15 years to five to ten years (Lowder, 2012). PWC reports that Europe's largest financial institutions, including HSBC and Deutsche Bank, are expected to sell a combined USD 78 billion, of so-called non-core loans (including project finance) in 2014, a 33% rise compared with 2012 (PWC, 2014). This contraction in the supply and duration of available bank debt is said to threaten to drive up financing costs for renewable energy projects. Since the dominant renewable energy generating technologies, such as wind and solar, require high upfront costs, any increase in the cost of long-term debt finance will undermine project economics (BNEF, 2013).

Ceres (2014) argues perhaps most challenging is that – by diminishing the portion of bank balance sheets that can be allocated to asset-backed securities – Basel III may discourage banks from securitising portfolios of loans to renewable energy projects. Since securitisation is a key long-term solution to scaling up renewable energy investment, implementation of Basel III may cause short-term pain (as banks curb project finance lending) and also delay progress toward the long-term goal of connecting renewable energy projects with capital markets.

Currently, securities play relatively little role in direct low-carbon financing. Bonds do play a role in corporate financing and public financing (public banks and government entities), and hence in low-carbon financing via these entities' balance sheets. However, low-carbon project bonds and the securitisation of low-carbon assets remain negligible. Nonetheless, the need to scale up and accelerate low-carbon investment has created interest in tapping new sources of capital such as institutional investors, including via low-carbon bonds and securitisation (Kaminker and Stewart, 2012).

Broadly speaking, these regulations imply that the low-carbon sector will need to develop highly rated, transparent, liquid and standardised securities if it is to tap such sources of capital. Given the relatively small size and lack of depth of low-carbon secondary markets and regulatory evolutions, developing such instruments may be a challenge.

On the risk side of the equation, a number of interesting arguments have been made over the implications of Basel III for both high and low carbon assets. Alexander (2014:4) states that preliminary findings from his research show that bank lending and risk management and measurement practices do not take into account the financial stability risks associated with carbon-intensive activities that are financed by bank credit. He argues that under Pillar 2 of Basel 'bank supervisors have not engaged bank risk management officers to incorporate into their stress tests the financial stability risks of climate change or to devise forward-looking models that estimate the potential social costs of supplying credit to carbon-intensive activities over time and of the potential social benefits of supplying credit to low-carbon assets.' Alexander (2014) explains that based on interviews with regulators and bank risk officers and a review of regulatory documents and risk management strategy plans, there has been no meaningful dialogue between bank risk officers and bank supervisors regarding the financial stability risks associated with carbon-intensive energy production.

On the other side of the coin, Alexander (2014:11) argues that Basel III has failed to take account of the 'positive externalities or macro-prudential benefits of low carbon bank assets that can reduce macro-economic risk and systemic risk associated with climate change and ocean acidification'. This regulator omission is suggested to have contributed in part to a disproportionately large supply of credit for high carbon asset projects relative to the available credit for low carbon asset projects. One of the preliminary conclusions of the report is that cheap

⁴ Though the above discussion emphasises the impacts of Basel III implementation in Europe, note that regulators in the US and China are also fully implementing the Basel III requirements. For example, a recent report from the Bank of International Settlements (BIS) – the organisation responsible for overseeing creation of Basel III – found China's implementation of the Basel capital framework to be closely aligned with the Basel III global standards. Basel Committee on Banking Supervision, 'Regulatory Consistency Assessment Programme (RCAP)'; 'Assessment of Basel III regulations – China', Bank for International Settlements, September 2013, http://www.bis.org/bcbs/implementation/l2_cn.pdf

bank credit for carbon-intensive projects can exacerbate environmental externalities and contribute to financial stability risks over the medium to long-term.

4.6 The uncertainty around deployment, application and calibration of Solvency II

Focusing on the European Union, Solvency II – often described as “Basel for insurers” – is a directive that seeks to lower the risk exposure of European insurance companies by imposing higher capital requirements (EIOPA, 2014). The objective is to ensure the financial security of these companies. Climate Policy Initiative (2013) states that the rule sets reserve requirements for different asset classes, which as structured could make project investment in renewable energy – particularly project debt – considerably more expensive by requiring companies to hold more reserves against these projects. Standard & Poor’s (2013) describe this as a ‘concern in the market’. The European Insurers and Occupational Pensions Authority (EIOPA) discussion paper on this topic published in May 2013 is widely regarded as not having gone far enough. Some market participants believe that project finance default and recovery rates are superior to corporates and should be reflected more in the capital allocation and weighting under Solvency II. This view is widely held in the market and backed up by Standard & Poor’s latest default and recovery study, *Project Finance Default and Recovery: Shale Gas Fuels Rise in U.S. Defaults* (August, 2013).

Ceres (2014) states that even for investors allowed to invest in infrastructure, financial regulations still pose considerable challenges to investing in projects related to clean energy (whether via direct or semi-direct means). In a recent BNEF poll of 65 senior institutional investors, asset managers, bankers, utility executives, project developers, and policymakers, 35% of respondents cited financial regulation as ‘the most important issue deterring institutions from making investments in clean energy projects’ in Europe. BNEF (2013) states that ‘Solvency II regulations governing the need for insurance companies to hold capital in supposedly liquid and/or low-risk instruments like public equities and government bonds will reduce their appetite for long-term investments for which there is no public market, even though such investments have well-understood yield characteristics and a well-developed private market.’

The impacts of Solvency II on the low-carbon sector are more prospective in nature, given the current small role played by institutional investors in general. However, in the context of banking sector disintermediation from long-term lending, institutional investors may have a role to play in bridging the long-term financing gap. Macroeconomic conditions, notably historically low yields on sovereign debt, are also increasing institutional investor interest in such non-traditional assets; several low-carbon projects in the EU have recently attracted equity involvement from institutional investors, notably pension funds. Concerning insurers, Spencer and Stevenson (2013) state that Solvency II will discourage this kind of investment, specifically equity investment in infrastructure. Given the underdevelopment of low-carbon securities and the unfavourable treatment of asset backed securities under Basel III/CRD IV, direct equity investment in infrastructure could be a key channel for insurers to participate directly in low-carbon investment.

The risk-based solvency rules at the core of Solvency II have been proposed for application to European pension funds as well, although no decision had been reached at the time of writing. Interestingly, Climate Policy Initiative (2013) states that this uncertainty around the eventual application of these rules seems to hamper pension funds more than insurance companies, even though insurance companies are the main target of the rules. Climate Policy Initiative (2013) describes interviews recorded with several European pension funds where they highlighted their own concerns about potential regulations that may apply to them: ‘Solvency II does not necessarily affect us, but the uncertainty about whether it will or whether future related regulation may be applied to us, makes us very concerned about the cost of having private placement debt in our portfolio.’

Solvency II regulation is also thought to create incentives for higher rated, shorter dated securities. Solvency Capital Requirement (SCR) charges are inversely proportional to the investments’ rating; they are also increasing with lengthening tenor. Low-carbon pure play companies are generally smaller and lower rated, and this may increase the cost of their access to capital markets. By contrast, the structure of SCR charges may benefit larger,

more diversified players such as integrated utilities or multi-sector equipment providers, as these tend to benefit from higher credit ratings.

Solvency II will have ambiguous impacts on insurers' investments in infrastructure, i.e. direct equity investment in capital assets, such as power plants, energy transmission infrastructure, or transport infrastructure. On the one hand, Solvency II no longer quantitatively limits the amount that insurers may invest in non-listed assets (infrastructure, private equity, venture capital), as was the case under Solvency I. However, under Solvency II infrastructure investments are subject to SCR charges in excess of the expected annual returns, which tend to be low but consistent. This mismatch between SCR charge and return for infrastructure investment creates a strong disincentive to direct investment in infrastructure. This may have negative repercussions on the low-carbon sector, in particular given the underdevelopment of the low-carbon securities market (Spencer and Stevenson 2013).

Despite the strong credit characteristics of project finance (see discussion above from S&P), Standard & Poor's (2014) argues that the regulatory capital treatment proposed under Solvency II would appear to penalise insurers for holding long-dated, low- to mid-investment-grade project debt (that is, debt rated in the BBB and A categories). This is mainly because the regulation has been drawn up according to a corporate loan matrix and does not take into account the specific default and recovery characteristics of the project finance sector, or other characteristics such as a strong security package and transaction structure. For example, a 12-year BBB+ rated project loan would incur a 22% capital charge. This is considerably higher than for, say, a two-year BB corporate loan. Indeed, speculative-grade short duration loans (rated BB+ and below) require less capital allocation by insurers than a four-year BBB+ or eight-year A+ project investment.

As a result, insurers either have to charge higher margins to remain profitable or develop their own internal models that capture the specific credit characteristics of project finance transactions and have these models approved by a local regulator. Despite these disincentives, we observe that the insurance sector generally continues to view the sector as attractive, at least for the time being (Standard & Poor's, 2014).

4.7 Accounting regulations

Recent trends in accounting include the introduction of mark-to-market accounting for investments to increase transparency. As Climate Policy Initiative (2013) describes, in broad strokes, mark-to-market accounting has driven pension funds in some countries towards higher allocations to fixed income securities, and encouraged greater use of liability-driven investing to immunize plan sponsors from large swings in funding status. However, mark-to-market accounting can be difficult to apply to illiquid investments with long holding periods such as unlisted equity and debt. Countries vary in the time frame that changes in market value need to be accounted for, but in some cases, there can be large differences in the short-term market value of an illiquid long-term asset and the expected value of the asset over its full life. These issues can be mitigated by allowing long-term investments to be valued in ways that reflect their true long-term economic value (Climate Policy Initiative, 2013).

