RESOURCE SCARCITY AND ENVIRONMENT:

Review of evidence and research gap analysis

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July 2013

EVIDENCE ON DEMAND

CLIMATE & ENVIRONMENT
INFRASTRUCTURE | LIVELIHOODS

This report has been produced by Dr Ben Daley for Evidence on Demand with the assistance of the UK Department for International Development (DFID) contracted through the Climate, Environment, Infrastructure and Livelihoods Professional Evidence and Applied Knowledge Services (CEIL PEAKS) programme, jointly managed by HTSPE Limited and IMC Worldwide Limited.

DOI: http://dx.doi.org/10.12774/eod_hd062.jul2013.daley

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Report Summary

This report presents the results of a rapid, desk-based review of current and recently concluded (since 2008) research into resource scarcity and its effects on the environment, environmental resources, growth and poverty in developing countries, together with an assessment of research and evidence gaps in the same area. The study focused primarily on peer-reviewed literature, although other major and influential works were also considered. The geographical scope was Sub-Saharan Africa and South Asia with specific reference to DFID-focus countries in each continent and region (excluding South Africa and India), although studies relating to other locations have been considered if they provide information transferrable to other contexts.

The main findings of this review are:

- The issue of natural resource scarcity has received considerable attention at the global scale, and it is an increasingly prominent issue on global agendas. Many studies consider resource scarcity at the global scale (often using surrogate measures such as commodity prices as reflective of scarcity). On the other hand, there is a comparatively rich literature of resource scarcity studies for particular locations, and some detailed studies of the resource scarcity context for particular countries (such as Ethiopia). In between these two scales there is a comparative paucity of research and it is not clear how the global-scale studies and the myriad local-scale studies connect to form a coherent body of study, if indeed they do. Further research might valuably explore the conceptual space between global- and local-scale dimensions of resource scarcity to determine if this issue can be approached in a more integrated manner across geographical scales.
- There is an accumulation of evidence to suggest that resource scarcity and poverty are closely related, although the precise nature of that relationship is both contested and vague. In particular, there is limited clarity on the exact linkages involved between resource scarcity, poverty and poverty reduction, and further research might valuably clarify those linkages. Some studies have acknowledged that the issues are more complex than simply ‘resource scarcity causes poverty’; some work has acknowledged that ‘poverty causes resource scarcity’; yet relatively few studies have investigated exactly how and why these links occur. Where researchers have probed these areas in greater detail, they reach the almost unanimous conclusion that resource scarcity is a political (economy) issue that is much more about distributive issues and access to resources than it is about absolute resource shortages. Moreover, those studies tend to reach the (related) conclusion that improved resource efficiency – perhaps in conjunction with improved demand management – is likely to form part of an appropriate response to resource scarcity issues.
- Resource scarcity issues are increasingly viewed as some form of ‘nexus’, given their complexity and tight interconnections, and indeed it is difficult to isolate resource scarcity issues in the current and recent research literature. However, again, there is a lack of precision in defining the nature of that nexus, and various different types of nexus have been considered by researchers. On the one hand, the research literature suggests that almost any environmental issues – and many economic and social ones, too – might reasonably be included in the nexus of issues linked to research scarcity. On the other hand, some issues are clearly more prominent – and seems to have greater explanatory power – than others in understanding what drives resource scarcity. Further research might prioritise and clarify the question of which factors matter most in driving – and in explaining – resource scarcity.

- In particular, the issue of climate change pervades the current and recent literature on resource scarcity and very few of the studies reviewed failed to consider climate change as an issue. However, it is difficult to find evidence of research that probes below the simple observation that climate change is likely to exacerbate resource scarcity issues, through a wide range of direct and indirect effects. Again, whilst climate change conceivably affects every aspect of resource scarcity, some of the effects of climate change are likely to be more important than others in explaining resource scarcity. Therefore, further research might provide valuable focus on clarifying the precise mechanisms by which climate change, resource scarcity and poverty interact.
- Water scarcity is a very prominent issue in the current and recent literature on resource scarcity and poverty, and this area may be reasonably well characterised, although this is also an area in which resource scarcity issues are particularly acute and are projected to become yet more critical in future.
- Resource scarcity is acknowledged to be an important potential driver of conflict – and to become more so with climate change, population growth and economic growth – yet there is debate about the particular factors that most strongly promote conflict, and this is a potential area in which further research might yield valuable insights.
- Overall, the literature of resource scarcity, environment and poverty is highly patchy, both in terms of topic, and geographically. In terms of topic, very limited material specifically on urban themes, industrial processes, metal resources, minerals and fossil fuels was found for developing countries for the period since 2008 (although some of these themes are covered in studies relating to security, and some material relating to developed-country issues has been published). Nevertheless, these are important issues that require adequate understanding and it is possible that original research could be focused on these topics. In terms of geographical coverage, again, studies specifically considering DFID-focus countries were relatively sparse and further work could be undertaken for these countries.

The following areas were identified as possible areas in which new research could potentially be of value to DFID:

- Original studies of the precise links between resource scarcity and poverty in DFID-focus countries, focusing on those factors with greatest explanatory power.
- Original studies of the drivers and impacts of renewable resource scarcity in DFID-focus countries, focusing on the precise connections between resource scarcity and poverty.
- Original investigations of the *specific* ways in which climate change, resource scarcity and poverty interact in particular locations (in DFID-focus countries).

SECTION 1

Introduction

Aims and scope of the study

This study focuses on the issue of resource scarcity and how it affects the environment and environmental resources (including natural resources) as well as growth and poverty in developing countries.

The aims of this study were:

(a) To identify current and recently concluded research on resource scarcity and its effects on the environment, environmental resources, growth and poverty in developing countries;

(b) To identify research and evidence gaps in the same area.

The objective of the study was to conduct a rapid desk-based evidence search on this topic, identifying current and recently concluded research (published since 2008) and focusing in particular on peer-reviewed literature, although other major and influential works were also considered.

