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Sustaining natural resources in a changing environment: evidence, policy and impact

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Themed Issue on ‘Sustaining natural resources in a changing environment’

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& Ashley Thomas Lenihan**

**Sustaining natural resources in a changing environment: evidence, policy
and impact**

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Sustaining natural resources in a changing environment: evidence, policy and impact

Abstract

This article explores the global impacts of a changing environment on the sustainability of resources. In a global context characterised by continued rapid population growth and accelerated urbanisation in emerging economies and the least developed regions of the world, pressures on environmental resources are intensifying. Extreme effects on ecosystems in both urban and rural communities are of enduring concern, as evidenced in water and food insecurity, and poor air quality. The author compares varying approaches to the collection and use of evidence, and the ways in which researchers may influence policy decisions and their implementation. Drawing on large and small-scale studies conducted in different regions of the world from a range of disciplinary perspectives, the article seeks to unravel the triangular relationship between research evidence, policy and impact, while paying attention to the tools used to assess impact on, and of, policy. In conclusion, the author considers how co-ordinated efforts by academics, public, private and third-sector practitioners across disciplines and national borders might produce stronger evidence and knowledge with which to inform decision-makers, empower citizens and achieve sustainable development, thereby supporting the needs of present and future generations.

Keywords: sustainable natural resources, changing environments, multidisciplinary approaches, evidence-based policy, policy impacts

Introduction

The availability of nutritious food, clean air and water are essential components in fostering ecosystems for a healthy life and improved well-being. In the early twentieth century, Mahatma Gandhi (1869–1948) articulated his belief that ‘the earth provides enough to satisfy every man’s need but not every man’s greed’. He also stated that what we are doing to the forests of the world is a reflection of what we are doing to ourselves and to one another. The predictive power of his words has even greater relevance in the twenty-first century, as awareness has grown that the damage to the environment could be due to human factors, prompting action by researchers and policymakers to halt the degradation of natural resources, as exemplified in reports by the United Nations’ Intergovernmental Panel on Climate Change (IPCC, 2014a), and as articulated in the Millennium and Sustainable Development Goals.

Despite substantial improvements in the production of systematic information regarding changing environments and their impacts on natural resources, the use of available knowledge to inform policy continues to be hampered by low levels of confidence in much of the data and in many of the assumptions on which they are based (Leysdon, 2014). This article considers international and multidisciplinary research evidence of the possible impacts that changing biophysical and social environments can have on the sustainability of natural resources, and explores how such evidence is being used globally and nationally to influence policy decisions.

We begin by defining what we mean by a changing environment. We explore some of the policy relevant aspects of these changes that contribute to an understanding of the concept of sustainable development encompassing: population growth and urbanisation; public awareness of extreme weather events; attitudes to climate change predictions; and perceptions of the power of governments to generate change.

We then examine the varying approaches adopted internationally and by different disciplines in the collection and use of evidence. The article reviews the ways in which researchers, professionals and practitioners from public, private and third sectors have sought to influence policy decisions and their implementation (Loorback, 2010). It draws on large and small-scale studies conducted in different regions of the world, spanning North and South America, Africa, Asia and the Middle East, carried out by researchers from disciplines ranging from engineering and climatology, through the social sciences, to architecture, anthropology and philosophy. In seeking to unravel the triangular relationship between research evidence, policy and impact at global, national and local levels, attention is given to international targets for sustaining natural resources, and the tools used to achieve targets and assess research impacts. Our aim is to demonstrate the importance of developing multi-level thinking and planning for long-term sustainability, extending beyond short-term profit making and partisan politics, as argued by Sachs (2015) in his work on pathways to sustainable development, and by Jacobs & Mazzucato (2016) with reference to inter-sectoral co-production for sustainable and inclusive growth.

In conclusion, we consider how co-ordinated efforts by academics, public, private and third-sector practitioners, drawing on natural and social science methodologies, and different national perspectives, might become more effective in producing strong evidence and knowledge to inform decision-making, empower citizens and achieve sustainable development.