Participants at a Financial Stability Board Roundtable (2013c) noted that accounting standards are intended to be neutral in that they do not reward specific behaviours or promote key outcomes. But the FSB notes that they do incentivise preparers to manage what they measure, and there is some evidence that this includes short-termism (e.g. banks can and do manage assets and liabilities to help achieve leverage ratio targets).

The World Economic Forum (2013) describes how public sector accounting rules can influence the choice and level of incentive mechanisms available to policymakers to encourage clean energy deployment. Even when there is a clear intention to support clean energy, the fact that liabilities associated with feed-in tariffs or green certificates may be included in tax or spending totals – even though the cost will, in fact, be borne by electricity consumers – puts pressure on treasury departments to limit support for clean energy.

4.8 Quarterly reporting cycle and intra-day reporting requirements

Generation Investment Management (2012) describes how quarterly earnings guidance can create incentives for executives to manage for the short term and encourage some investors to over-emphasise the significance of these measures at the expense of longer-term, more meaningful measures of sustainable value creation. They advocate ending this default practice in favour of only issuing guidance as deemed appropriate by the company (if at all), which would encourage a long-term view of the business rather than the current focus on quarterly results. They propose that a more thoughtful issuance of earnings guidance is compatible with enhanced standards of disclosure.

4.9 Fiduciary duty and modern portfolio theory

A Global Agenda Council report (World Economic Forum, 2013) argues that laws governing the fiduciary duties of pension fund trustees have been interpreted as directing pension funds to adopt a narrow focus on risk-adjusted returns. Because they do not explicitly require trustees to take account of systemic risks such as climate change, or of performance on environmental, social or governance dimensions, investors have tended to avoid such analysis. In particular, no account is generally taken of the risk of write-downs to the value of fossil fuel assets if future action on climate change renders them stranded.

Clark (2011) writes that ‘fiduciary duty is the golden rule “regulating” the relationship between trustees and beneficiaries. In principle, it regulates behaviour by pre-empting those actions that would harm the interests of beneficiaries while promoting duties of care consistent with the interests of those that stand to gain from well-intentioned and responsible decision-making.’ But, in many respects, Clark argues (2011:1) that fiduciary duty ‘is a chimera: it looks to convention rather than forward to innovation in investment management. As such, governance policies and practice must provide the instruments that simple recipes of fiduciary duty are ill-equipped to provide.’ In the paper, he argues that the design and governance of investment management institutions is, actually, more important than honouring the principle fiduciary duty which, ‘in the context of Anglo-American statute, is increasingly empty’.

While the business case for sustainability is increasingly clear (Harvard Business Review, 2014), some directors of companies and of investment funds continue to be unsure about whether sustainability is a fiduciary issue. Accordingly, the Generation Foundation conducted a review of the legal case for sustainability as a fiduciary issue in 2005. In the years since, the idea of sustainability as a fiduciary duty has gained momentum, even though implementation lags. Generation Investment Management (2012) argues that it is clear that the broad trend is toward the acceptance of sustainability issues as a legitimate consideration by directors and even, increasingly, as an obligatory consideration. In this regard, they draw attention to the precedent-setting action by Intel Corporation, when in March 2010, the company made sustainability a fiduciary duty by amending its corporate charter to include mandatory reporting on ‘corporate responsibility and sustainability performance’.

Ellsworth and Spalding (2013) write that the overriding objective of institutional trustees and managers is to generate sufficient, consistent risk-adjusted returns that enable the fund to pay benefits and meet its liabilities over multiple generations. This goal is embedded in fiduciary duty and is often cited as an obstacle to incorporating ESG factors into the investment process. The argument that ESG-inclusive investing is inconsistent with fiduciary duty is based on the premise that including ESG factors in investment decision-making would compromise returns to achieve extraneous social or environmental objectives. This perspective, they argue, misses the mark on both the nature and goals of ‘sustainable investing’.

Ceres (2010) argues that modern portfolio theory (MPT), an approach to portfolio construction first developed in the 1950s, has played a dominant role in prevailing concepts of fiduciary duty – in particular the duty of care and its principles of prudence and diversification – over the past several decades. Briefly, MPT is a mathematical formulation of the concept of diversification of assets in a portfolio, in which higher risk demands higher returns. According to MPT, portfolio risk is reduced by investing in multiple non-correlated asset classes,

thereby maximising risk-adjusted returns. MPT is based on a number of economic assumptions, including that markets are fully efficient and investors are entirely rational: that all market players have access to all relevant information and act in their economic self-interest based on that information.

Ceres (2010) argues that the interpretation of fiduciary duty has evolved significantly over time and must continue to evolve to adjust to changing social and economic realities. For example, rigid rules specifying prohibited and permitted investments gave way to MPT and diversification across multiple asset classes. It underscores that today, ‘new investment risks and opportunities based on emerging trends like climate change and resource scarcity require consideration by prudent fiduciaries’. This approach, which it has termed sustainable investing, adopts a longer-term focus, is less tied to short-term benchmarks as the sole measure of success, and incorporates ESG factors into investment analysis and strategy. It argues that this is fully compatible with MPT and provides a clear path for today’s fiduciaries to comply with their duties of loyalty and prudence.

Ceres (2010) concludes its report by stating that ‘environmental and social variables can no longer be treated as extraneous “non-financial” matters. These drivers of investment risk and opportunity are becoming increasingly important in developing strategies to manage risk and seek adequate risk-adjusted returns. Given the increased availability of ESG data and evidence of its materiality to company and investment performance, we believe that disregarding such information would be inconsistent with the responsibilities of 21st century fiduciaries.’

4.10 Investment restrictions

Institutional investors are obliged to meet a variety of prudential regulations and to comply with accounting standards. On the regulatory side, investment choices may be constrained by the need to meet prudential limits. For example, ceilings on certain types of investments (such as equity or non-liquid/marketable debt) apply to pension funds in some European countries, and are relatively common in emerging and developing market economies (Financial Stability Board, 2013b).

Ceres (2014) highlights that pension funds in many countries face a barrier to clean energy infrastructure investment that is more fundamental than most of the issues discussed in this report so far and comes in the form of regulations that prohibit investment in infrastructure outright. For example, Indonesia’s civil servants pension fund (Jamsostek) and nearly all public pension funds in China (with the exception of the National Social Security Fund) are barred from investing in infrastructure. Nor is the issue of regulatory obstacles to infrastructure investment relevant only to emerging markets: many EU countries also proscribe their pension funds from allocating money to infrastructure (Kaminker et al, 2012; Inderst, 2013).

Though regulations on pension investment in infrastructure usually aim to serve legitimate purposes (e.g. preventing pension funds from becoming piggy-banks for government-backed infrastructure projects), Ellsworth and Spalding (2013) and Ceres (2014) write that they are often also excessive and increasingly unnecessary over time as pension fund fiduciaries become more professional and independent from political meddling. They continue that reforming such regulations will often be necessary to increase institutional allocations to clean energy infrastructure (particularly in developing countries), and is an issue that will have to be reckoned with on a country-by-country basis.

The OECD (Della Croce et al, 2011:2) write that regulatory barriers in some countries may be preventing institutional investors from investing in such assets. ‘Though investment restrictions are important to protect pension fund members, there may be unintended consequences preventing investment in infrastructure through bans on unlisted or direct investments.’ The Financial Stability Board (2013b:17) states that while investment restrictions ‘strive to ensure that institutional investors are able to meet their obligations, they may have influenced investment behaviour and constrained the long-term outlook of those investors’.

At the FSB roundtables in 2013, participants also highlighted that national limits on different types of investment by institutional investors could impede greater finance provision. And while additional data and information on long-term investment projects could aid improved risk assessment and support regulatory policy, it was also noted that disclosures need to be carefully designed to avoid transparency inhibiting the participation of certain specialist investment funds (Financial Stability Board, 2013c).

Table 5: Key differences between pension fund and insurance company investment restrictions

	Insurance Companies	Pension Funds
Duration	Life insurers have long duration liabilities leading to long investment horizons Property and casualty policies are renewed annually	Funds with older members have less time to beat investment performance downturns, so focus on conservative strategies (e.g., fixed income)
Funding / Reserve Levels	Companies with larger reserves can take more risk or expand business offerings Uncertainty can be met through reinsurance or investment policy	Well-funded funds can take more risk utilizing reserves Under funded funds take on risk to make up for gaps, if regulation permits
Regulation	Heavy regulation requires insurers to maintain adequate coverage of mismatches between investments and liabilities (often limiting illiquidity)	Corporate pension funds are often more regulated than government pension funds and may be subject to greater reporting requirements Some, particularly corporate pension funds, are required to mark shortfalls to market. Increased performance volatility may make fund managers more conservative (or shift to defined contribution)
Result	Life insurers tend to be conservative investors (heavily liability driven) with sophisticated ALM processes	Pension funds tend to seek higher risk/return but face a wider range of objectivities and perspectives. Regulatory changes push many towards Liability Driven Investing or defined contribution and pension outsourcing

Source: Climate Policy Initiative, 2013

4.11 Financial, investment and competition policies with unintended consequences

As Climate Policy Initiative and Kaminker et al (2013) state, the investment case for low carbon energy almost always has a significant policy element, while the institutions investing are themselves subject to their own set of regulations. As such, unintended consequences can manifest when policies designed to encourage renewable energy are implemented using mechanisms or incentives that either discourage institutional investors or favour other types of investors. For instance, in some countries renewable energy support is driven through the tax code. To benefit from tax credits, institutional investors must first have a tax liability. Tax-exempt pension funds or sovereign wealth funds and other foreign entities are therefore excluded.

