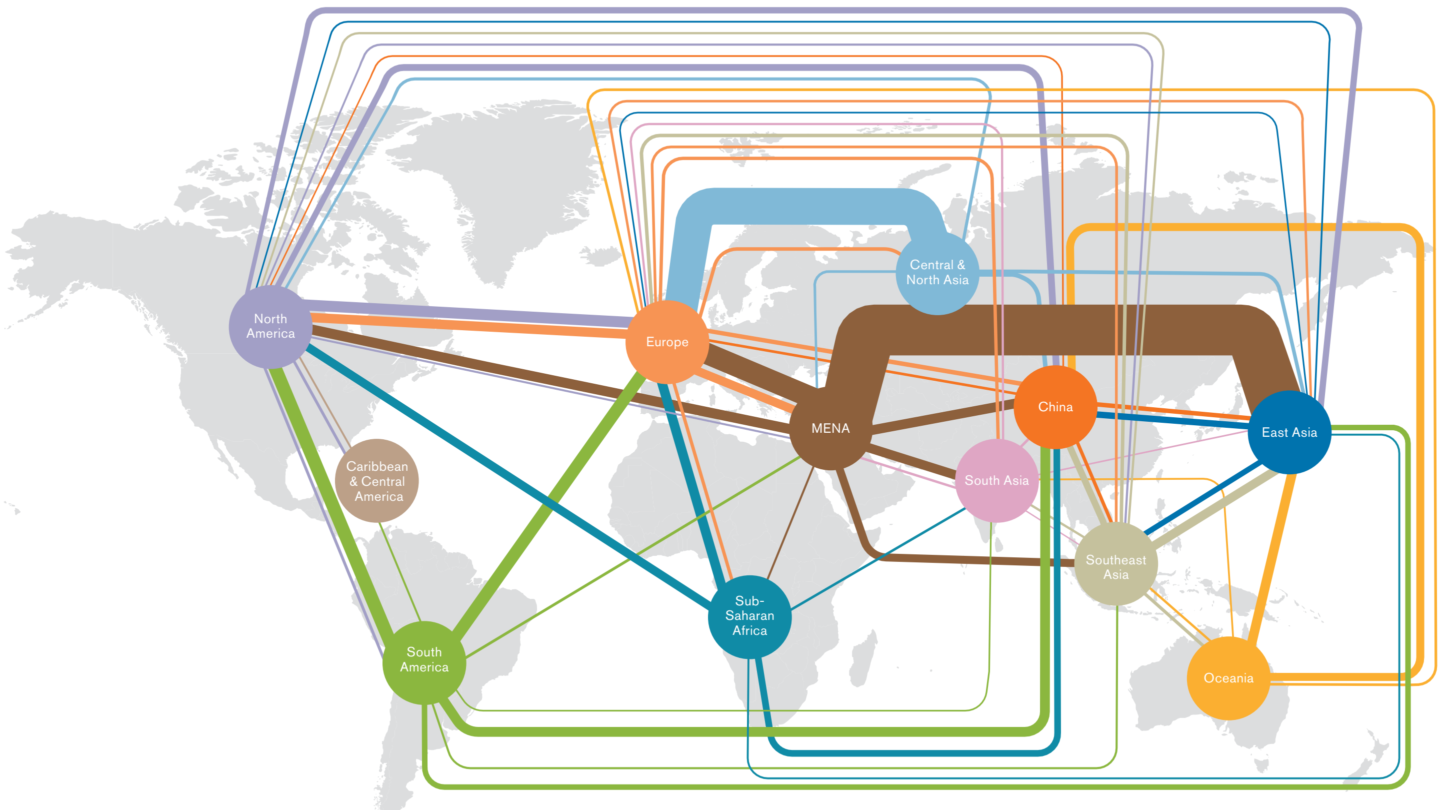
Resources Futures

A Chatham House Report

Bernice Lee, Felix Preston, Jaakko Kooroshy, Rob Bailey and Glada Lahn



CHATHAM HOUSE

www.chathamhouse.org

Resources Futures

Bernice Lee, Felix Preston,
Jaakko Kooroshy, Rob Bailey and Glada Lahn

A Chatham House Report

December 2012

CHATHAM HOUSE

www.chathamhouse.org

Chatham House has been the home of the Royal Institute of International Affairs for ninety years. Our mission is to be a world-leading source of independent analysis, informed debate and influential ideas on how to build a prosperous and secure world for all.