Global perspectives on changing environments

Much has been written about climate change and natural resources, and the causal relationship between them. In their Summary for Policymakers (SPM), the IPCC (2014a) unambiguously presents the current state of scientific thinking about the relationship between

climate, its impact on natural and human systems and the ways in which governments should be tackling the problems facing humanity:

SPM 1: Human influence on the climate system is clear.... Recent climate changes have had widespread impacts on human and natural systems;

SPM 1.1: ...changes in climate have caused impacts on natural and human systems on all continents and across the oceans;

SPM 1.3: Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia;

SPM 4.5: Climate change is a threat to sustainable development. ...there are many opportunities to link mitigation, adaptation and the pursuit of other societal objectives through integrated responses.... Successful implementation relies on relevant tools, suitable governance structures and enhanced capacity to respond....

Within the confines of this short article, the intention is not to attempt to assess IPCC's scientific findings but to seek evidence of the extent to which their statements have, or have not, been acted on by policymakers in different parts of the world. In an analysis of 'critical issues in social science climate change research', Leyshon (2014), a geographer, addressed the ontological politics of climate change and the epistemological questions faced by social scientists tackling climate change. The present article draws selectively on a wider multidisciplinary literature to illustrate the relationship between research evidence, public perceptions and policymaking at global, national and local levels. Our interest in this section is in locating this relationship within the framework of the multifarious aspects of the changing environments in which natural resources are exploited and consumed, and in which public attitudes to the issues raised are formed and informed.

In a review of hierarchies of evidence in the context of the relationship between researchers and policymakers, political economists and social policy specialists have argued that 'no

single source of evidence is likely to be determining or irrefutable' (Hantrais, Lenihan & MacGregor, 2015, p. 108). Both across and within countries, sectors and socio-economic groups, not all evidence can be said to carry the same weight, or generate the same responses. These observations are particularly relevant in respect to climate change and sustainability of natural resources, where social science evidence is in competition for influence on public opinion and policymakers with scientific evidence and other factors such as political ideologies, long-held convictions and value systems. The wide range of evidence evoked in this section indicates the varied and conflicting interests of the research community studying the sustainability of natural resources in a changing environment. It also illustrates how different bodies of scientific evidence can be said to shape public perceptions and influence policy.

This section refers to case studies by researchers from the natural and social sciences and by practitioners working in different regions of the world. We consider the impacts on natural resources of both climate change and other contextual factors shaping the changing environment, including population growth and urbanisation in combination with technological developments. We examine how they affect public perceptions and attitudes, and exert additional pressure on policymakers in the public, private and third sectors, inciting them to develop and implement mitigation strategies.

The impact of population growth and urbanisation on natural resources

Underpinning current policy thinking at international level is the acknowledgement of the pressures on natural resources from population growth. The world population is currently around 7.5 billion and is estimated to reach 9.7 billion in 2050 (United Nations, 2017). The population in the least developed regions is predicted to continue growing, with an estimated 1.3 billion inhabitants to be added in Africa (doubling its current population), 0.9 billion in Asia and 0.2 billion in the rest of the world by 2050.

Around 54 per cent of global population is currently urban according to United Nations' (2017) estimates. Evidence from urban geographers, sociologists and engineers shows how growing urbanisation is intensifying pressures on natural resources (Rout, 2018), creating extreme levels of air pollution (Nathan & Srikanth, 2018), the lack of clean water (Sansom, Hirst & Kayaga, 2018), unequal access to energy (Brown et al., 2018), and continued food insecurity (Kenton & Singha, 2018) in both urban and rural communities (Zong & Cai, 2018). Much of the growth in mega cities (with a population of over 10 million) is predicted to be in less developed countries: 21 among 27 mega cities by 2025. The population in some mega cities already exceeds that of the estimates provided by the United Nations (2008) for that year: for example, the population of Tokyo is currently 37.8 million; the population of Delhi is estimated to have reached 25 million; and that of Shanghai, the most populated city in China, exceeds 24 million.