There are also instances of policies addressing unrelated policy objectives – for instance, the security of financial markets – that are structured in ways that have severe unintended consequences on the ability of institutional investors to invest in renewable energy. Competition policy in the EU designed to protect electricity markets from manipulation or other anti-competitive actions by unbundling or prohibiting simultaneous ownership of both transmission and electricity generators forces institutional investors to choose between owning transmission assets or generation assets.

4.12 A lack of instruments and vehicles

As described by the OECD (2014), highly liquid vehicles exist for other investment asset categories, but they have not yet been permitted for use in green infrastructure investments. A master limited partnership is a publicly traded limited partnership that includes one or more partners who have limited liability. A real estate investment trust (REIT) is a corporation or trust that uses the pooled capital of many investors to purchase and manage income property and/or mortgage loans.

5. Overview of stakeholder responses

5.1 Financial regulations and investor practices

In the wake of the global financial crisis, as new financial reform is being pursued this has the potential to have a positive impact on the transition to a low carbon economy, but in practice there are few instances where environmental sustainability issues have been integrated or even discussed in this context.

For instance, the possibility that regulatory reforms may have unintended impacts has been recognised at the G20 level but, as of the time of writing, no specific attention has been called to issues pertaining to green or sustainable infrastructure. In the G20 Communiqué of the Meeting of Finance Ministers and Central Bank Governors in July 2013, G20 leaders asked the FSB to continue the, 'monitoring [of] the impact of financial regulatory reforms on the supply of long-term investment financing'.

The Financial Stability Board (2013c) writes that since many of regulatory reforms are still in the process of policy development or at an early stage of implementation, it is too early to observe the effects of regulatory reforms on the provision of long-term finance. In addition, financial regulation is only one of a number of influences that affects the incentives of providers to offer long-term finance and financial products. It argues that it is also difficult to distinguish the effects of stronger financial regulation from other influences such as the desire of finance providers to improve their internal risk management practices and to hold higher capital and liquidity buffers as a response to the lessons of the crisis. Further, it underscores that it is also challenging to separate structural factors such as stronger regulation and risk management from the impact of weak growth and continuing deleveraging in major parts of the global financial system.

Thus, it argues that any assessment of the impact of financial regulation on long-term finance needs to take account of the changes in incentives on different potential finance providers and risk holders throughout the life of a project. All risks in the project need to be identified and properly managed. If a particular agent is not a natural holder of that risk then a lack of a ready mechanism to hedge or offload the risk could substantially weaken the provision of overall long-term finance. 'An assessment of the impact of regulation thus also needs to factor in the ease of transferring risks and finance provision between different intermediaries. For example, how easy is it for finance providers holding construction risks to exit the project once the build stage is completed, and for institutional holders to enter at that point? And how easy is it for potential investors to hedge and manage any long-term exchange rate and interest rate exposures?' (Financial Stability Board, 2013c: 21)

Despite these difficulties, Alexander's findings (2014:9) suggest that some changes can be identified and plausibly made. For instance, the market discipline approach in Pillar 3 of Basel III should be enhanced to include mandatory rules on both qualitative disclosures (e.g. voluntary codes and industry standards) and quantitative disclosures (e.g. as defined by the financial regulator). This, he argues, would provide an effective and a more economically efficient tool, which would simultaneously improve accountability through further clarifying fiduciary duties of a bank board to undertake risk assessments to obtain this information.

Narbel (2013) writes that a potential solution is pooling capital intensive renewable energy projects in a portfolio and selling down the portfolio in tranches to various types of investors. The benefit of this solution for banks is that it would allow them to maintain the financing of capital intensive renewable energy projects, while complying more easily with Basel III.

With regards to credit rating agencies (CRAs), the goal of the FSB's principles (Financial Stability Board 2013a) is to end mechanistic reliance on CRA ratings by banks, institutional investors and other market participants by reducing the 'hard wiring' of CRA ratings in standards, laws and regulations and by providing incentives for firms to develop their own capacity for credit risk assessment and due diligence. A contingent benefit of building firm capacity for credit risk assessment and due diligence could be to disperse an appreciation of climate risk in ratings far beyond the four CRAs that traditionally have been over-relied on.

Ceres (2014:20) has called for regulators to move towards, 'removing or reducing barriers to investing in infrastructure – whether in the form of outright prohibitions or excessively high capital requirements – may therefore expand possibilities to capture higher risk-adjusted returns'. It has also stated that regulators ought to, 'consider how to reconcile stronger liquidity requirements with continued bank lending to clean energy'.

The OECD (Della Croce et al, 2011:5) has stated that, 'financial regulators and supervisors also have a role to play in encouraging long-term, active investment. They can support national or international codes of good practice (such as the Stewardship Code which is gaining widespread support in the UK) and issue guidance themselves of how they expect institutional investors to behave.' The OECD proposes that, 'in order to nudge investors to follow such guidance, supervisors can shift the focus on their investigations, enquiring as to the turnover of funds, the length of mandates given to external managers, how fees are structured, voting behaviour etc.'

It argues that if supervisors believe that investors may be acting in too short-term a manner, they could increase their oversight of the institution. Such actions could help address the agency problem, making institutional investors aware of their fiduciary duties and that they are the ultimate owners of the companies in which they invest, with the consequent responsibilities this entails. Supervisory authorities could also help to foster a focus on longer-term performance by releasing or requiring comparative data on returns over longer time periods (Della Croce et al, 2011).

The OECD (Kaminker et al, 2013:47) argues that the prerequisite to increasing institutional investor allocation to green infrastructure is to make sure that green investments are competitive on a risk-adjusted return basis. It argues that, 'investors with fiduciary responsibilities will not make an investment just because it is green – their primary concern is that it simply has to deliver financially. This principle is codified in the Employee Retirement Income Security Act of 1974 (ERISA), whereby it is in investors' legal duty to invest solely in assets with competitive risk-adjusted returns.' It submits then that the challenge is for, 'governments to design efficient and prudent policy frameworks and corporations to structure deals that allow this and encourage evolution of the industry towards a sustainable state, allowing investors to capture the increasing price competitiveness of renewable energy while providing the regulatory certainty that long-term investors need.'

In some cases progress is being made by countries towards creating 'investment grade policy settings', with an estimated 40 countries and 20 subnational jurisdictions putting a price on carbon, but in other major investment destination countries there is inertia (the United States) or, even worse from the perspective of interested investors, progress is being undone through the dismantling of carbon pricing mechanisms (Australia) or retroactive change to support mechanisms for renewable energy (Spain, Bulgaria and elsewhere in Southern Europe).

5.2 New business models

Standard & Poor's (2014) writes that all told, deepening capital markets and the greater participation of non-bank investors can help expand private financing opportunities for infrastructure, with banks still likely to step in as arrangers and facilitators, or to provide bridge financing. New business models are emerging with European banks potentially providing bridge financing during a project's construction phase, with refinancing coming from a bond sale or investment from the infrastructure funds, insurers, or pension managers that need

long-term yields. Alternatively, the bond market might provide all of the required financing from the outset, which has been the US model for many years. But it echoes the OECD's statements (above) in believing that 'significant increases in institutional involvement are possible only with sufficient supply of infrastructure assets and favorable political-economic environments'.

Meanwhile, the agency argues that in Latin America the need for infrastructure spending could create an opportunity for further development of the capital markets. In most of the region's countries, regulations have fostered an infrastructure project bond market, including allowing pension funds and other institutional investors to participate. In Asia-Pacific, by contrast, project finance bonds remain unpopular and have a very limited presence, compared with loans. Nevertheless, given the aforementioned large financing gap, it expects non-loan instruments such as project financing bonds to become more prominent there (Standard & Poor's, 2014).

5.3 ESG reporting and disclosure

According to Ceres (2014), investor demand for mandatory environmental and social disclosure is pushing ESG reporting into the mainstream. Seventeen countries already require some form of corporate sustainability disclosure, and there is increasing support for similar requirements in the United States. The first concerted initiative in the US occurred in June 2009 when investors representing USD 1.4 trillion in assets called on the SEC to issue interpretive guidance concerning disclosure of material sustainability risks in financial filings. In response to this letter and other investor requests that were initiated as early as 2003, the SEC issued formal guidance on climate risk disclosure in February 2010. A few weeks later 56 investors with over USD 2 trillion in assets under management praised the SEC for issuing the guidance, but noted that 'few companies disclose sufficient information about climate change issues in SEC filings to allow us to make more informed investment decisions' (Congressional Research Service, 2013).

Institutional investors and investment managers, by writing letters to the SEC, by focusing attention on companies exemplifying best and worst practices, and by participating in face-to-face meetings with regulators and other policymakers, can help make disclosure of all material ESG risks both mandatory and more complete. As more investors support mandatory disclosure of sustainability risks, the systematic efforts of other organisations to bring about change in this area will also be strengthened – organisations that include the International Federation of Accountants, SASB, IIRC and the Canadian Institute of Chartered Accountants.

Indeed, some pension funds have been taking the lead with voluntary disclosure of their carbon footprints. Asset owners such as the UK Environment Agency Pension Fund, ERAFP in France, and GEPP in South Africa have assessed their carbon footprint and see this as an indicator both of risk in their portfolio and of their own contribution to addressing climate change. However, measurement is a huge challenge here. ESG disclosure by companies still makes it difficult to track real-world environmental and social performance. CFA Institute (2014) states that, '...aggregating up from company level to a portfolio is even harder. But the pressure on investors to demonstrate their positive impacts is strong. Asset owners' beneficiaries want to see proof that their funds are making a difference. Managers who can help their clients meet this challenge will be well positioned.'