The Royal Institute of International Affairs
Chatham House
10 St James's Square
London SW1Y 4LE
T: +44 (0) 20 7957 5700
F: + 44 (0) 20 7957 5710
www.chathamhouse.org

Charity Registration No. 208223

ISBN 978 1 86203 277 4

A catalogue record for this title is available from the British Library.

Designed and typeset by Soapbox, www.soapbox.co.uk

Printed and bound in Great Britain by Latimer Trend and Co Ltd

The material selected for the printing of this report is Elemental Chlorine Free and has been sourced from well-managed forests. It has been manufactured by an ISO 14001 certified mill under EMAS.

MIX
Paper from
responsible sources
FSC® C013436
FSC
www.fsc.org

Contents

Acknowledgments

This report is an output of the Resources Futures project, which explores the range of critical constraints and uncertainties faced globally, and the implications for future policies and political agendas. The report builds on the findings of a study prepared for the National Intelligence Council (NIC) in early 2012 assessing the impacts of natural resources on US national security by 2020, 2030 and 2040.

Chatham House would like to thank the Fondation Hoffmann for its generous financial support for this project. Special thanks to André Hoffmann, Louise Muhdi and Sylvie Léget for their critical engagement and advice.

The authors would like to extend their sincere appreciation to Trineesh Biswas, Peter Borkey, Richard Engel, David Humphreys, Paul Stevens, Shane Tomlinson, Dominic Waughray and Benjamin Zala for their significant and considered feedback on earlier drafts. The authors also wish to express their gratitude to Philip Andrews-Speed, James Bacchus, Christophe Bellmann, Raimund Bleischwitz, Melinda Bohannon, Jaime de Bourbon Parme, Mat Burroughs, David Concar, Sarah Cullum, Carolyn Deere-Birkbeck, Kate Hampton, Vincent Klassen, Pim Kraan, Gustavo Lagos, Nick Mabey, Ricardo Meléndez-Ortiz, John Mitchell, Robin Niblett, Cleo Paskal, Gareth Price, Dan Smith and Brian Wright, who all provided valuable ideas, insights and comments along the way.

Chatham House is grateful to Stefan Giljum and Friedrich Hinterberger at the Sustainable Europe Research Institute (SERI), Christian Kerckhoffs, Yoshihide Wada, Simon Moores and James Hewitt for their input and advice on the Chatham House Resource Trade Database and other statistics used in the report. Thanks also go to John Corbett, Jens Hein, Theresa Helke, James Norman, Paul Quinn, Estelle Rouhaud, Matúš Sámel, Laurène Tréhan, Joy Tuffield and Natasha White who have provided valuable research support and assistance for this report. Many thanks to Gabriela Flores for her much appreciated input and advice in communicating the report's narrative and to Margaret May and Nicolas Bouchet for copy-editing the report and overseeing the production process at Chatham House.

Chatham House would like to thank the participants at the following workshops which helped generate and clarify ideas around key resources issues:

- Policy Options for Food Insecure Countries workshop, Abu Dhabi, 19–20 November 2012.
- The meeting of the QUAD, Berlin, 20 September 2012.

- Translating Early Warning into Early Action (EWEA), Affected Country workshop, Chatham House, 2 July 2012.
- The Environment Funders Network meeting held at the Baring Foundation, London, 17 April 2012.
- Natural Resources in 2020, 2030, 2040 and the Implications for U.S. National Security, hosted by the Transatlantic Academy and The German Marshall Fund in Washington, DC, 4 April 2012.
- Corporate and Government Strategies in a Resource-Stressed World workshop at Chatham House, 11–12 November 2011.
- Resources, Rights and Development in a Changing World workshop organized by Rights and Resources Initiative and Chatham House, 3–4 May 2011.
- Stakeholder Dialogue on Climate Change and Security workshop organized by the Foreign & Commonwealth Office and Chatham House, 12 April 2011.