The geographical scope of the evidence search was Sub-Saharan Africa and South Asia with specific reference to DFID-focus countries in each continent and region (excluding South Africa and India).

This document presents the results of the review of the investigation, identification and mapping of recent research on resource scarcity and the environment. It also identifies the evidence and research gaps in the same area, based on the evidence reviewed.

Definitions and context

In relation to natural resources, resource scarcity is defined as an absolute or relative shortage of natural (or environmental) resources which may occur for several reasons:

- Absolute scarcity of resources – where there is a limited supply.
- Increasing consumption of resources – so that demand exceeds the available supply.
- Uneven distribution of resources – if resources are not located where they are needed.
- Uneven access to resources – if people cannot obtain/use otherwise available resources.

Resource scarcity is an important issue because resource scarcity in turn imposes social costs. The issue of resource scarcity has long caused concern and controversy, extending back at least to Malthusian fears that population growth could periodically outstrip the availability of food resources, resulting in poverty and population decline. Resource scarcity remains an issue of concern, particularly in the context of rapidly increasing resource consumption in some parts of the world. This concern reflects both the direct effects of resource scarcity (the fact that human needs will not be met if key resources are not available) and the indirect effects (such as conflict) that may occur as humans compete for

increasingly scarce resources. A further area of concern is that, increasingly, environmental degradation may occur as a result of more intensive efforts to obtain ever-scarcer resources.

However, there are conflicting views about the severity of current and future resource scarcities – and about human capacity to adapt to those scarcities. Three main positions have been identified:

- Neo-Malthusians argue that finite natural resources impose strict limits on the growth of human population and consumption. If those limits are exceeded, poverty and social breakdown will result.
- Neoclassical economists argue that there are few, if any, absolute limits to human population, consumption and prosperity. Properly-functioning economic institutions (particularly markets) provide incentives to promote conservation, resource substitution, the development of new stocks of resources, and technological innovation.
- 'Distributionists' accept that there may be resource limits to human population growth, but argue that the main problem is the inequitable distribution of resources and wealth at all scales. Poverty and inequality, in this view, are the cause rather than the consequence of high population growth rates and of poor resource management.

Whilst this debate has been long-running, it is worth acknowledging that the neoclassical view is the dominant one and it tends to inform multilateral development agency policies towards resource issues in developing countries (Homer-Dixon 1995).

SECTION 2

Review of current and recent research

General overviews and research on broad-scale issues

A number of studies have examined the general topic of resource scarcity and its relation to broad-scale issues of environment, poverty and growth. The following main themes and key insights have been identified:

(a) The issue of resource scarcity is rising on global agendas

Many studies have identified that the issue of resource scarcity is increasing in importance on global agendas – particularly, but not only, in relation to concerns about national security. In relation to conflicts in Somalia and Rwanda, Theisen (2008) articulated the view that natural resource issues are arguably the most important national security issue of the early 21st century. Those resource issues include population growth, spreading disease, deforestation, soil erosion, water depletion, air pollution and rising sea levels, many of which have at least a resource scarcity dimension. Collectively, those issues represent a significant foreign policy challenge. Bell et al. (2012) have also acknowledged the significance of resource scarcity concerns at the global scale. They argue that world population growth and increased consumption are leading to a worldwide scarcity of several natural resources. Bell et al. (2012) focus particularly on the scarcity of critical natural resources (oil, water, food and precious metals), arguing that such scarcities may threaten commercial activities over the course of this century. The significance of resource scarcity as an issue has also been acknowledged by DEFRA/BIS (2012) in a report highlighting private sector concerns about the availability of some raw materials (although their report focuses on metal and mineral resources, and it does not cover energy or food, nor the poverty reduction agenda). Notably, the DEFRA/BIS (2012) report uses the terminology of resource 'security' rather than 'scarcity', as supplies of most resources are not expected to run out; this reflects the developed-nation focus of their report.

Another significant study of resource scarcity was published by McKinsey Global Institute (2011) *Resource Revolution: Meeting the world's energy, materials, food and water needs*. This influential and authoritative report states that the unprecedented rate and magnitude of economic development in emerging markets is creating soaring demand for resources, as reflected in rises in most prices over the last decade. McKinsey Global Institute (2011) argues that both resource price inflation and volatility could increase, for several reasons:

- New supplies of some resources are becoming more expensive to extract.
- Resource prices are becoming more linked.
- Environmental 'spill-over effects' are affecting crop yields and water availability.

The report notes that these trends could drive protectionism and political unrest, and they require action to expand supply and boost resource productivity in order to avoid entering an era of higher and more volatile resource prices as well as increased risk of resource-related shocks. In turn, the report argues, this would have impacts on economic growth, the welfare of citizens (especially those on low incomes), public finances and the environment. Yet McKinsey Global Institute (2011) suggests that resource scarcity is an area in which

substantial progress can be made: it states that, by 2030, worldwide, savings of US $2.9–3.7 trillion could potentially be achieved through the adoption of a range of resource productivity measures.

Similarly, another report, published by the Center on International Cooperation at New York University, has highlighted that resource security is rapidly rising up the global agenda and is becoming a major issue in international development (Evans 2012). In this report, Evans (2012) points to several indicators of this trend, as well as to some associated issues:

- The combined food and fuel price spike of 2007 and 2008 strongly suggests the growing scarcity of these resources – especially given that, after initial falls, the prices for both commodities remained high even during the recent global recession, with the price of oil exceeding US $100 per barrel and the Food and Agriculture Organization's food price index exceeding its 2008 record. (High resource prices are regarded as a reliable reflection of scarcity, although other factors may also determine pricing.)
- Widespread and intensifying 'scrambles' are occurring, worldwide, to secure rights to energy, land and water resource. Land 'grabbing' is one manifestation of this trend, with 80 million hectares of land secured in leasing arrangements since 2000. There is also increasing competition for oil rights in many parts of the world, including in many African countries.
- Growing resource scarcity has undoubtedly affected international trade, with food export bans or restrictions being imposed in more than 30 countries since 2008, as well as periodic waves of panic-buying in import-dependent countries, not least during the early stages of the 'Arab Spring' uprisings.
- Increasing concern has been expressed about the national, regional and local security impacts of resource scarcities, as exemplified by civil disturbances related to food or fuel prices experienced in more than 60 countries during 2008, as well by as concerns about the implications of unrestrained strategic resource competition between states.