French public pension fund ERAFP in particular has been advocating for more transparency on the carbon footprints of investors' portfolios. In March 2014, ERAFP released its own listed equity carbon footprint (ERAFP, 2014). This was based on the hypothesis that encouraging asset owners (pension funds and insurers) to make the carbon footprint of their portfolios public would create:

- strong incentives for asset owners to think about the risk they are already bearing in their assets (sometimes without even being conscious of it);
- encourage index providers to keep on working on the designing of new benchmarks; and
- catalyse asset managers in their search for new products or new solutions.

An interview with Paul Simpson, CEO of CDP, in the Financial Times illuminates how pension funds' ability to measure the carbon exposure of their underlying investments has become easier following several regulatory developments. This includes action in the UK where from September 2014, more than 1,000 UK-based companies listed on the main exchanges will have to report their carbon emissions in their annual reports. The European Union has also recently drawn up its accounting directive, which will require more than 6,000 companies to report regularly on environmental, social and governance factors from 2016. This is all in addition to the aforementioned US SEC guidance encouraging companies to publish their climate risk in their 10-k filings (Financial Times, 2014).

Ellsworth and Spalding (2013) write that, frustrated by disparate ESG reporting globally, investors are also increasingly focused on stock exchanges to spur greater comparability and consistency of ESG data in the marketplace. At the same time, stock exchanges are concerned that if they act alone in requiring more robust ESG disclosure through tougher listing rules, it will prompt companies to move to markets with less stringent reporting requirements on sustainability.

To address such concerns, investors are engaging with exchanges in more than a dozen stock markets on ESG issues. In the US, investors managing more than USD 7 trillion in assets are collaborating with NASDAQ OMX on a listing rule mandating ESG disclosure. This specific initiative, being led by the Investor Network on Climate Risk (INCR), is part of a broader investor collaboration under the United Nations-sponsored Sustainable Stock Exchanges (SSE) Initiative. Investors are also working closely within the Principles for Responsible Investment through an SSE investor working group. These collaborations have led to listing requirements on integrated reporting in South Africa, disclosure of multiple ESG key performance indicators in India and Hong Kong, and recommended ESG reporting and training in Brazil and Singapore.

INCR (2014) and many investors have been pressing corporations to disclose material sustainability risks and opportunities, often through shareholder resolutions. Similar transparency, they argue, should be expected from asset owners and investment managers, and will almost certainly be demanded in due course by their stakeholders, including beneficiaries who are increasingly being mobilised to question investment policies that may exacerbate climate change risks and jeopardise sustainable risk-adjusted returns.

Ceres (2014) writes that in the near future 'political gridlock will in many countries continue to thwart adoption of an explicit price on carbon. Legislative inaction, however, does not relieve the need to begin preparing for a low-carbon future.' It argues that prudent companies are already doing this by implementing a 'shadow price' on carbon in their long-term financial plans. CDP (2014) recently reported that 29 large companies based or operating in the US across multiple sectors (including Google, Walmart, ExxonMobil and Walt Disney) are using shadow carbon prices of USD 6-60/tCO₂. CDP (2014) notes that such companies use a shadow carbon price as, 'a planning tool to help identify revenue opportunities, risks, and as an incentive to drive maximum energy efficiencies to reduce costs and guide capital investment decisions.' It argues that investors should encourage all companies to adopt shadow carbon prices as a means for properly evaluating the costs and benefits of investments decisions, in particular those related to clean energy.

Ellsworth and Spalding (2013) illustrate that because many trustees do not have an investment background, and those that do are not necessarily familiar with ESG risks, trustee education on these issues is crucial. Such training can be done in-house, preferably in collaboration with experts in relevant aspects of sustainability risks or in off-site sessions conducted by established programmes for trustee training, such as those affiliated with Harvard and Stanford universities. Ceres, the Initiative for Responsible Investing at Harvard, ICGN or PRI are useful resources for identifying or developing trustee training programs.

5.4 Active ownership

Ellsworth and Spalding (2013) write that many issues that affect the safety and soundness of the financial markets are too big to be tackled alone. Investors, such as CalPERS, are responding accordingly, 'our governance

program has a work stream focusing on financial market stability, in which we work with other long-term investors to advocate regulation and legislation, which protects investors and promotes market stability.’ (Ellsworth and Spalding, 2013:61).

Mass active ownership became more organised with the creation of the Carbon Disclosure Project (CDP) in 2001. The CDP is an independent organisation working to drive emissions reduction and sustainable water use by business and communities. It is currently backed by 551 institutional investors with over USD 70 trillion in assets under management. However, the rise of active ownership is also sowing seeds of change for fund managers, who will increasingly be asked by asset owners to consider longer term issues like the direction of future carbon prices. This is unlikely to be a smooth transition for fund managers who are still generally incentivised over a much shorter period than the underlying investors – pension fund members who are typically investing for more than 40 years (AODP, 2013).

The Global Investor Coalition on Climate Change (2013) writes that its annual survey results indicate that identifying climate change as a material investment risk does not necessarily lead to changes in investment practice at the portfolio level, but rather that changes are being made in other ways. Almost all asset owners and asset managers identify climate change as a material risk, and about half use a risk assessment framework across the portfolio to interpret it, but only about a quarter have changed an investment process or decision-making process as a result of their analysis. 61% of asset owners do not seek advice on climate change at the portfolio level, reinforcing the trend for analysing and addressing climate risk within asset classes and for specific investments. These results raise questions about how investment practice should change as a result of awareness of the risks of climate change.

The survey results also indicate that analysis of climate risk within asset classes and particularly in public equities, infrastructure and real estate is the most widely used analytical approach for investors. The survey quotes an anonymous North American asset manager: ‘We view climate change as a risk/opportunity across all portfolios. It is more material in some asset classes than others. The risk/opportunity is most material in our real estate portfolios. We are eager to find ways to make the link to public equity and fixed income. However, issues around climate change tend to be longer term in nature and not deemed material in the typical holding period for public equities and fixed income. We would welcome more support in the effort to identify materiality in public portfolios.’ (The Global Investor Coalition on Climate Change, 2013:10).

Analysis appears to focus on the impact of expected weather events on assets or of policies to reduce emissions on the earnings of companies. The extent to which analysis is performed on how climate risk in one asset class or industry might impact investment performance in other asset classes or industries was not examined in this survey and is a potential area for exploration in future.

In recent years there has been rapid growth in the number of financial indices that address sustainability, including the S&P/IFCI Carbon Efficient Index, HSBC Climate Index, Prudential Green Commodities Index, the NASDAQ Global Sustainability 50 Index, and full suites of sustainable and environmental indexes by FTSE and MSCI. Some major stock exchanges, including those in London, Rio de Janeiro and Johannesburg are requiring public disclosure of sustainability-related information (such as greenhouse gas emissions) by all listed companies. In response to a petition from Ceres and leading investors, the US Securities and Exchange Commission issued climate change disclosure guidance in 2010 that requires disclosure of material climate-related risks by publicly-held companies (Ellsworth and Spalding, 2013).

Finally, a study by UNEP and the UN Principles for Responsible Investment (UN PRI 2010) helps investors measure the unaccounted costs of business activities by putting a price on natural resources that power business but rarely show up on corporate balance sheets. This provides an important rationale for action by large institutional investors that have a financial interest in the wellbeing of the economy as a whole. By exercising ownership rights and through constructive dialogue with companies and public policy makers, these ‘Universal

Owners' can encourage the protection of natural capital needed to maintain the economy and investment returns over the long term.

5.5 Short termism in financial markets

Regarding the issue of short-termism in financial markets more generally, Dominic Barton, the global managing director of McKinsey & Company, proposes that given the complexity of this issue, there will never be a one-size-fits-all approach. However, he argues that the compensation structures set by boards, and specifically remuneration committees, should be modified to allow the consideration of links between compensation and the fundamental drivers of long-term value – such as innovation and efficiency – and not just links to share price; those setting compensation should also consider extending the timeframe for executive evaluations by using rolling multi-year milestones; and they should create real downside risk for executives who do not manage for long-term value creation (Generation Investment Management, 2012; Barton, 2012).

Generation Investment Management (2012) suggests that companies can take a proactive stance against this growing trend of short-termism by attracting long-term investors with patient capital through the issuance of loyalty-driven securities. Loyalty-driven securities offer investors financial rewards for holding a company's shares for a certain number of years. This practice encourages long-term investment horizons among investors and facilitates stability in financial markets (Generation Investment Management, 2012).

Ellsworth and Spalding (2013) describe another method for gauging the effectiveness of a sustainable investment strategy and combating short-termism is to measure portfolio return over longer time horizons versus the designated performance benchmarks, most of which have at least three and five-year track records. The obligation of having to report investment returns measured over longer timeframes will cause more managers to consider longer-term risks and opportunities, including risk factors and return opportunities that ESG analysis can help identify.

Conclusion

This Working Paper has attempted to do three things: first, summarise the underlying logic for why the financial sector should care about the state of the environment and environment-related risks; second, review the main structural barriers that could prevent the financial system from managing such issues; and third, identify the main researchers and organisations undertaking work on these topics internationally. The aspiration being that this document should be a useful initial reference guide to those concerned with both how environment-related risks could affect the financial sector and what financial institutions can do to manage such risks. Based on our review we have found the following:

- The available literature has focused predominantly on OECD countries and comparatively little research exists for emerging economies and developing countries. This is unfortunate and should be an area of great significance for future research.
- It is clear that financial institutions hold divergent perspectives on the materiality of environment-related risks to current and future value. Natural capital underpins the health of global economic and financial systems, however, these contributions remain largely unpriced within the economy and are largely absent from the balance sheets of financial institutions, and metrics quantifying economic growth.
- Environmental change, natural capital depletion and degradation could potentially pose systemic risks to financial stability; however, the processes through which this may happen are currently unclear and

may be remote. Though we find little evidence to suggest that environment-related risks currently pose a systemic risk to the financial system beyond large-scale natural catastrophe events, there is growing evidence that these risks are becoming increasingly material and will figure greatly in financial valuation in coming years.