Major shifts in population from rural to urban environments, in conjunction with climate change, are recognised by international organisations to have intensified pressure on ecosystems (including crops, livestock, fisheries and forestry) and food security, resulting in an increase in the number of undernourished people since 2014 (FAO, IFAD, UNICEF, WFP & WHO, 2017). Evidence from a study carried out by environmental and ecophysiology scientists (Medek, Schwartz & Myers, 2017) suggests that climate-related disruptions to agriculture will become more severe, with ever more serious implications for food supply, plant nutrients and human health. The authors conclude that 148.4 million of the world's population might be at risk of protein deficiency due to elevated atmospheric carbon dioxide concentrations (eCO₂) by 2050. The situation in sub-Saharan Africa, South Asia, and especially India presents daunting challenges. They therefore recommend that eCO₂ effects on crop nutrient contents should be incorporated into future food security policies. An earth science study for the US National Aeronautics and Space Administration (NASA), based on

evidence from global crop models collated by climate scientists, suggests, however, that eCO₂ levels could both ‘help and hurt crops’ (Reiny, 2016).

The US Global Change Research Program (USGCRP, 2015) was established by Presidential Initiative in 1989 and mandated by Congress in the Global Change Research Act of 1990 to ‘assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change’. The USGCRP works with academics, the state, industry, and other groups on global change research to study climate change impacts on every type of natural resource from plants to animal species, and the alterations it brings to ecosystems. The Huron River Watershed Council (HRWC, 2016) was founded in 1965 in southeast Michigan and dedicated to river protection. The Council argues that increased risks of flooding, droughts and fires, and the severe degradation of natural resources are the result of reduced water levels, ground water recharge and wetland coverage, due to the warmer water and air temperatures.

The extent to which the American public believes such scientific evidence is revealed in an analysis by Marlon, Howe, Mildenerger & Leiserowitz (2016) of the Yale Climate Opinion Maps. These authors used statistical modelling of national public opinion data gathered between 2008 and 2016 in the US. They found that: 70 per cent of adults thought global warming was happening; 53 per cent thought that it was due to human activities, while 32 per cent attributed it to natural changes; 49 per cent said that they believed evidence from scientists about global warming, whereas only 28 per cent realised that no consensus existed; 71 per cent said they somewhat/strongly trusted scientists, while 26 per cent said that they did not. When Cook et al. (2013) analysed the evolution of the scientific consensus on anthropogenic global warming in peer-reviewed scientific literature, they found that, over time, the number of published papers rejecting the consensus on global warming had fallen to less than 3 per cent. These findings suggest that, although members of the wider public in the

US are rarely exposed to contradictory scientific evidence, they are not necessarily convinced by the views presented by professionals.

The European Commission's Joint Research Centre, Directorate for Sustainable Resource, analysed disaster records and high-resolution hazard and demographic projections for the period 1981–2010. Using a prognostic modelling framework through to the end of the twenty-first century, they examined human vulnerability in Europe due to extreme events: heat and cold waves, river and coastal floods, windstorms, droughts and wildfires. The evidence from their evaluation of spatial and temporal variations in intensity and frequency of greenhouse gas emissions demonstrated that, during the reference period, around 3,000 Europeans lost their lives each year due to weather disasters (Forzieri, Cescatti, Silva & Feven, 2017, p. e202). The authors predicted that, in the absence of appropriate adaptation measures, the figure could reach 152,000 by 2071–2100, with about two-thirds of European population affected annually by weather-related disasters by 2100. They suggested that their results 'could aid in prioritisation of investments to address the unequal burden of effects of weather-related hazards and differences in adaptation capacities across Europe' (Forzieri, Cescatti, Silva & Feven, 2017, p. e207).

The role of technology in raising public awareness of changing environments

The rapid expansion of visual communication and social media has become an important component in evidence gathering and dissemination. By the end of the twenty-first century, technological developments had not only created a vast array of tools for assessing the impact of climate change on human and natural resources globally, they had also provided new instruments for raising and measuring public awareness of the impact of such changes on everyday life.