Evans (2012) has argued that these trends may be explained by changing global patterns of demand and supply. Demand for resources is rising as global population grows and as the global middle class gets larger and wealthier. As reflected in a subsequent report by the National Intelligence Council (2013), Evans (2012) suggests that, by 2030, global demand for food may have increased by 50 per cent, for oil by 45 per cent, and for water by 30 per cent over 2012 levels. At the same time, concerns exist about the capacity of resource supplies to increase by equivalent amounts. At the global scale, Evans (2012) notes that:

- The area of arable land available per capita has reduced by 50 per cent since 1960.
- 3 billion people already live in areas of high water stress.
- The rate of agricultural yield improvements since the Green Revolution has declined recently.
- Global oil production has not increased substantially since around 2004, with many mature oil fields nearing economic exhaustion and with remaining oil concentrated in increasingly hard-to-reach places (leading to concerns about when global oil production will peak).

Consequently, Evans (2012) has acknowledged that the evolving resource scarcity agenda has become a prominent one at the global level (for instance, as an item on G20 summit agendas); it has become a key analytical theme (for instance, for McKinsey and for the World Economic Forum); and it is the focus of increasing attention within multilateral agencies and international development organisations.

A major report that has included some consideration of resource scarcity and environmental issues has been published by the National Intelligence Council of the Office of the National

Director of Intelligence (ONDI), entitled *Global Trends 2030: Alternative Worlds* (National Intelligence Council 2013). That study forecasts security-related trends over the coming two decades and their impact on international relations. In relation to the food-water-energy nexus, the report states that demand for these resources will grow substantially due to increasing global population. Those issues are tightly interrelated: the task of addressing problems pertaining to one commodity will inevitably affect demand for, and supply of, the others. Furthermore, the report acknowledges, resource scarcities will be profoundly affected by climate change:

- Climate change in conjunction with a dwindling supply of natural resources is likely to trigger major conflicts in the near future.
- Demand for food, water and energy will grow by approximately 35, 40 and 50 per cent respectively, due to an increase in the population and in the consumption patterns of an expanding middle class.
- Climate change is expected to constrain or reduce the production and availability of food, water and energy.
- Climate change could potentially create or catalyse regional instabilities and international tensions, in part through intensifying competition for available food, water, energy and other natural resources.

The National Intelligence Council (2013) argues that critical resource scarcities can be avoided, but that this will require co-ordinated action by key industries and economies to improve resource productivity and efficiency. The report also acknowledged that many developing countries will not have the capacity to overcome resource scarcities – particularly food and water shortages – without substantial external assistance.

(b) Resource scarcity and poverty are closely related and co-located

Another insight from recent research is that resource scarcity and poverty are closely related and often occur in the same places (Lee 2011). Addressing this question, Lopez (2012) has concluded that natural resource scarcity is one of three new structural factors that underlie the recent global economic crisis. Lopez (2012) argues that resource scarcity – in conjunction with the growth of several high-population countries and the dramatic concentration of income and wealth in advanced economies over the last two decades – is a structural change that has had profound effects on the world economy. Together, these factors have significantly strengthened the links between global growth and commodity demand; they have made world commodity supplies increasingly inelastic; and they have made economic growth more dependent on 'light-touch' monetary and financial policies. Lopez (2012) argues that the combination of these factors may make the world economy highly crisis-prone and they may hinder the recovery from the current one. If this analysis is correct, then resource scarcity is one important element in a combination of factors that may make the global economic context a more challenging one in which to achieve poverty reduction goals. However, the precise nature of the relationship between resource scarcity, poverty and growth is not clear. Varghese et al. (2013) make the point that there is currently no consensus among researchers on the influence of scarcity on common pool resource use: some studies suggest that scarcity may lead to more prudent resource use, whilst others suggest that it tends to encourage the over-extraction of resources. Varghese et al. (2013) argue that this question is a particularly acute one for developing countries, where natural resources are becoming scarce at an unprecedented rate.

Barbier (2012a, 2012b) has examined the broad-scale relationships between natural resources, scarcity, poverty and development. He argues that successive human responses to natural resource scarcity have been a critical driving force behind global economic development. Barbier (2012b) argues that this has occurred as result of both improved resource efficiency and the development of new supplies. He considers how frontier

development has been related to economic development, and he examines the implications for resource-based development for the period since 1950. In relation to poverty, Barbier (2012a) acknowledges that many of the rural poor live in ecologically fragile and remote areas. In such areas, he argues, the main resource scarcity problem is an interconnected one that takes the form of a vicious cycle: of declining livelihoods; increased ecological degradation and loss of common resources; and declining ecosystem services on which poor people in particular depend. Barbier (2012a) emphasises the importance of the relationship between resource scarcity and poverty: he shows that developing countries with large proportions of their populations living on fragile lands and in remote areas not only display high rates of rural poverty, but are also among the poorest countries in the world. Barbier (2012a) argues that policies and practices to eradicate poverty therefore need to be directed at poor communities in the places where they live, especially the rural poor who are clustered in fragile environments and remote areas. Barbier (2012a) states that the specific elements of such a strategy would include:

- Involving the poor in payment for ecosystem services schemes and other measures that enhance the environments on which the poor depend.
- Targeting investments directly to improving the livelihoods of the rural poor, thus reducing their dependence on exploiting environmental resources.
- Tackling the lack of access of the rural poor in less favoured areas to well-functioning and affordable markets for credit, insurance and land.
- Reducing the high transportation and transaction costs that prohibit the poorest households in remote areas from engaging in off-farm employment and limit smallholder participation in national and global markets.