- Public policy responses to environment-related risks also have the potential to impact the financial system and financial stability. These include through monetary and fiscal policy responses to environment-related risks in commodity markets, environmentally-motivated trade policy (including export restrictions), as well as more direct environmental control policies.
- Due to their spread of investments and activities across sectors and geographies, the indirect exposure of financial institutions to natural capital risks may have equally costly impacts on balance sheets and system function than those firms with clear direct linkages to natural capital value.
- Accounting for environment-related risk in the financial sector involves a range of uncertainties and variables which can make assessment complex. At a higher level, key metrics used in valuing economic growth (such as GDP) may not be very useful in illustrating economic costs of drastic environmental change. Addressing these issues is a priority for informed financial sector decision-making.
- The phenomenon of short-termism in financial markets undermines the ability to invest and manage risk with due consideration for environmental-related risk factors. It is driven in part by the practices and regulations that govern asset owners. These include short-term benchmarks for performance measurement, risk management, reporting and compensation along with other factors such as decreasing CEO tenure, but also in the realm of financial regulation with the application of mark-to-market accounting practices, liquidity requirements, and insufficiently granular risk-based calibration and modelling.
- A number of major financial and investment policies unrelated to facilitating a transition to a low carbon and environmentally resilient economy, are widely accused of being structured in ways that have unintended consequences on the ability of the financial sector to participate in this economic transition. These include Solvency II, Basel III, EU unbundling regulation and certain accounting regulations and standards. At the same time, sparse empirical evidence exists to support some of these claims, possibly because it is difficult to model the impacts of regulations which are under development and in varying stages of implementation, or to distinguish between transitional and permanent effects, as well as the type of market or region that may be affected.
- The lack of a mandate for companies to integrate ESG factors in decision-making, undertake materiality assessments or disclose environment-related risks hinders both consistent understanding of the issues and the ability to mitigate risks.
- The interpretation of fiduciary duty has evolved significantly over time and must continue to evolve to adjust to changing social and economic realities. Fiduciary duty is often cited as an obstacle to incorporating ESG factors into the investment process. The argument that ESG-inclusive investing is inconsistent with fiduciary duty is based on the premise that including ESG factors in investment decision-making would compromise returns to achieve extraneous social or environmental objectives.
- In recent years, major analytical research efforts have been aimed at quantifying and describing the nature of some of these above-mentioned issues and proposing solutions, from short-termism in financial markets to drivers of and responses to asset stranding. As more data and research become available and as the environmental sustainability agenda becomes integrated with the broader long-term investment agenda, potential for meaningful and catalytic change exists.

References

- ACCA (2012) Is Natural Capital a Material Issue? An evaluation of the relevance of biodiversity and ecosystem services to accountancy professionals and the private sector. ACCA, FFI, and KPMG.
<http://www.accaglobal.com/content/dam/acca/global/PDF-technical/environmental-publications/natural-capital-summary.pdf>
- ACCA (2013a) Identifying Natural Capital Risk and Materiality. ACCA, FFI and KPMG.
<http://www.accaglobal.com/content/dam/acca/global/PDF-technical/sustainability-reporting/natural-capital-materiality-paper.pdf>
- ACCA (2013b) Carbon Avoidance: Accounting for the emissions hidden in reserves.
<http://www.accaglobal.com/content/dam/acca/global/PDF-technical/sustainability-reporting/tech-tp-ca.pdf>
- AccountAbility (2013) Redefining Materiality II: Why it Matters, Who's Involved, and What It Means for Corporate Leaders and Boards.
http://www.accountability.org/images/content/6/8/686/AA_Materiality_Report_Aug2013%20FINAL.pdf
- Adam, C. (2013). Coping with adversity: The macroeconomic management of natural disasters. *Environmental Science & Policy*, 27, S99-S111.
- Ahmad, Y., Serafy, S. and Lutz, E. (1989). Environmental Accounting for Sustainable Development. UNEP-World Bank Symposium Working Paper. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/1999/12/03/000178830_98101901491957/Rendered/PDF/multi_page.pdf
- Alesina, A. & Tabellini, G. (1989). External debt, capital flight and political risk. *Journal of International Economics*, 27(3), 199-220.
- Alexander, K. (2014). The links between natural resource constraints and Basel III's financial stability objectives - summary of preliminary findings. CPSL Working Paper, pp. 1-13.
- Antia, M., Pantzalis, C. & Park, J.C., (2010). CEO decision horizon and firm performance: An empirical investigation. *Journal of Corporate Finance*, 16(3), pp. 288-301. Available at:
<http://econpapers.repec.org/RePEc:eee:corfin:v:16:y:2010:i:3:p:288-301> [Accessed March 12, 2014].
- Ansar, A., Caldecott, B.L., & Tilbury, J. (2013) *Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets?* Smith School of Enterprise and Environment, University of Oxford (Oxford, UK).
- Ano Sujithan, K., Koliai, L., & Avouyi-Dovi, S. (2013). Does Monetary Policy Respond to Commodity Price Shocks?
- Artemis (April, 2014). Artemis Catastrophe Bond and Insurance-Linked Securities Deal Directory.
http://www.artemis.bm/deal_directory/
- AODP (2013). Global Climate Index 2013-14. Asset Owners Disclosure Project.
- Atkinson, T., Luttrell, D. and Rosenblum, H. (July, 2013). How bad was it? The costs and consequences of the 2007-2009 financial crisis. Dallas Fed Staff Papers No. 20.
- Auty, R. M. (2001). The political economy of resource-driven growth. *European Economic Review*, 45(4), 839-846.

- Auty, R. M. (2007). Natural resources, capital accumulation and the resource curse. *Ecological Economics*, 61(4), 627-634.
- Basel Committee on Banking Supervision (2014). Progress report on implementation of the Basel regulatory framework.
- Barton, D. (2012). Capitalism for the long term. pp. 68-76.
- Bhattacharyya, S. & Collier, P. (2014). Public capital in resource rich economies: is there a curse? *Oxford Economic Papers*, 66(1), 1-24.
- Blas, J. (2013). "Protecting Nigeria oil SWF is no easy task". *Financial Times*, October 23, 2013.
<http://www.ft.com/cms/s/0/69325c28-2440-11e3-a8f7-00144feab7de.html#axzz2wJfdoea5>
- Blyth, W., Bradley, R., Bunn, D., Clarke, C., Wilson, T. & Yang, M. (2007). Investment Risks under Uncertain Climate Change policy. *Energy Policy*, 35(11), 5766-5773. doi:10.1016/j.enpol.2007.05.030
- BMZ (2013). Mobilising Investment for Inclusive Green Growth in Low-Income Countries.
- Böhringer, C., & Jochem, P. E. (2007). Measuring the immeasurable – a survey of sustainability indices. *Ecological Economics*, 63(1), 1-8.
- Bowman, M. (2013). Corporate 'Care' and Climate Change: Implications for Bank Practice and Government Policy in the United States and Australia. *Stanford Journal of Law, Business & Finance*.
- Boyd, J. (2007). Nonmarket benefits of nature: What should be counted in green GDP? *Ecological Economics*, 61(4), 716-723.
- Boyd, J. & Banzhaf, S. (2007). What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics*, 63(2), 616-626.
- Caldecott, B.L. & Elders, G. (2013) Bloomberg Carbon Risk Valuation Tool. White Paper, 25th November 2013. Bloomberg New Energy Finance (London, UK).
- Caldecott, B., Howarth, N. and McSharry, P. (2013). Stranded Assets in Agriculture: Protecting Value from Environment-Related Risks. Stranded Asset Programme, Smith School of Enterprise and the Environment, Oxford University.
- Caldecott, B.L., McDaniels, J. & Dericks, G. (2014) *Stranded Assets Forum, Waddesdon Manor 14th – 15th March 2014. Summary of Proceedings*. Smith School of Enterprise and the Environment, University of Oxford (Oxford, UK).
- Caldecott, B.L. & McDaniels, J. (2014) *Stranded generation assets: implications for European capacity mechanisms, energy markets and climate policy*. Working Paper. Smith School of Enterprise and the Environment, University of Oxford (Oxford, UK).
- Caldecott, B.L., Tilbury, J. & Carey, C. (2014) *Stranded assets and scenarios*. Discussion Paper. Smith School of Enterprise and the Environment, University of Oxford (Oxford, UK).
- Caldecott, B.L., Tilbury, J. & Ma, Y. (2013) *Stranded Down Under? Environment-related factors changing China's demand for coal and what this means for Australian coal assets*. Smith School of Enterprise and the Environment, University of Oxford (Oxford, UK).

Carbon Disclosure Project (2013). Use of internal carbon price by companies as incentive and strategic planning tool – A review of findings from CDP 2013 disclosure. CDP North America White Paper, December 2013. <https://www.cdp.net/CDPResults/companies-carbon-pricing-2013.pdf>

Carbon Tracker Initiative. (2011). Unburnable Carbon: are the world's financial markets carrying a carbon bubble? <http://www.carbontracker.org/>

Carbon Tracker Initiative (2013). Unburnable Carbon 2013: Wasted Capital and Stranded Assets. <http://www.carbontracker.org/>

Carbon Tracker Initiative (2014). Carbon supply cost curves: Evaluating financial risk to oil capital expenditures. <http://www.carbontracker.org/>

Cavallo, E., Galiani, S., Noy, I. & Pantano, J. (2013). Catastrophic natural disasters and economic growth. *Review of Economics and Statistics*, 95(5), 1549-1561.