About the Authors

Lead authors

Bernice Lee is Research Director for Energy, Environment and Resources, Chatham House

Felix Preston is Research Fellow, Energy and Climate Security, Chatham House

Jaakko Kooroshy is Research Fellow, Resources, Chatham House

Rob Bailey is Senior Research Fellow, Food and Environmental Security, Chatham House

Glada Lahn is Research Fellow, Energy and Development, Chatham House

Contributing authors

Gemma Green, Charles Emmerson, Duncan Brack (timber), Heike Baumüller (fisheries) Benjamin Zala (conflict), Antony Froggatt (energy), Paul Stevens (energy), John Mitchell (oil) and Oli Brown.

The Chatham House Database on Global Resource Trade has been developed by Jaakko Kooroshy and Felix Preston with the support of James Norman and John Corbett.

Acronyms and Abbreviations

AMIS	Agricultural Market Information System
ASEAN	Association of Southeast Asian Nations
b	barrel
BACI	Base pour l'Analyse du Commerce International
bcf/d	billion cubic feet per day
bcm	billion cubic metres
bcm/y	billion cubic metres per year
BRIC	Brazil, Russia, India and China
BRICS	Brazil, Russia, India, China and South Africa
BRIICS	Brazil, Russia, India, Indonesia, China and South Africa
CBM	Coalbed methane
CCS	Carbon capture and storage
CDB	Chinese Development Bank
CHBTD	Chatham House Bilateral Trade Database
CNOOC	Chinese National Offshore Oil Corporation
CNPC	Chinese National Petroleum Corporation
CO_2	Carbon dioxide
COMTRADE	United Nations Commodity Trade Statistics Database
DRC	Democratic Republic of the Congo
DRR	Disaster Risk Reduction
EAHG	Easily accessible and high-grade
EIA	US Energy Information Administration
EOR	Enhanced oil recovery
ERM	Emergency Response Mechanism
EU	European Union
EWS	Early Warning System
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations Statistics Division
FDI	Foreign direct investment
G8	Group of Eight
G20	Group of Twenty
GATT	General Agreement on Tariffs and Trade
GCC	Gulf Cooperation Council
GDP	Gross domestic product
GM	Genetic modification
Gt	Gigaton (trillion tonnes)
ha	hectare
IEA	International Energy Agency

IFA	International Fertilizer Industry Association
IMF	International Monetary Fund
IMTS	International Merchandise Trade Statistics
IPCC	Intergovernmental Panel on Climate Change
LNG	Liquefied natural gas
M&A	Mergers and acquisitions
mb/d	million barrels per day
MENA	Middle East and North Africa
Mt	Megaton (million tonnes)
NGO	Non-governmental organization
ODA	Official development assistance
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PES	Payments for Ecosystem Services
PV	Solar photovoltaic cells
R&D	Research and Development
R30	Resources 30 – a proposed informal grouping of systemically important resources producers, consumers and importer/exporter countries.
REE	Rare earth element
RFS	Renewable Fuel Standard
RRF	Rapid Response Forum
SCM	Subsidies and Countervailing Measures
SET	European Strategic Energy Technology
SOE	State-owned enterprise
SWF	Sovereign wealth fund
tcf	trillion cubic feet
UAE	United Arab Emirates
UNCTAD	United Nations Conference on Trade and Development
UNCTADSTAT	United Nations Conference on Trade and Development Statistics
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USAID	US Agency for International Development
USDA	US Department of Agriculture
USGS	US Geological Society
WDI	World Development Indicators (World Bank)
WEF	World Economic Forum
WFP	World Food Programme (United Nations)
WRI	World Resources Institute
WTO	World Trade Organization
YPF	Yacimientos Petrolíferos Fiscales

Executive Summary and Recommendations

The spectre of resource insecurity has come back with a vengeance. The world is undergoing a period of intensified resource stress, driven in part by the scale and speed of demand growth from emerging economies and a decade of tight commodity markets. Poorly designed and short-sighted policies are also making things worse, not better. Whether or not resources are actually running out, the outlook is one of supply disruptions, volatile prices, accelerated environmental degradation and rising political tensions over resource access.

Fears of resource scarcity are not new. On many occasions, higher rates of investment and improved technology have resolved the problem of the day, though often with additional environmental and social costs. With the maturation of technologies to access non-conventional gas and oil, as well as the global economic downturn, some analysts suggest that the resource boom of the past decade is coming to an end – especially in the extractive industries – and that resource-related tensions will ease.