However, Barbier's (2012a) study focuses on rural – rather than urban – poverty, and comparatively little attention has been paid to the nature and implications of resource scarcity in urban environments.

(c) Resource scarcity issues should be viewed as a nexus

Whilst resource scarcity issues are sometimes analysed in isolation, increasingly, resource scarcity issues are regarded as some form of nexus (Stockholm Environment Institute 2011). This is because of the importance and intricacy of the linkages and feedback effects between the different dimensions of resource scarcity; it also means that many resource scarcities may be regarded as 'wicked' problems. Evans (2012) has provided examples of some of these linkages:

- Oil scarcity (as reflected in high oil prices) can lead to high food prices, as costs increase for fertiliser, on-farm energy use, processing and transportation (see also McNally and Levi 2011).
- High oil prices can also intensify competition for land: for example, as biofuels become cost-effective as an alternative to fossil fuels.
- High oil prices can lead to higher water prices as a result of the energy intensity of water pumps, desalination plants and purification systems.
- These effects are exacerbated by climate change, which is already reducing some crop yields in low latitudes – and which is projected to do so worldwide once global average warming exceeds 2°C.
- Climate change will alter precipitation patterns and reduce water availability, particularly in the dry tropics, leading to accelerated and more intense land degradation and desertification.
- In addition, the need to respond to climate change could provoke unprecedented shifts in both energy and food production systems, as policymakers confront the need to reduce greenhouse gas emissions.

The resource scarcity nexus can also be conceived in different ways (for instance, as a water-land-energy nexus). For instance, Selby and Hoffman (2012) have examined another nexus – that involving environmental resource scarcity, conflict and migration – highlighting the well-recognised observation that scarcities of environmental resources can potentially have significant impacts on conflict and migration patterns. Selby and Hoffman (2012) consider the question of whether, in the context of accelerating global environmental change, such impacts are likely to become more significant still. Those authors recognise that such impacts are complex and are often indirect rather than direct; they acknowledge that there are many drivers of conflict and migration, of which environmental resource scarcities represent only one. Despite these caveats, the authors argue that recent studies have overstated the current and likely future significance of environmental changes and resource scarcities in contributing to conflict and migration. Instead, Selby and Hoffman (2012) point to what they regard as a far more important causal pathway: that from conflict and migration to environmental vulnerabilities. Selby and Hoffman (2012) illustrate their argument with a comparative analysis of water-migration-conflict linkages in Cyprus and Israel and the West Bank and Gaza, although their conclusions are also likely to apply to other contexts. Another way of approaching resource scarcity as a nexus is exemplified by Lone and Rather (2012), who investigated the 'poverty and food security nexus' in India, emphasising that, as elsewhere, this issue is principally one of access and distribution – and is *not* one of absolute scarcity.

An earlier, but nevertheless significant, study of resource scarcity as a nexus was produced by Lufumpa (2005), who examined the poverty-environment nexus in Africa. Lufumpa (2005) argues that this nexus has emerged as a major development challenge for the continent. Specifically, Lufumpa (2005) highlighted the importance of the interrelated issues of deforestation, land degradation, low agricultural productivity, water scarcity, threats to biodiversity and the effect of civil conflict. Lufumpa (2005) derives some significant policy implications, including the need for institutions and individuals to reconcile immediate survival strategies with longer-term environmental protection and resource security objectives. The specific policy recommendations in Lufumpa's (2005) study include sector-specific interventions and cross-cutting policy initiatives to address gender disparities and to promote greater institutional reform.

(d) Climate change is a particular concern in relation to resource scarcity

As mentioned above, climate change is widely acknowledged to be a particular concern in relation to resource scarcity (Evans 2012; National Intelligence Council 2013; see also Mendelsohn 2011); this theme pervades many current and recent studies of resource scarcity.

(e) Water scarcity is a prominent theme in studies of resource scarcity

Water scarcity is another theme that emerges prominently in the current and recent literature on resource scarcity and environment (examples include Cook et al. 2009; Cruikshank and Grover 2012; Hallowes et al. 2008; Harrington et al. 2009; Jemmali and Matoussi 2013; Nitikin et al. 2012; Panahi et al. 2009; Selby and Hoffmann 2012; Sullivan 2011; Varghese et al. 2013). One significant study, by the 2030 Water Resources Group (2009), has examined the increasing demand for water, worldwide, and attributes that increase to global population and economic growth in conjunction with the effects of climate change. This study acknowledges that these factors are already combining to create water scarcity in many parts of the world, with serious implications for livelihoods, human health and ecosystems. The 2030 Water Resources Group (2009) argues that, by 2030, over one-third of the global population will live in river basins that are characterised by significant water stress, including many of the countries and regions that drive global economic growth. In 20 years, the study argues, the global demand for water will be 40 per cent higher than it is today, and more than 50 per cent higher in the most rapidly developing countries. The 2030 Water Resources Group (2009) states that these trends are giving rise to a significant 'water gap' that requires

urgent attention; unless it is addressed, this water gap is anticipated to exacerbate poverty, hunger and environmental degradation, and to hinder economic growth, particularly in the poorest countries. The 2030 Water Resources Group (2009) calls for co-ordinated action at local, national and international levels to improve water management, increase water efficiency, augment water supplies and reduce the water intensity of economic activities. The 2030 Water Resources Group (2009) also points out that the issue of water scarcity requires greater political attention and more strategic thinking, especially since trade-offs must inevitably be made in the pursuit of water resource security.