Cavallo, E. & Noy, I. (2009). The economics of natural disasters: a survey. IDB Working Paper 35. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1817217

Ceres (2010). Climate Change Risk Perception and Management: A Survey of Risk Managers.

Ceres (2013). 'Investors ask fossil fuel companies to assess how business plans fare in low-carbon future'. Press Release – October 23, 2013. <http://www.ceres.org/press/press-releases/investors-ask-fossil-fuel-companies-to-assess-how-business-plans-fare-in-low-carbon-future>

Ceres (2014). Cool response: the SEC and Corporate Climate Change Reporting. <http://www.ceres.org/resources/reports/cool-response-the-sec-corporate-climate-change-reporting/view>

Ceres (2014). Investing in the Clean Trillion: Closing the clean energy investment gap.

CFA Institute (2014). The Big Picture of Responsible Investing: An Interview with Rob Lake. <http://blogs.cfainstitute.org/investor/2014/04/23/the-big-picture-of-responsible-investing-by-large-asset-owners-an-interview-with-rob-lake/>

Cheng, I. H. & Xiong, W. (2013). The Financialization of Commodity Markets. National Bureau of Economic Research, Working Paper No. 19642.

Citi (2013a). Global Oil Demand Growth – The End Is Nigh. Citi Research, March 26, 2013. <http://s3.documentcloud.org/documents/809476/citicldemand.pdf>

Citi (2013b). The Unimaginable: Peak Coal Demand in China. Citi Research, September 4, 2013. <https://ir.citi.com/z5yk080HEXZtoIax1EnHssv%2Bzm4Pc8GALpLbF2Ysb%2FI21vGjprPCVQ%3D%3D>

Clements-Hunt, P. (2012). Financial Stability and Systemic Risk: Lenses and Clocks. International Institute for Sustainable Development, UNEPFI, and the Blended Capital Group. http://www.iisd.org/pdf/2012/lenses_clocks_june_2012.pdf

Climate Policy Initiative (2013). The Challenge of Institutional Investment in Renewable Energy.

Club of Rome (1972). Limits to Growth.

Collier, P., Van Der Ploeg, R., Spence, M. & Venables, A. J. (2010). Managing Resource Revenues in Developing Economies. *IMF Staff Papers*, 57(1)

Cologni, A. & Manera, M. (2013). Exogenous oil shocks, fiscal policies and sector reallocations in oil producing countries. *Energy Economics*, 35, pp. 42-57.

Congressional Research Service (2013). SEC Climate Change Disclosure Guidance: An Overview and Congressional Concerns. <http://www.fas.org/sgp/crs/misc/R42544.pdf>

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... & van den Belt, M. (1998). The value of the world's ecosystem services and natural capital. *Ecological Economics*, 25(1), 3-15.

Creti, A., Joëts, M. & Mignon, V. (2013). On the links between stock and commodity markets' volatility. *Energy Economics*, 37, 16-28.

Cummins, J. and Mahul, O. (2008). Catastrophe risk financing in developing countries: principles for public intervention – overview. The World Bank, Washington, DC.

Cunado, J. & Ferreira, S. (2014). The Macroeconomic Impacts of Natural Disasters: The Case of Floods. *Land Economics*, 90(1), 149-168.

Curtis, I. A. (2004). Valuing ecosystem goods and services: a new approach using a surrogate market and the combination of a multiple criteria analysis and a Delphi panel to assign weights to the attributes. *Ecological Economics*, 50(3), 163-194.

Della Croce, R., Stewart, F. & Yermo, J. (2011). Promoting Longer-Term Investment by Institutional Investors: Selected Issues and Policies. *OECD Journal: Financial Market Trends*, 1(April), pp. 1-20.

Dempsey, J. (2013). Biodiversity loss as material risk: Tracking the changing meanings and materialities of biodiversity conservation. *Geoforum*, 45, 41-51.
<http://www.sciencedirect.com/science/article/pii/S0016718512000796>

Dietz, S. (2009). High impact, low probability? An empirical analysis of risk in the economics of climate change, (10), 1-32.

Dooley, M. P. (1988). Capital flight: a response to differences in financial risks. *Staff Papers - International Monetary Fund*, pp. 422-436.

Dow Chemical (2013). The Nature Conservancy & Dow 2013 annual progress report.
http://www.dow.com/sustainability/pdf/2013_Nature_Conservancy_Annual_Progress%20.pdf

Du, X., Yu, C. L. & Hayes, D. J. (2011). Speculation and volatility spillover in the crude oil and agricultural commodity markets: A Bayesian analysis. *Energy Economics*, 33(3), 497-503.

European Insurance and Occupational Pensions Authority (2014). Solvency II.
<https://eiopa.europa.eu/en/fixed-width/activities/insurance/solvency-ii/index.html>

Ekins, P., Simon, S., Deutsch, L., Folke, C. & De Groot, R. (2003). A framework for the practical application of the concepts of critical natural capital and strong sustainability. *Ecological Economics*, 44(2), 165-185.

Ellsworth, P. & Spalding, K. S. (2013). The 21st Century Investor: Ceres Blueprint for Sustainable Investing.

Emanuel, K. (2014). 'MIT Climate Scientist Responds on Disaster Costs and Climate Change'. FiveThirtyEight Science, March 31, 2014. <http://fivethirtyeight.com/features/mit-climate-scientist-responds-on-disaster-costs-and-climate-change/>

- ERAFP (2014). Press Release: ERAFP commissions the first carbon audit of its investments in listed equities.
- Ernst & Young (2013). Renewable energy assets: An interesting investment proposition for European insurers.
- European Commission. (2013a). Commission staff working document: Long-Term Financing of the European Economy Accompanying.
- European Commission. (2013b). Green paper: Long-Term Financing of the European Economy.
- European Commission – MAES (2013). Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Discussion paper. Technical Report, 2013 –067.
http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/MAESWorkingPaper2013.pdf.
- FAO (2006). Roles of Agriculture Project Policy Brief: Food Security and Wheat Policy in Egypt. UN Food and Agriculture Organization. ftp://ftp.fao.org/es/esa/roa/pdf/policybrief2_en.pdf
- Farber, S. C., Costanza, R. & Wilson, M. A. (2002). Economic and ecological concepts for valuing ecosystem services. *Ecological Economics*, 41(3), 375-392.
- Field, E. H., Seligson, H. A., Gupta, N., Gupta, V., Jordan, T. H. & Campbell, K. W. (2005). Loss estimates for a Puente Hills blind-thrust earthquake in Los Angeles, California. *Earthquake Spectra*, 21(2), 329-338.
<http://pubs.er.usgs.gov/publication/70029508>
- Financial Stability Board (2013a). Credit Rating Agencies: Reducing reliance and strengthening oversight: Progress Report to G20.
- Financial Stability Board (2013b). Financial regulatory factors affecting the availability of long-term investment finance: Report to G20 Finance Ministers and Central Bank Governors.
- Financial Stability Board (2013c). Update on financial regulatory factors affecting the supply of long-term investment finance. (August), pp.1-13.
- Financial Times (2014). Pension funds urged to publish climate risks.
<http://www.ft.com/intl/cms/s/0/1c5e0b58-f795-11e3-90fa-00144feabdc0.html?siteedition=intl#axzz35N7EkBzm>
- Fischer-Kowalski, M. & Swilling, M. (2011). Decoupling: natural resource use and environmental impacts from economic growth. United Nations Environment Programme.
- G20/OECD (2013). G20/OECD High-Level Principles on Long-Term Investment Financing by Institutional Investors.
- Gatzert, N. & Kosub, T. (2014). Insurers' Investment in Infrastructure: Overview and Treatment under Solvency II. *The Geneva Papers on Risk and Insurance Issues and Practice*, (December 2012), 1-22. Available at:
<http://www.palgrave-journals.com/doi/10.1057/gpp.2013.34> [Accessed March 12, 2014].
- Gboyega, A., Soreide, T., Le, T., Shukla, G. P. (2011). Political economy of the petroleum sector in Nigeria. World Bank Policy Research working paper no. WPS 5779 http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2011/08/24/000158349_20110824134316/Rendered/PDF/WPS5779.pdf