Technology has increasingly made it possible for citizens to engage directly by generating their own evidence through globally connected electronic media platforms, citizen journalism and other social media channels. Through print, audio and visual media, accounts of natural disasters and extreme weather events from across the world are disseminated on almost a daily basis, making the public aware of the adverse impacts on their everyday lives. Widely reported weather events in 2017 alone encompass: wild fires, droughts, and crop damage in Spain and Italy (Henley, 2017); the heat wave in Asia, the Middle East and Europe (Masters, 2017); wind damage, hail, tornadoes and floods in the US (Dolce, 2017); mudslides in Sierra Leone (McAllister, 2017; Roy-Macaulay & Oyekanmi, 2017); and floods in South Asia (BBC, 2017).

Images such as those of the 2004 Indian Ocean Tsunami, the severe annual floods in Bangladesh, and the devastation caused by hurricanes Harvey, Irma, Jose, Katia and Maria in 2017, in rich and poor nations alike, play a crucial role in raising and maintaining public awareness of the impact of extreme weather events. Al Gore's film, 'The inconvenient truth' in 2006 and the Stern (2006) review on the economics of climate change, commissioned by Gordon Brown as UK Chancellor of the Exchequer in the Blair Government in the same year, were produced at a time when evidence based on events such as the Indian Ocean Tsunami had made the public receptive to new global policies. Fanny Armstrong's 2009 drama-documentary hybrid film 'The age of stupid', and its sequels, attracted crowd-funding, enabling it to achieve a global impact and to be credited with influencing the UK's energy policy (Puma, 2011).

In another example, a study in spring 2017 by the Pew Research Centre, a non-profit, non-partisan and non-advocacy US (fact) think tank, used global surveys and other social science instruments to inform the public about the issues, attitudes and trends shaping the world. The authors (Poushter & Manevich, 2017) reported that climate change is perceived as the

greatest threat in 13 of the 38 countries surveyed, particularly in Latin America and Africa. Most of the other countries in the study ranked it as the second highest threat to national security. An earlier study by the Pew Research Centre (2015) suggested that people in countries with the highest per capita carbon emissions, such as the US, are less concerned about climate change and its potential implications than in Latin America and Africa where carbon emissions are much lower (Stokes, Wike & Carle, 2015).

The same study found that 54 per cent of respondents agreed with the statement that ‘rich countries such as the US, Japan and Germany should do more than developing countries because they have produced most of the greenhouse gas emissions so far’; 38 per cent were of the view that ‘developing countries should do just as much as rich countries because they will produce most of the world’s greenhouse gas emissions in the future’. The authors attributed differences in the level of concern to perceptions of the capability of governments to cope with the impacts. Across all the countries in the Pew study, 78 per cent of respondents expected their governments to take greater responsibility for limiting greenhouse gas emissions as part of the international Paris agreement, while 67 per cent accepted that the population will have to make lifestyle changes. Only 22 per cent believed that technology would solve the problem without major changes in how people live (see also Canter, 2013; Gough, 2017).

In their examination of national public opinion in the US, Marlon et al. (2016) found strong support for policies to tackle climate change: 82 per cent of respondents agreed that funding should be provided for research into renewable energies; 66 per cent that utilities should be required to produce 20 per cent of electricity from renewable sources; 75 per cent that CO₂ should be regulated as a pollutant; and 69 per cent that strict CO₂ limits should be set on existing coal-fired power plants.

Awareness of the major threats to natural resources and human security from the combined impact of population growth, intensified urbanisation and observation of extreme weather events associated with climate change has, undoubtedly, increased pressure for action at global level (Mitchell, Lowe, Wood & Vellinga, 2006). As noted above (Marlon et al., 2016), a sizeable proportion of the US public remains sceptical about the causal relationship between climate change and human activities. However, public awareness and concern about the impact of changing environments on their livelihood, combined with their support for government intervention, could be said to lend legitimacy to mitigation and adaptation strategies at different levels of governance to reduce the impacts of climate change.