In a study of water and food scarcity in river basins, Cook et al. (2009) draw attention to the conflicting demands for these resources – conflicts that are exacerbated by an increasing global population. The authors show that conflicting resource demands increase the risks of food insecurity, poverty and environmental degradation in major river systems. Whilst agriculture remains the predominant water use across these systems, the authors point out that the connections between water, agriculture and livelihoods are more complex than simply 'water scarcity increases poverty'. Cook et al. (2009) highlight the fact that the response of both agricultural and non-agricultural systems to increased scarcity will in turn play a part in affecting livelihoods. One consequence is that development will be constrained in closed basins if increased demand for irrigation deprives other users of water, or if existing agricultural uses constrain non-agricultural activities; these constraints will also occur in open basins if agriculture cannot feed expanding or changing populations, or if river systems lose capacity due to degradation or over-exploitation. Another study of water scarcity and its impact on livelihoods in river basins was conducted by Harrington et al. (2009); those researchers compared water availability, use, productivity and poverty across the river basins studied by the CGIAR Challenge Program on Water and Food. Harrington et al. (2009) conclude that the ways in which water scarcity affects poverty is influenced by changes in demography, climate, and rural society. Nonetheless, in most river basins, the authors show that these issues involve trade-offs that require good governance at local, regional and basin scales.

Another, earlier study highlighting the complexity of water scarcity issues is Franks and Cleaver (2007), which considers the need to meet development goals for water through interventions that promote good governance. In 2007, the authors acknowledged that this was an under-researched area; there remains scope to conduct research on this topic. Franks and Cleaver (2007) propose an analytical framework for understanding water governance – as interlinked processes with variable practical outcomes for poor people – and they apply this framework to a case in south-western Tanzania. They emphasise the need for further research relating to access to water resources by poor people.

(f) Resource scarcity is a potential driver of conflict

Several studies have acknowledged that resource scarcity – particularly of renewable resources – is a major driver of violent conflict (for instance, in Rwanda, Kenya, South Africa, Assam, Chiapas and Sudan; see Dinar 2011; Theisen 2008; Wutich 2010). However, this issue is not a straightforward one and Theisen (2008) has acknowledged that the studies examining the link between resource scarcity and conflict have reached divergent conclusions in the past. There are strong reasons to suspect that relationships may exist between population density, soil degradation, deforestation, water scarcity and the occurrence of civil war. However, Theisen (2012) found that there is in fact little evidence to support a link between resource scarcity and civil war. On the other hand, poverty, instability and dependence on fuel exports are factors that are apparently strongly related to civil war. Theisen (2012) concludes that natural resource scarcity has limited explanatory power in terms of civil violence, whereas poverty and dysfunctional institutions are strongly associated with conflict. Furthermore, Theisen (2012) states that future studies should focus on local and less intense conflicts, should pay more attention to a context of low economic development, should look more thoroughly into the role of state actors in the 'escalatory

phase' of conflict, and should assess the importance of the distribution of resources relative to scarcity *per se.* In another study, Adano et al. (2012) have also examined the relationship between resource scarcity and conflict, with particular reference to conflict in Kenya. They conclude that in many regions of natural resource scarcity – especially in remote regions where arable land and water are scarce – violence and ethnic strife are more prevalent. Adano et al. (2012) acknowledge the convergence of economic, political and ecological marginality in several African countries; however, they also point out that there has been limited empirical research into the role of violence in pastoral livelihoods across ecological and geographical locations.

(g) Technical aspects of resource scarcity research are progressing

The study of resource scarcity issues involves various technical aspects of conceptualising, measuring, modelling and developing indicators of resource scarcity. Some progress has been made in these areas since 2008. Silva et al. (2008) have developed a general equilibrium model for both renewable and non-renewable resources; that model allows the authors to analyse the interaction and compatibility between economic growth and environmental quality. Their study demonstrates that endogenous technical change is a key factor in decoupling economic growth from environmental degradation. A critical dimension of that technical change is the substitution of renewable for non-renewable resources. Another study, by Smith (2012), investigates the relationship between 'peaking' (for instance, of oil production), focusing on the question of whether (and how) peak economic production is related to resource scarcity. Smith (2012) concludes that peaking is an ambiguous indicator of resource scarcity since it is difficult to tell whether the earlier arrival of a given 'peak' is a good or a bad thing in terms of resource scarcity.

Another technical study is the work of Lotze-Campen et al. (2008), who investigated the relationships between land and water resource scarcity, global food demand and productivity growth using a mathematical model of agricultural crop and livestock production types in ten economic regions worldwide. Lotze-Campen et al. (2008) argue that, over the decadal timescale, greater competition for global land and water resources will occur due to increasing demands for food and biofuel production, biodiversity conservation, and changing production conditions under climate change. However, these authors argue that the potential of technological change in agriculture to adapt to these trends is unknown. Applying their model to future scenarios up to 2055, the authors estimate the rates of technological change in agricultural production that will be required to meet future food demand. A more recent modelling study is produced by Hassani-Mahmooei and Parris (2013), which focuses on resource scarcity following environmental degradation induced by climate change, which may in turn lead to economic and political insecurity. Hassani-Mahmooei and Parris (2013) use an agent-based model to address the question of whether resource scarcity is likely to lead to an increase in the use of natural resources; their results support previous empirical findings that the main link between resource scarcity and conflict is through changes in the distribution of resources, rather than through their overall availability.

Jemmali and Matoussi (2013) conducted a multi-dimensional analysis of water poverty at the local scale, developing an improved water poverty index (WPI) for Tunisia which could potentially be applied elsewhere. This study combined measures of both water availability and the socioeconomic capacity to access it in order to provide new insights into water resource management and poverty alleviation. This study used recently-developed, multi-dimensional water scarcity indexes that contributed to the definition of the WPI; the authors then attempted to derive an improved WPI which could have applications in other countries facing water scarcity. In a similar type of study, Sullivan (2011) described a multi-dimensional approach to quantifying water scarcity in the context of overpopulation, farming pressure, agrochemical and industrial runoff, and climate factors which together can cause problems of erosion and land degradation. Sullivan (2011) emphasises that these issues will probably be exacerbated by climate change, arguing that a better understanding of all of the

complexities of managing water across heterogeneous basins is required. Sullivan (2011) underlines the point that effective water management is now more dependent on effective governance than on hydrological regimes. She provides an outline of an index-based methodology on which an assessment of water vulnerability can be made, leading to the production of a water vulnerability index (WVI). An additional, technical study of measurement of water scarcity is provided by Forouzani and Karami (2011), who propose an agricultural water poverty index (AWPI) to assess agricultural water poverty among farmers and regions and to provide guidelines for sustainable water management.