- Generation Investment Management (2012). Sustainable Capitalism.
- Girardi, D. (2012). A brief essay on the financialization of agricultural commodity markets. MPRA Paper 44771.
- Global Investor Coalition on Climate Change (2013). *Global Investor Survey on Climate Change*.
- Gómez-Baggethun, E., De Groot, R., Lomas, P. L. & Montes, C. (2010). The history of ecosystem services in economic theory and practice: from early notions to markets and payment schemes. *Ecological Economics*, 69(6), 1209-1218.
- Gómez-Baggethun, E. & de Groot, R. (2010). Natural capital and ecosystem services: the ecological foundation of human society. *Ecosystem Services, Issues in Environmental Science and Technology*, 30, 118-145.
- Graham, J.R., Harvey, C.R. & Rajgopal, S., (2004). The Economic Implications of Corporate Financial Reporting. NBER Working Papers. <http://ideas.repec.org/p/nbr/nberwo/10550.html>
- Gray, A. (2013) 'PRA Highlights catastrophe bond risks', *Financial Times*, September 29, 2013. <http://www.ft.com/cms/s/0/5485cd20-276d-11e3-8feb-00144feab7de.html#axzz2xiTSyPMO>
- Greenbiz Group and Trucost (2014). State of Green Business 2014. <http://www.greenbiz.com/blog/2014/01/21/state-green-business-2014>
- Greenpeace (2014). Locked in the Past: Why Europe's Big Energy Companies Fear Change. <http://www.greenpeace.org/eu-unit/Global/eu-unit/reports-briefings/2011%20pubs/2014%20Jan-April/20140227%20RP%20LOCKED%20IN%20THE%20PAST%20-%20Why%20Europe's%20big%20energy%20companies%20fear%20change.pdf>
- Gunter, M. (2014). 'Natural Capital: Breakthrough or Buzzword?' *The Guardian*, March 6, 2014. <http://www.theguardian.com/sustainable-business/natural-capital-nature-conservancy-trucost-dow>
- Gurenko, E. (2004). Introduction. In Gurenko E (Ed), *Catastrophe Risk and Reinsurance: a country risk management perspective*. Risk Books, London, pp 3-16
- Hallegatte, S. and Przyluski, V. (2010). The Economics of Natural Disasters – Concepts and Methods. World Bank Policy Research Working Paper 5507. Washington DC, World Bank.
- Hagendorff, B., Hagendorff, J., Keasey, K. & Gonzalez, A. (2014). The Risk Implications of Insurance Securitization: The Case of Catastrophe Bonds. *Journal of Corporate Finance*.
- Hajkowicz, S. (2006). Multi-attributed environmental index construction. *Ecological Economics*, 57(1), 122-139.
- Hartwick, J. M. (1990). Natural resources, national accounting and economic depreciation. *Journal of Public Economics*, 43(3), 291-304.
- Henderson, B., Pearson, N. & Wang, L. (2012). New evidence on the financialization of commodity markets. *SSRN eLibrary*.
- Hepburn, C., & Bowen, A. (2012). Prosperity with growth: Economic growth, climate change and environmental limits. Grantham Research Institute on Climate Change and the Environment, Working Paper No 93.
- Hill, M., Lowrance, C., Mulder, I., Boucher, J. & Green, J. (2011). Embedding Environmental Risks in Finance: Current Methods and Ongoing Challenges. *Journal of Environmental Investing*, 2(1), 36-51.

- House of Commons Environmental Audit Committee (2014). Green Finance Report, Volume 1. March 6, 2014. <http://www.publications.parliament.uk/pa/cm201314/cmselect/cmenvaud/191/191.pdf>
- HSBC (2014). Coal and Carbon Revisited. HSBC Climate Change Centre.
- Ikelegbe, A. (2013). *Oil, Environment and Resource Conflicts in Nigeria* (Vol. 7). LIT Verlag Münster.
- International Energy Agency (2013). World Energy Outlook Special Report: Redrawing the energy climate map.
- IFC (2013). A Dialogue Platform for Inclusive Green Growth Investment: An Expanded Stocktaking for the G20 Development Working Group.
- IMF (2013). Economic Prospects and Policy Challenges for the GCC Countries. International Monetary Fund report to the Gulf Cooperation Council - Annual Meeting of Finance Ministers and Central Bank Governors. October 5, 2013. <http://www.imf.org/external/np/pp/eng/2013/100513b.pdf>
- Index Mundi (2013). Wheat Imports by Country in 1000 MT. <http://www.indexmundi.com/agriculture/?commodity=wheat&graph=imports>
- Inderst, G. (2013). Private Infrastructure Finance and Investment in Europe. EIB Working Papers 2013/02.
- IPCC (2014). Climate Change 2014. Working Group II report: Impacts, Adaptation and Vulnerability. Chapter 10: Key economic sectors and services. http://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap10_FGDall.pdf
- Jansson, A. (1994). Investing in natural capital: the ecological economics approach to sustainability. Island Press.
- Johnson, L. (2013). Catastrophe bonds and financial risk: Securing capital and rule through contingency. *Geoforum*, 45, 30-40.
- Johnstone, S., & Mazo, J. (2011). Global warming and the Arab Spring. *Survival*, 53(2), 11-17.
- Jones, H. (2013) 'Britain won't intervene in catastrophe bond market for now'. Reuters, October 2, 2013. <http://www.reuters.com/article/2013/10/02/britain-boe-insurance-idUSL6N0HS2BK20131002>
- Kahn, J. and Greene, P. (2013). Selecting discount rates for natural capital accounting. Issue Paper 2.4 valuation for accounting seminar, November 11, 2013. UK Office for National Statistics.
- Kaminker, C., Kawanishi, O., Stewart, F., Caldecott, B. & Howarth, N. (2013). Institutional Investors and Green Infrastructure Investments: Selected Case Studies. OECD Publishing, (35).
- Kaminker, C. & Stewart, F. (2012). The Role of Institutional Investors in Financing Clean Energy. OECD Publishing, (23).
- Kamp-Roelands, N. (2013). Private Sector Initiatives on Measuring and Reporting on Green Growth (No. 2013/6). OECD Publishing. <http://www.iadb.org/intal/intalcdi/PE/2013/11878a05.pdf>
- Kapoor, S., Oksnes, L. & Hogarth, R. (2011). Funding the Green New Deal: Building a Green Financial System, (Vol. 6).

-
- Kering (2014). Environmental Profit and Loss Accounting. <http://www.kering.com/en/sustainability/environmental-pl>
- Kim, J. Y. (2014). World Bank Group President Jim Yong Kim Remarks at Davos Press Conference (12-14).
- KKS Advisors, (2014). Earnings Guidance - Part of the Future or the Past?
- Knight, Z., Robins, N. and Chan, W. (2013). Natural Capital: Identifying implications for economies. HSBC Climate Change Centre, HSBC Global Research.
- Kousky, C. & Cooke, R. M. (2009). Climate Change and Risk Management: Challenges for Insurance, Adaptation, and Loss Estimation. *SSRN Electronic Journal*. doi:10.2139/ssrn.1346387
- KPMG (February, 2014). Report on Financial Services: Evolving Banking Regulation - Is the end in sight?
- Lamberton, G. (March 2005). Sustainability Accounting – a brief history and conceptual framework. In *Accounting Forum* (Vol. 29, No. 1, 7-26).
- Lampietti, J. A., Michaels, S., Magnan, N., McCalla, A. F., Saade, M. & Khouri, N. (2011). A strategic framework for improving food security in Arab countries. *Food Security*, 3(1), 7-22.
- Leigh, D. & Olters, J. P. (2006). *Natural resource depletion, habit formation, and sustainable fiscal policy: lessons from Gabon*. International Monetary Fund.
- Linnerooth-Bayer, J. & Hochrainer-Stigler, S. (2014). Financial instruments for disaster risk management and climate change adaptation. *Climatic Change*, 1-16.
- Litterman, B. (2012). Tail risk and the price of carbon emissions.
- Litterman, B. (2013). What Is the Right Price for Carbon Emissions?
- Loayza, N., Olaberria E., Rigolini, J. and Christiaensen, L. (2012). Natural Disasters and Growth: Going Beyond the Averages. *World Development* 40 (7): 1317–36.
- Lowder, T. (2012). Who's Afraid of Basel III?
- MacKenzie, C. (2013) 'Is the tide turning on "big carbon"? The surprising step change in the stranded assets debate.' *Responsible Investor*, August 30, 2013. http://www.responsible-investor.com/home/article/c_mac_sa/
- Mantell, N., Seneca, J., Lahr, M. and Irving, W. (2013). The Economic and Fiscal Impacts of Hurricane Sandy in New Jersey: A Macroeconomic Analysis. Rutgers regional report Issue Paper 34, January 2013. <http://policy.rutgers.edu/reports/rrr/RRR34jan13.pdf>
- Mazzanti, M. (2002). Cultural heritage as multi-dimensional, multi-value and multi-attribute economic good: toward a new framework for economic analysis and valuation. *The Journal of Socio-Economics*, 31(5), 529-558.
- MEA (2005). Ecosystems and human well-being. Vol. 5. Washington, DC: Island Press.
- Melecky, M. & Raddatz, C. (2014). Fiscal Responses after Catastrophes and the Enabling Role of Financial Development. *The World Bank Economic Review*, lht041.
- Mitchell, G. (2006). Problems and fundamentals of sustainable development indicators.
-

- Munich RE (2014). 2013 Natural Catastrophe Year in Review, Accessed https://www.munichre.com/touch/site/touchnaturalhazards/get/documents_E2138584162/mr/assetpool.shared/Documents/5_Touch/Natural%20Hazards/NatCatNews/2013-natural-catastrophe-year-in-review-en.pdf
- Narbel, P.A. (2013). The likely impact of Basel III on a bank's appetite for renewable energy financing. NHH Dept. of Business and Management Science Discussion Paper No. 2013/10. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2341519
- Natural Capital Committee (March, 2014). The State of Natural Capital: Restoring our Natural Assets. Second Report to the Economic Affairs Committee. Natural Capital Committee, HM Government UK.
- Natural Capital Degradation (2013). Natural Capital Degradation Roadmap.
- Nazlioglu, S., Erdem, C. & Soytaş, U. (2013). Volatility spillover between oil and agricultural commodity markets. *Energy Economics*, 36, 658-665.
- OECD (2011). Towards Green Growth: Monitoring Progress – OECD Indicators. <http://www.oecd.org/greengrowth/48224574.pdf>
- Okuyama, Y. (2007). Economic modeling for disaster impact analysis: past, present, and future. *Economic Systems Research*, 19(2), 115-124.
- Ouattara, B. & Strobl, E. (2013). The fiscal implications of hurricane strikes in the Caribbean. *Ecological Economics*, 85, 105-115.
- Pacific Catastrophe Risk Assessment and Financing Initiative (PCRAFI) (2013) <http://pcrafi.sopac.org/>
- Parris, T. M., & Kates, R. W. (2003). Characterizing and measuring sustainable development. *Annual Review of Environment and Resources*, 28(1), 559-586.
- Pearson, N. (2012). Asia Risks Water Scarcity amid Coal-Fired Power Embrace. *Bloomberg News*. September 9, 2012. <http://www.bloomberg.com/news/2012-09-09/asian-water-scarcity-risked-as-coal-fired-power-embraced.html>
- Pelling, M., Özerdem, A. & Barakat, S. (2002). The macro-economic impact of disasters. *Progress in Development Studies*, 2(4), 283-305.
- Prato, T. (1999). Multiple attribute decision analysis for ecosystem management. *Ecological Economics*, 30(2), 207-222.
- Price, R., Thornton, S. and Nelson, S. (2007). The Social Cost of Carbon and the Shadow Price of Carbon: what they are, and how to use them in economic appraisal in the UK. DEFRA Economics Group. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/243825/background.pdf
- PWC (2014). European outlook for non-core and non-performing loans. <http://www.pwc.co.uk/transaction-services/publications/european-outlook-for-non-core-and-non-performing-loans.jhtml>
- Raschky, P. A. (2008). Institutions and the losses from natural disasters. *Natural Hazards and Earth System Sciences*, 8(4).
- Regnskogfondet (March, 2013). 'World's largest sovereign wealth fund divests from palm oil companies'. *Rainforest News*. <http://www.regnskog.no/en/rainforest-news/global/the-worlds-biggest-sovereign-wealth-fund-joins-battle-against-rainforest-destruction>