Collaborative international policy responses to evidence of changing environments

Several of the studies cited in the previous section report on large-scale research carried out globally by international organisations. They show how sustainability of natural resources raises issues that engage researchers from multiple disciplines and sectors. Here, we consider further the opportunities provided by such engagement for collaboration across and within countries and sectors, particularly in the framework of international agreements and the assessment of internationally set targets. This section explores the contribution of researchers from a range of cultural and scientific backgrounds and disciplines, using a variety of methodological approaches, sometimes working collaboratively across the natural and social sciences, and usually in conjunction with governments and other stakeholders. These programmes and collaborations offer further insights into the relationship between evidence, policy and impact on the multiple aspects of sustainable environmental development at international, national and local levels.

Setting international targets

On 12 December 2015, the Paris Agreement on climate change was adopted by consensus by 195 of the 197 countries (excluding Syria and Nicaragua) subscribing to the United Nations

Framework Convention on Climate Change. The Agreement was ratified by 160 countries and entered into force on 4 November 2016. Nicaragua subsequently indicated its intention to sign the Agreement in October 2017. The UN's Sustainable Development Goals (SDGs) adopted at a summit in September 2015 came into force on 1 January 2016. Evidence based on multiple bodies, systems, processes and 'advocacy coalition approaches' (Sabatier & Jenkins-Smith, 1993) was crucial in enabling these two agreements to be reached by countries jointly representing over 90 per cent of world population. A key component in these global negotiations was the impact of the strong evidence presented regularly by heads of small island states concerning their vulnerability to global warming and extreme weather events (UNFCCC, 2005).

The United Nations' SDGs through to 2030 were designed to protect the planet from degradation by ensuring sustainable consumption, production and management of its natural resources, to promote urgent action on tackling climate change, and to end poverty. The growing body of evidence and knowledge about the vulnerability of the planet ensured that the majority of the seventeen SDGs focused directly, or indirectly, on sustaining natural resources in changing environments by improving the harmony between human beings and nature, and the well-being of global society. The most relevant goals in the context of the present article are those intended to:

- SDG 2: end hunger, achieve food security and promote sustainable agriculture;
- SDG 6: ensure availability and sustainable management of clean water;
- SDG 7: ensure access to affordable, reliable, sustainable and modern energy for all;
- SDG 8: promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;
- SDG 11: develop resilient and sustainable cities;
- SDG 12: promote responsible consumption and production;

SDG 15: protect, restore and promote air quality, sustainable use of terrestrial ecosystems, sustainable management of forests, combat desertification, and halt and reverse land degradation;

SDG 17: develop global partnerships for sustainable development.

(United Nations, 2015)

The SDGs have evolved through an inclusive process of intergovernmental negotiations between policymakers, through regular conferences and dialogues building on evidence and research, shared experiences, understanding, impact and lessons learned through fifteen years of implementation of the Millennium Development Goals (MDGs). The UN SDGs set the targets and standards that need to be attained in full awareness that the levels of achievement would vary across different regions of the world, and be contingent on prevailing regimes and stages of development.

The case studies described here highlight the difficulties of achieving an effective relationship between the producers (researchers) and users of evidence (policymakers), even in instances where the evidence and its implications for policy in a local context appear to be strong and clear. A case study by Sansom, Hirst & Kayaga (2018), a team of UK and Ugandan civil engineers specialising in water engineering, considered how SDG 6 for universal piped water supplies could be reconciled with country realities in Sub-Saharan Africa. Their work demonstrates the importance of national medium-term target setting and reviewing and systematic planning approaches. They also identify the role played by careful global reporting of national performance against the SDG targets, portrayed as essential components for countries seeking to achieve these goals in the long term. The research team worked closely with their stakeholders to achieve realistic targets in the medium term. Their article draws attention to the need to make adaptations to the SDGs when they are implemented in different environments to avoid demotivating countries with limited capacities and resources.