A further, technical study, by Szonyi et al. (2010), makes an innovative contribution to the mapping of natural resource-based poverty, based on the Syrian context but potentially with wider applicability. This study represents a considerable improvement in resource-based poverty mapping; it demonstrates how high-resolution, low-cost agricultural income distribution maps can be produced, especially in low income countries where agriculture is a major source of rural income and where poverty mapping is rarely undertaken due to the relatively high costs involved.

Research on specific issues

A number of studies have examined the general topic of resource scarcity and its relation to specific issues and cases. A selection of these studies is presented below.

(a) Resource scarcity and climate change in Ethiopia

Researchers at the Center on International Cooperation at New York University have undertaken considerable work on resource scarcity. Evans (2012) provides a country-specific case study for Ethiopia, investigating how resource scarcity issues are manifest 'on the ground', how governments are responding, and how international organisations could potentially contribute to building resilience to the effects of resource scarcity. (Further case studies, covering resource scarcity in Pakistan and Nigeria, are expected to be published.) For Ethiopia, Evans (2012) demonstrates that resource scarcity is a major challenge. Ethiopia's current resource scarcity context includes:

- Low agricultural yields and small farm sizes: even if farm productivity increased by a factor of three, an average farm would still not produce enough food for a family of five, creating a major food security challenge.
- Significant exposure to drought: Ethiopia has erratic rainfall, acutely limited water storage capacity, and very low levels of irrigation.
- Limited access to energy: Ethiopia depends on waste and biomass for 90 per cent of its energy needs, resulting in deforestation and soil degradation.
- High dependence on imported oil and food: Ethiopia currently imports all of its liquid fuels and a significant proportion of its food, with consequent vulnerability to global commodity price volatility.
- Relatively high population growth rates (around 2.73 per cent per year), significantly increasing demand for land, water, energy, food and other resources.
- Relatively strong economic growth, further increasing the demand for resources.
- Climate change is already affecting Ethiopia and is projected to lead to temperature increases of 1.1-3.1°C by around 2060, exacerbating resource scarcity issues by reducing crop yields, increasing land degradation, reducing water availability, increasing pressure on food systems and creating additional challenges for the energy sector.

Thus there is a significant interconnection and interaction of issues in this case. Evans (2012) states that, whilst the Ethiopian government is making some attempts to address these issues, those efforts are undermined by capacity constraints and by limitations in the quality of data underpinning policy decisions; this is an area where additional research might yield valuable information to reduce vulnerability to resource scarcity.

Evans (2012) proposes several ways in which Ethiopia and its international and multilateral partners could respond to the linked challenges of resource scarcity and climate change:

- Fully characterise the resource scarcity context (for instance, by promoting uptake of the Climate Resilient Green Economy program).
- Invest in obtaining high-quality data on resource scarcity (for instance, on agricultural yields, fertility rates, food insecurity and GDP growth).
- Build distributed capacity to respond to resource scarcity challenges.
- Expand current resilience approaches to social protection, climate adaptation, livelihoods promotion and disaster risk reduction.
- Acknowledge that resource scarcity is primarily a political economy issue, although it is also a multidimensional issue that cuts across many areas of work by international donors (humanitarian assistance, social protection, livelihoods, environment, climate, infrastructure, private sector, health and governance); resource scarcity trends will create new winners and new losers – as will decisions on how to respond to scarcity, made by government and donors alike. Donors in particular need to understand how scarcity issues relate not only to each other, but also to wider social, political and economic drivers of change in Ethiopia.
- Deepen the policy dialogue (particularly around major agriculture and hydroelectric projects in rural Ethiopia).
- Undertake a full, independent study of large commercial farms and their potential contribution to inclusive, sustainable development plans in Ethiopia.
- Engage with and influence controversial large projects (such as the Ethiopian Grand Renaissance Dam, or large commercial farms).
- Contribute to international processes to reduce vulnerability to resource scarcity and climate change, including international climate change mitigation policy.
- Build new international partnerships, particularly in the area of climate policy.

(b) Studies focusing on resource scarcity, agriculture and food issues

Several studies focus on resource scarcity, agriculture and food issues. Erenstein (2012) examines resource scarcity gradients and agricultural technologies in relation to the Indo-Gangetic Plains, highlighting the recent reduction in the growth of cereal productivity and continuing poverty in the area. Erenstein (2012) draws attention to the important role of capital in this post-green revolution setting, especially in the densely-populated eastern part of the study area which is particularly capital-scarce. Erenstein (2012) calls for greater investment in adaptive agricultural research in order to promote innovation to overcome prevailing resource scarcities. Another study, by Brown (2010), examines the projected effect of absolute grain shortages which threaten global food security in the immediate future. Brown (2010) identifies the underlying causes of food shortages: increasing demand due to growing population, and decreasing supply as a result of soil erosion and climate change, issues which could be addressed by increasing land and water productivity, reducing carbon emissions, promoting poverty reduction and limiting grain exports. A further study of food scarcity issues is Meier (2010), which also points to a global rise in demand for agricultural products, combined with the effects of climate change, which will both decrease the available amount of food aid and simultaneously increase the demand for it. Meier (2010) argues that closing this 'food gap', in order to minimise the number of acutely undernourished people worldwide, requires the reformation of the global food security architecture together with improvements in international and national trade, agriculture and research policies.