-
- Ross, M. L. (1999). The political economy of the resource curse. *World Politics*, 51, 297-322.
- IPE (November, 2012). 'Solvency II to "kill" renewable energy investment', report of the IPE Awards seminar. <http://www.ipe.com/ipe-awards-solvency-ii-to-kill-renewable-energy-investment/48714.fullarticle>
- Russi D. and ten Brink P. (2013). Natural Capital Accounting and Water Quality: Commitments, benefits, needs and progress. A briefing note. The Economics of Ecosystems and Biodiversity (TEEB).
- RTCC (2014). 'World Bank chief backs fossil fuel divestment drive'. <http://www.rtcc.org/2014/01/27/world-bank-chief-backs-fossil-fuel-divestment-drive/>
- Schapiro, M. (2010). Speech by SEC Chairman: Statement before the Open Commission Meeting on Disclosure Related to Business or Legislative Events on the Issue of Climate Change , 2-3.
- Severinson, C. & Yermo, J. (2012). The Effect of Solvency Regulations and Accounting Standards on Long-Term Investing , pp. 1-42.
- Singh, R. K., Murty, H. R., Gupta, S. K., & Dikshit, A. K. (2009). An overview of sustainability assessment methodologies. *Ecological indicators*, 9(2), 189-212.
- Smith, A. B. & Katz, R. W. (2013). US billion-dollar weather and climate disasters: data sources, trends, accuracy and biases. *Natural Hazards*, 67(2), 387-410.
- Smithwood, B. & Hodum, R. (2013). Power Factor: Institutional Investors' Policy Priorities Can Bring Energy Efficiency to Scale. Ceres.
- Spencer, T. & Stevenson, J. (2013). EU Low-Carbon Investment and New Financial Sector Regulation: What Impacts and What Policy Response? IDDRI, SciencesPo, Working Paper No 05/2013.
- SSE (2014). Sustainable Stock Exchange Initiative. <http://www.sseinitiative.org/>
- Standard & Poor's (2013). How to Unlock Long-Term Investment in EMEA Infrastructure. RatingsDirect.
- Standard & Poor's (2014). Global Infrastructure: How to Fill a \$500 Billion Hole. RatingsDirect.
- Stern, N. (2013). The structure of economic modeling of the potential impacts of climate change: grafting gross underestimation of risk onto already narrow science models. *Journal of Economic Literature*, 51(3), 838-859.
- Sternberg, T. (2012). Chinese Drought, Bread and the Arab Spring. *Applied Geography* 34: 519-524.
- Sternberg, T. (2013). Chinese Drought, Wheat, and the Egyptian Uprising: How a Localized Hazard Became Globalized. In Werrell, C. E., & Femia, F. (Eds.) *The Arab Spring and Climate Change: A Climate and Security Correlations Series*. Center for American Progress.
- Stiglitz, J. E., Sen, A. & Fitoussi, J. P. (2010). Report by the Commission on the Measurement of Economic Performance and Social Progress.
- SWFI (February, 2014). Sovereign Wealth Fund Rankings. Sovereign Wealth Fund Institute. <http://www.swfinstitute.org/fund-rankings/>
-

-
- Taleb, N.N. (2013). Letter to Stewart Brand. The Artangel Longplayer Letters.
- TEEB (2008). The Economics of Ecosystems and Biodiversity – Initial Report.
- TEEB (2010). The Economics of Ecosystems and Biodiversity – Findings for Policymakers.
- TEEB for Business Coalition (2013). Natural Capital at Risk: Top 100 Externalities.
- Tomorrow's Company (2014). Tomorrow's Value: Achieving long-term financial returns - a guide for pension fund trustees.
- Trucost (2014). Natural Capital Leaders Index 2014. http://www.trucost.com/_uploads/News-logs/Natural%20Capital%20Leaders%20Index%20infographic_v7.pdf
- UNEPFI (2010). Demystifying Materiality: Hardwiring biodiversity and ecosystem services into finance. CEO Briefing document. http://www.unepfi.org/fileadmin/documents/CEO_DemystifyingMateriality.pdf
- UNEPFI (2012). E-RISC: A New Angle on Sovereign Credit Risk. Phase 1 report. http://www.unep.org/PDF/PressReleases/UNEP_ERISC_Final_LowRes.pdf
- UN PRI (2010). Universal Ownership: why environmental externalities matter to institutional investors.
- UNSTATS (1993). System of Environmental-Economic Accounting. Appendix to 1993 SNA. <https://unstats.un.org/unsd/envaccounting/seea.asp>
- Van der Ploeg, F. (2011). Natural Resources: curse or blessing? *Journal of Economic Literature*, 366-420.
- Van der Ploeg, F. & Venables, A. J. (2011). Harnessing Windfall Revenues: Optimal Policies for Resource Rich Developing Economies*. *The Economic Journal*, 121(551), 1-30.
- Van Wijnbergen, S. (1985). Trade reform, aggregate investment and capital flight: on credibility and the value of information. *Economics Letters*, 19(4), 369-372.
- von Dahlen, S. and von Peter, G. (December, 2012). Natural catastrophes and global reinsurance – exploring the linkages. *BIS Quarterly Review*. http://www.bis.org/publ/qtrpdf/r_qt1212e.pdf
- von Peter, G., von Dahlen, S. and Saxena, S. (December, 2012). Unmitigated Disasters? New evidence on the macroeconomic cost of natural catastrophes. *BIS Working Papers* No 394. <http://www.bis.org/publ/work394.pdf>
- Wackernagel, M., Onisto, L., Bello, P., Callejas Linares, A., Susana López Falfán, I., Méndez García, J. & Guadalupe Suárez Guerrero, M. (1999). National natural capital accounting with the ecological footprint concept. *Ecological Economics*, 29(3), 375-390.
- Wackernagel, M. & Rees, W. E. (1997). Perceptual and structural barriers to investing in natural capital: Economics from an ecological footprint perspective. *Ecological Economics*, 20(1), 3-24.
- Wills, S. (2013). Optimal Monetary Responses to Oil Discoveries. OxCarre Research Paper 121.
- World Economic Forum (2013). *Financial Regulation – Biased against Clean Energy and Green Infrastructure?*
- World Economic Forum (2014). Global risk report 2014.
-

World Economic Forum. (2014). Infrastructure Investment Policy Blueprint.

Welton, G. (2011). The impact of Russia's 2010 grain export ban. *Oxfam Policy and Practice: Agriculture, Food and Land*, 11(5), 76-107.

Woods, C. (2009). Funding Climate Change: how pension fund fiduciary duty masks trustee inertia and short-termism. University of Oxford School of Geography and the Environment.

World Bank (2014). Putting a Price on Carbon: Nations opt for market-based solutions.
<http://blogs.worldbank.org/climatechange/putting-price-carbon-nations-opt-market-based-solutions>

World Resources Institute (August, 2013). 'Majority of China's Proposed Coal-Fired Power Plants Located in Water-Stressed Regions'. <http://www.wri.org/blog/majority-china%E2%80%99s-proposed-coal-fired-power-plants-located-water-stressed-regions>

World Resources Institute (November, 2013). 'Water Risks on the Rise for Three Global Energy Production Hot Spots'.
<http://www.wri.org/blog/water-risks-rise-three-global-energy-production-hot-spots>

WWF (March, 2014). 'Move by Norway Sovereign Wealth Fund to invest in renewables could have "global impact"'. Press release. http://www.wwf.org.uk/what_we_do/press_centre/index.cfm?uNewsID=7062

Yuvejwattana, S. (November, 2011). 'Thailand Cuts Interest Rate as Floods Force First Policy Easing since 2009'. *Bloomberg News*. <http://www.bloomberg.com/news/2011-11-30/thailand-lowers-benchmark-rate-as-flooding-forces-first-easing-since-2009.html>

Zhang, F. (2010). High-frequency trading, stock volatility, and price discovery. Social Science Research Network. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1691679

STRANDED ASSETS

PROGRAMME

Smith School of Enterprise and the Environment
University of Oxford
South Parks Road
Oxford, OX1 3QY
United Kingdom

E enquiries@smithschool.ox.ac.uk

T +44 (0)1865 614963

F +44 (0)1865 275885

www.smithschool.ox.ac.uk/research/stranded-assets/



SMITH SCHOOL OF ENTERPRISE
AND THE ENVIRONMENT