SDGs 2, 6, 7, 8, 12 and 15 were all relevant to a study by Srikanth and Nathan (2018) of open-cast coal mining in India. The authors describe the potentially harmful environmental impact of surface opencast mines, due to loss of forests and habitats, disruption of biodiversity and of local communities, and associated damage to agriculture, water resources, and local air quality. They identify the policy limitations in implementing the SDG principles due to inadequate guidelines, the lack of effective consulting mechanisms, and scarce local capacity and resources.

Although the SDGs were not explicitly targeted in their work, Zong & Cai (2018) applied international standard value measures in assessing the impact of urbanisation expansion on cultivated land resources and food security in Chongqing, China, as sought in SDGs 2, 11 and 15. They describe the interactive relationship between researchers and policymakers in developing and implementing strategies to ensure national food security in response to evidence from scientific data about the impacts of the urbanisation process. Their account suggests how, in the Chinese context, government commissioned empirical studies are used to inform policy and to produce more efficient policymaking, in this case by researchers assisting governments in their efforts to protect cultivated land.

Inter-sectoral collaboration

The United Nations MDGs involved public and private sectors, civil society and communities, and enabled them to work closely together to improve global development. In 2016, the Earth Security Group (ESG), a London-based inter-sectoral team from science, industry, finance and policy, carried out a study in collaboration with the Federation of Indian Chambers of Commerce and Industry and British High Commission in New Delhi. The study was designed to identify business innovations and policy partnerships enabling the insurance sector to play a more prominent role in building India's resilience to climate change in the

energy and agriculture sectors (SDGs 2, 7). The ESG report, involving a forum of policymakers and business leaders, served as a catalyst for collaboration between insurers, industry and the Indian government. The Group drew on their strong networks within the policy community to communicate their findings to various ministers in India and to feed their evidence into discussions in the Indian Parliament in 2017.

Governments, international financial institutions and business leaders across the world are promoting insurance policies in the form of aid to developing countries with the aim outlined in SDG 17 of building global partnerships for sustainable development. In 2015, for example, based on available evidence about the impacts of climate change at global level, the G7 countries pledged to provide climate risk insurance for an additional 400 million people in the developing world by 2020, with Germany, Japan and the UK playing a lead role (Ralph & Aglionby, 2017).

Wiersma & Devine-Wright (2014) compared drivers and influences in projects concerned with the contribution of decentralised energy to the low carbon transition led by public, private and professional third-sector actors (SDG 7). They concluded that the substantial diversity within and between cases and across sectors is not sufficiently accounted for in academic projects interested in pursuing policy goals, again emphasising the importance of and in-depth understanding of a range of contextual factors determining the effectiveness of policy implementation.

Drawing on other internationally agreed standards and targets contributing to the attainment of SDG7, Oppong (2018) examined the dynamics of NGO participation in the Extractive Industries Transparency Initiative (EITI), an international auditing and multi-stakeholder oversight initiative adopted in Ghana in 2003. He highlights the negative effects of resource rents on state institutions, policy processes and economic output in resource-rich countries.

His political economy analysis found that contestations within the NGO community around intervention processes inhibited meaningful implementation of evidence in resource governance. He concludes that, if the EITI is to avoid criticism for promoting transparency without improving accountability, it will need to achieve a closer fit with the strategic, normative and institutional values that different organisations, notably NGOs, attach to it in implementing countries.

When framed within wider national and international contexts, small-scale case studies are useful in shedding light on the ways in which social science evidence can be used both in policy and practice at community level. Rout (2018) examines forest governance policies in India and their impact on the livelihood (in)security of forest communities, as signalled in SDG 15. The evidence from his case studies shows how participatory models of governance based on bottom-up and rights-based approaches have sought to address environmental concerns. He argues that national policies, when implemented at community level, can produce divergent and unwanted results if they do not take sufficient account of local contextual factors.