(c) Studies focusing on water scarcity and poverty

As mentioned above, numerous studies have focused on water scarcity and its effects on poverty and growth. Hallowes et al. (2008) examine the concept of Fractional Water Allocation and Capacity Sharing (FWACS) – a method of allocating and managing water entitlements to achieve greater water efficiency – in the South African context (although with broader applicability). In a study of water scarcity, Sabir (2012) draws attention to the close connection between poverty reduction initiatives, national economic development and irrigated agriculture in Pakistan. Sabir (2012) states that water scarcity has been directly associated with rapid population growth and poor management of water resources in the country; consequently, Pakistan has followed a downward trajectory from water surplus in 1950 to relatively abundant in 1980, water stressed by 2010, and experiencing widespread water scarcity by 2035. Varghese et al. (2013) examine the effect of water scarcity on rice farming in south India, where groundwater is becoming increasingly scarce; those authors conclude that policy measures to conserve groundwater should include supply enhancement to remove the threat of immediate scarcity on farms (to avoid inefficient pumping) in addition to demand management measures and improved governance. Another study, of water scarcity and poverty reduction in rural Iran, found that the availability of irrigation water is closely linked to poverty alleviation, both directly and indirectly (Panahi et al. 2009). The authors call for agricultural intensification based on improved irrigation techniques as a strategy for poverty reduction, a process which would require more efficient use to be made of agricultural wastewater. On similar lines, Hanjra and Gichuki (2008) have studied investment in agricultural water management for poverty reduction in Africa (based on case studies of the Limpopo, Nile and Volta river basins), arguing that such investment would increase yields and cropping areas; in turn, this would promote higher-value crops, increase rural household income, generate employment and reduce consumer food prices, in addition to a range of broader economic, social and environmental benefits. One more specific area of water scarcity and poverty research, by Alam et al. (2009), has investigated the topic of sovereignty bargains as a potential response to the global water crisis. This approach is based on a benefit-sharing principle involving the notion of allocating the outputs from water use, rather than the water itself; it has been used in Senegal to ensure the provision of key services such as electricity despite a context of poverty, climate change and intra-basin political disputes.

(d) Studies focusing on forest and ecological resources and poverty

Several studies have focused specifically on forest and ecological resources and poverty. Bandyopadhyay et al. (2011) considered forests, biomass use and poverty in Malawi, a country that has experienced significant deforestation. The authors examine the nature of the relationship between poverty and forests in Malawi, focusing on three main questions: (i) what is the extent of biomass available for meeting the energy needs of the poor in Malawi and how is this distributed; (ii) to what extent does fuelwood scarcity affect the welfare of the poor; and (iii) do households spend more time in fuelwood collection in response to scarcity? The authors' analysis suggests that biomass scarcity is associated with lower household welfare, particularly for the rural poor, and that, at the current high levels of scarcity, 80 per cent of rural poor households would probably benefit from an increase in biomass in the community. In particular, the authors note that rural women spend more time on fuelwood collection where biomass is scarce. The study demonstrates that any effort to reduce degradation and deforestation in Malawi requires an accurate understanding of household adaptation to fuelwood scarcity. Another study, by Vedeld et al. (2012), investigates the relationship between protected areas, poverty and conflicts, based on a livelihood case study of Mikumi National Park in Tanzania. The authors draw attention to the impact of the park on livelihoods, which exacerbates other economic, social and environmental problems (such as increasing land scarcity, population density and income inequalities) that in turn aggravate conflicts about resource use. Similar issues have been examined for Ranomafana National Park in Madagascar, where ecotourism development forms part of a natural resource management strategy (Sarrasin 2013). The author concludes that tourism is far

from being an ‘axis of development’ for the Malagasy economy, and it fails to address the environmentally destructive practices occurring in the area.

(e) Energy

McKinsey Global Institute (2011) has examined resource scarcity issues in relation to energy. The report notes that, before the 1970s, real energy prices (including coal, natural gas and oil) were roughly constant as supply and demand increased concurrently. The report acknowledges that several factors explain this situation: there were discoveries of new, low-cost sources of supply; energy producers had low pricing power; and there were advances in the conversion efficiency of energy sources during their processing. However, a seven-fold increase in real oil prices occurred in the 1970s, after which energy prices declined for several reasons:

- Developed countries moved to other sources besides oil for electricity generation.
- OPEC’s pricing power was reduced as non-members expanded their own supplies.
- The collapse of the Soviet Union led to a large reduction in demand for oil.
- Developing country governments supported lower energy prices by introducing significant consumption subsidies for energy, particularly during the 1970s oil crisis.

However, McKinsey Global Institute (2011) notes that demand for oil by the transportation sector has not followed this trend: energy demand by this sector has more than doubled since the 1970s. McKinsey Global Institute (2011) also points out that it has taken considerable time (decades) for the overall primary energy mix to change significant in response to changes in the cost of supply. The report also described the significant potential for unconventional sources of energy (such as shale gas, which can be extracted by hydraulic fracturing – or ‘fracking’) to play a greater role in the future energy mix.

(f) Materials

McKinsey Global Institute (2011) has examined resource scarcity issues in relation to material resources. It notes that materials prices fell by 0.2 per cent per year during the 20th century, although some variations occurred between mineral resources. The report explains that the main drivers of falling overall metals prices include the discovery of large, relatively low-cost deposits (such as Chile’s Chuquicamata copper mine). Technological advances (such as solvent extraction technology) have also driven metals prices down. McKinsey Global Institute (2011) also acknowledges that demand for metals in developed countries has stagnated, due to those countries emerging from their resource-intensive phase of growth. The report suggests that metal consumption of typically grows in line with income until a threshold of $15,000 to $20,000 per capita (in PPP-adjusted dollars) is reached as countries go through a period of industrialisation and infrastructure building. At higher incomes, the report states, growth typically becomes more services-driven and the per capita use of metals stagnates.

(g) Miscellaneous studies

Some miscellaneous studies present interesting views on particular aspects of resource scarcity, environment, poverty reduction and economic growth. Konstadakopulos (2008) examines the environmental and resource degradation associated with small-scale handicraft enterprise clusters in the Red River Delta of Northern Vietnam. This study demonstrates that entrepreneurial activities in the area are hindered by the depletion of natural resources, in conjunction with acute shortages of capital and land. In turn, these problems lead to overcrowding, poor working conditions and severe environmental degradation. Konstadakopulos (2008) also studies industrial ecology practices at the enterprise level, evaluating the role played by the government in providing incentives for enterprises to invest in new technology and in pollution control. Konstadakopulos (2008) identifies the major constraints to the adoption of new, environmentally ‘clean’ technologies

and to engagement with environmental management practices. Shortage of capital and lack of knowledge about the benefits of new technologies were viewed as the most important barriers, followed by shortage of skilled workers, poor market conditions and scarcity of land appropriate for industrial production.

A study of resource scarcity and smallholder agency in Thailand examines the contested concept of autonomous adaptation, which is widely used to describe spontaneous acts of reducing risks posed by resource scarcity and, increasingly, climate change (Forsyth and Evans 2013). The authors conducted research in eight Karen villages in Thailand to identify how resource scarcity is linked to adaptive responses, including livelihood diversification. Forsyth and Evans (2013) argue that autonomous adaptation is driven by how environmental change and scarcity present livelihood risks, rather than by physical risks alone. The authors argue that adaptation planning therefore should acknowledge different experiences of risk, as well as considering socioeconomic barriers to adaptation.

SECTION 3

Analysis of research gaps

Main research gaps

Based on the review of evidence presented above, the following main research gaps have been identified:

Need for research linking geographical scales

The issue of natural resource scarcity has received considerable attention at the global scale, and it is an increasingly prominent issue on global agendas. Many studies consider resource scarcity at the global scale (often using surrogate measures such as commodity prices as reflective of scarcity). On the other hand, there is a comparatively rich literature of resource scarcity studies for particular locations, and some detailed studies of the resource scarcity context for particular countries (such as Ethiopia). In between these two scales there is a comparative paucity of research and it is not clear how the global-scale studies and the myriad local-scale studies connect to form a coherent body of study, if indeed they do. Further research might valuably explore the conceptual space between global- and local-scale dimensions of resource scarcity to determine if this issue can be approached in a more integrated manner across geographical scales.

Need for research into the precise links between resource scarcity and poverty

There is an accumulation of evidence to suggest that resource scarcity and poverty are closely related, although the precise nature of that relationship is both contested and vague. In particular, there is limited clarity on the exact linkages involved between resource scarcity, poverty and poverty reduction, and further research might valuably clarify those linkages. Some studies have acknowledged that the issues are more complex than simply 'resource scarcity causes poverty'; some work has acknowledged that 'poverty causes resource scarcity'; yet relatively few studies have investigated exactly how and why these links occur. Where researchers have probed these areas in greater detail, they reach the almost unanimous conclusion that resource scarcity is a political (economy) issue that is much more about distributive issues and access to resources than it is about absolute resource shortages. Moreover, those studies tend to reach the (related) conclusion that improved resource efficiency – perhaps in conjunction with improved demand management – is likely to form part of an appropriate response to resource scarcity issues.

Need for research to clarify the factors driving resource scarcity

Resource scarcity issues are increasingly viewed as some form of 'nexus', given their complexity and tight interconnections, and indeed it is difficult to isolate resource scarcity issues in the current and recent research literature. However, again, there is a lack of precision in defining the nature of that nexus, and various different types of nexus have been considered by researchers. On the one hand, the research literature suggests that almost any environmental issues – and many economic and social ones, too – might reasonably be included in the nexus of issues linked to research scarcity. On the other hand, some issues are clearly more prominent – and seems to have greater explanatory power – than others in understanding what drives resource scarcity. Further research might prioritise and clarify the question of which factors matter most in driving – and in explaining – resource scarcity.

In particular, the issue of climate change pervades the current and recent literature on resource scarcity and very few of the studies reviewed failed to consider climate change as an issue. However, it is difficult to find evidence of research that probes below the simple observation that climate change is likely to exacerbate resource scarcity issues, through a wide range of direct and indirect effects. Again, whilst climate change conceivably affects every aspect of resource scarcity, some of the effects of climate change are likely to be more important than others in explaining resource scarcity. Therefore, further research might valuable focus on clarifying the precise mechanisms by which climate change, resource scarcity and poverty interact.

Water scarcity is a very prominent issue in the current and recent literature on resource scarcity and poverty, and this area may be reasonably well characterised, although this is also an area in which resource scarcity issues are particularly acute and are projected to become yet more critical in future.

Resource scarcity is acknowledged to be an important potential driver of conflict – and to become more so with climate change, population growth and economic growth – yet there is debate about the particular factors that most strongly promote conflict, and this is a potential area in which further research might yield valuable insights.

Need for research covering other topics

Overall, the literature of resource scarcity, environment and poverty is highly patchy in terms of topic. These themes have been covered in some detail by McKinsey Global Institute (2011), although the focus on poverty was not a prominent one in relation to these topics. Very limited other material specifically on urban themes, industrial processes, metal resources, minerals and fossil fuels was found for developing countries for the period since 2008 (although some of these themes are covered in studies relating to security, and some material relating to developed-country issues has been published). Studies on the effects of mineral wealth and of mineral dependency were found, but limited material specifically on mineral scarcity, for instance. Nevertheless, these are important issues that require better understanding and more original research could be focused on these topics.

Need for research covering more locations and geographical areas

The literature of resource scarcity, environment and poverty is also highly uneven in its geographical coverage. Studies specifically considering DFID-focus countries were relatively sparse and further work could be undertaken for these countries.

Potential areas of new research of value to DFID

The following areas were identified as possible areas in which new research could potentially be of value to DFID:

- Original studies of the precise links between resource scarcity and poverty in DFID-focus countries, focusing on those factors with greatest explanatory power.
- Original studies of the drivers and impacts of renewable resource scarcity in DFID-focus countries, focusing on the precise connections between resource scarcity and poverty.
- Original investigations of the *specific* ways in which climate change, resource scarcity and poverty interact in particular locations (in DFID-focus countries).

SECTION 4

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