In another example of evidence produced at community level, Kenton & Singha (2018) describe small-scale co-production action projects carried out by an international environmental design charity in the community development field. Their work in Venezuela and Palestine, two politically unstable countries, demonstrates how participatory methods can lead to greater community ownership and cohesion around shared concerns over access to healthy food and sustainable resource use in urban settings, reflecting the aims of SDG 2. Evidence from their studies, like that produced by Rout (2018), suggests how collaborative bottom-up processes can contribute to longer-term sustainable policy development at local level by encourage effective governance of scarce resources in challenging environments.

Assessing research and policy impacts

The importance of scientific assessments of environmental impacts and the ability and willingness of governments to accept and act on their conclusions are demonstrated by Hochstetler (2018) in a comparison of the regulatory Environment Impact Assessment (EIA) frameworks in regional states in Latin America. She explores the arrangements for collecting, disseminating and assessing evidence about the environmental, social and economic impacts of projects including mining, hydroelectricity and wind farms. Her work shows that, although these reviews are most often conducted by an environmental agency involving some consultations with the local communities, current EIA frameworks have nevertheless become highly politicised. The tension created by producing socio-environmental evidence and economic policymaking may, she suggests, compromise the very results sought by the process.

The rationale and mechanics of impact and assessment of research on low carbon energy and international development are the focus of an article by a multidisciplinary team of geographers, civil engineers and anthropologists (Brown et al., 2018). The authors exploit networking and team analysis in considering how new policy initiatives, technological innovations and business models combining disciplinary, institutional, managerial, technological and methodological approaches can develop more effective evidence-based policy. They trace some of the debates around the conceptualisation of impact within different communities and by other stakeholders involved in research and innovation, as sought in SDG 7. Their analyses prompt them to argue for greater recognition and the attribution of specific resources to achieving longer-term network and capacity-building impacts beyond individual projects.

International and multidisciplinary perspectives

A substantial proportion of the reviews here on sustainability in changing environments derived from available literature from the US and/or is published in English-language media. However, the topic lends itself readily to international and multidisciplinary approaches that extend beyond the social sciences and English-speaking world. Several of the authors cited in this article have been associated with the UN or IPCC. These institutions rely on large-scale international teams using a variety of methodologies and tools across the sciences to carry out, assess and report their findings to the public and to policymakers. In addition, reference has been made to smaller scale evidence-based policy studies by researchers from Ghana, China and India, and to work with a policy dimension by native English speakers carried out in Brazil, Palestine, Uganda and Venezuela, illustrating wide-ranging interest in the topic.

Adopting a multidisciplinary approach, Brown et al. (2018) show how geography brings an appreciation of scale to questions of energy access. For example, in their focus on multi-level governance, they analyse how actors involved in governing the energy sector intersect at different scales. The authors acknowledge, however, that the community for low carbon energy research for development in the UK is fragmented and 'silo-ised'. The same observation could be applied to other countries, disciplines and areas of research.

Opportunities are, Brown et al suggest, being missed for linking disciplines and enhancing systemic complexity by cross-fertilising it with the innovations taking place in the private sector. Hence, multidisciplinary research will, they argue, only contribute to the challenges of securing universal access to a minimum acceptable amount of electricity, and the acceleration of low carbon transitions if it clearly responds directly to the demands and needs of communities and the variety of organisations (private, public or third sector) working towards those aims.

Despite the tendency in many countries for individual researchers to be silo-ised, several of the researchers cited in this article themselves have multidisciplinary and international

backgrounds. For example, echoing the words of Mahatma Gandhi, cited in the introduction to this article, Gough (2017) brings to bear the multidisciplinary knowledge and methodologies of a social policy specialist in an analysis of *Heat, greed and human need: Climate change, capitalism and sustainable wellbeing*. Combining ethics and human need theory with political economy and climate science, he demonstrates how bridges can be built successfully between economy, ecology, social policy and politics. Oppong (2018), who is writing on extractive industries in Ghana, trained in political science, philosophy, international politics and development studies. He tackles his subject from the perspective of a political economist.

In their project on water targets in Uganda, Sansom, Hirst & Kayaga (2018) recognise that multidisciplinary work came about in at least two ways: firstly, by extending their areas of expertise, since two of the authors started their careers in engineering and then developed their expertise in water and sanitation management and institutional issues; secondly, through extensive interactions with experts over the years in other disciplines, including social scientists. The authors were thus able to contribute to research and advice on topics such as equity and community issues. Similarly, Nathan & Srikanth (2018) brought multidisciplinary and international perspectives to their case study in India. Nathan recorded three decades of experience in industry in the natural resources sector, and Srikanth's expertise extended to interdisciplinary research in sustainability and human development. Together, they contributed fresh insights by combining different but complementary perspectives from mining technology, mineral engineering management, policy and regulation, social consciousness and sustainability. Like Sansom, Hirst & Kayaga (2018), they worked closely with key stakeholders to explain the need for a unified regulator for surface coal mines to overcome current policy and regulatory gaps. The Chinese geographers Zong & Cai (2018) examined the urbanisation process in a city located in the western part of China from a spatial

perspective. They also worked closely with policymakers to reveal the different impacts of urbanisation on land resources.

Kenton & Singha (2018) combined the knowledge and expertise of an architect and a development practitioner with the experience of directing an international environmental design charity working in the field of disaster relief amid political upheaval in low- and middle-income countries. Their projects show how architects, engineers, development activists and designers are collaborating globally to safeguard environmental and cultural sustainability (Singha, 2012). The authors used methodologies that are locally relevant, empowering, and replicable to carry out community-led bottom-up projects, thereby offering a way forward for improved policymaking and efficient governance of resources at local level in a landscape of rapid change and scarce resources.

As argued by Hochstetler (2018), ‘politics’ is often blamed for environmental problems, and the most powerful economic and political actors frequently reach their position by indiscriminately using and degrading natural resources. Many solutions require collective authority as well, often from the state, necessitating the construction of new, more sustainable, political coalitions. Political scientists are, therefore, well placed to contribute to the body of knowledge about sustainable development. In examining how Brazilian impact assessment works in practice, Hochstetler (2018) acknowledges that natural scientists and engineers provided much of the information that she used. Her analysis required a social scientific analysis to assess social and economic changes, illustrating the key role played by social scientists at all stages of international and multidisciplinary projects.

Conclusion

An important aim in this article was to compare and contrast international and multidisciplinary perspectives on the development of policy in response to evidence about the

impact of environmental change on the sustainability of natural resources. To this end, the article has explored both the institutions involved in generating and mediating evidence, and the different methodologies employed in collecting and assessing evidence, informing policy, and contributing to governance.

In the field of sustainability of natural resources, the challenge of generating unbiased evidence with high levels of confidence requires a strong commitment and collaborations among researchers from a multiplicity of disciplines and sectors. The scale of the impacts and vulnerabilities due to climate change has encouraged physical and social scientists to work together in an unprecedented manner to gain a better understanding of the challenges it presents. IPCC (2014b) recognised the importance of understanding decision-making contexts in determining the type and scale of climate change risks based on physical climate science and impacts, adaptation and vulnerabilities assessment. The case studies reported in this article indicate how the effectiveness of implementation is often determined by a range of socio-economic and political contextual factors affecting the ability of researchers and policymakers to communicate and cooperate in setting, agreeing and achieving international targets.

While acknowledging the conceptual and contextual problems of working across national, disciplinary and sectoral boundaries (British Academy, 2016; Hantrais, 2009; Lunn & Ruane, 2013), this article has considered whether and how co-ordinated efforts by academics, public, private and third-sector practitioners can achieve reciprocal impacts. Drawing on natural and social science methodologies, and different national perspectives, our analysis suggests that collaborations across and between sectors can, if properly managed, lead to more effective generation and transfer of knowledge that informs decision-making and empowers citizens while seeking to achieve sustainable development.

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