The hard truth is that many of the fundamental conditions that gave rise to the tight markets in the past ten years remain. In the case of food, the world remains only one or two bad harvests away from another global crisis. Lower prices in the meantime may simply trigger another bout of resource binge, especially in the large and growing developing countries.

This report focuses on the new political economy of resources. It analyses the latest global trends in the production, trade and consumption of key raw materials or intermediate products and explores how defensive and offensive moves by governments and other stakeholders are creating new fault lines on top of existing weaknesses and uncertainties.

The report also proposes a series of critical interventions, including new informal dialogues involving a group of systemically significant producer and consumer countries ('Resource 30' or R30) to tackle resource price volatility and to improve confidence and coordination in increasingly integrated global resource markets.

The changing global resource landscape

- **Mainstream projections suggest continued demand growth for major resources** – from fossil fuels to food, minerals, fertilizers and timber – until at least 2030, notwithstanding the peril of forecasting. The scope and size of resource consumption, and the associated environmental impacts, risk overwhelming the ability of states, markets and technology to adapt.
- **The emerging economies lie at the epicentre of the new and evolving political economy of critical resources. The growth of China and India** – as both consumers and producers – has affected multiple resource markets. In the past decade, global use of coal, palm oil and iron ore has been growing at 5–10% a year, while that of oil, copper, wheat and rice has been growing at 2% a year.
- **Resource trade has grown nearly 50% from a decade ago in weight terms owing to expanding trade in oil, iron and steel, coal, oilseeds and cereals** – all feedstocks for China, the factory of the world. Beyond the traditional powers and emerging economies, a wave of developing countries will become important resource consumers in the next decade. They are likely to include Iran, Vietnam, Turkey and Thailand.
- **Large-scale resource extraction remains concentrated in a handful of countries.** Across 19 resources (crops, timber, fish and meat, metals, fossil fuels and fertilizers) the three largest producers on average account for 56% of global production. The eight dominant players are China, the United States, Australia, the European Union, Brazil, Russia, India and Indonesia. Others with significant production capacities for one or two major resources include Argentina (soybeans), Saudi Arabia (oil), Iran (oil and gas), Canada (potash and nickel) and Chile (copper). For resources with smaller production volumes, such as palm oil or many speciality metals, concentration among producer countries is even higher.
- **A new wave of increasingly important producers has emerged in the wake of the resource boom**, often fuelled by large-scale foreign investment. Peru has become an important producer of copper and zinc, as has Angola on oil. Mongolia (for copper and coal) and Mozambique (for coal and gas) are poised to follow suit. Paraguay has become the fourth largest soybean exporter. Their fast-expanding resource sectors are becoming a flashpoint for social and political tensions.
- **African countries are conspicuous by their absence from lists of major resource producers.** Despite the hype surrounding the so-called 'new scramble for Africa', many agricultural or resource-seeking investments remain speculative or have yet to commence production.
- **The dynamics of resource production and consumption are interlinked through markets, trade and the global environment.** Constraints on the future production of any particular resource lie not only in their availability and price, but also in the accessibility and cost of the other resources used to produce them.
- **Future availability of food, energy, timber and metal resources at affordable costs will be determined by a combination of factors** – including accessible reserves, transportation routes, environmental considerations, technology and input costs (such as water and energy). Reserve figures are often imperfect guides. Also significant will be investment conditions, shaped by the socio-political context in producer and consumer countries. The shale gas phenomenon illustrates the potential for technological innovation and policy incentives to transcend 'resource limits', as well as new risks.
- **Expanding the supply of many resources means a shift in production to more challenging technical and operating environments:** weaker governance, poorer-quality soils, greater climate vulnerability, deeper wells and lower ore grades. Even though the specific consequences will differ among sectors and geographies, the overall shift to more marginal and unconventional production will bring common challenges. These include ecological impacts associated with land-use change; increasing production in climate-sensitive areas; risks of technological failure; more resource-intensive production; and accelerating innovation.

Key findings

1. Volatility is the new normal

Resource price volatility is not just a problem for resource consumers or producers – it has long-term implications for global economic security. This is because volatility increases risk margins, which serve as a powerful deterrent to investment into supply. Short-term but frequent price fluctuations could therefore lead to higher long-term prices and greater supply insecurity.

Local disruptions – whether from extreme weather or labour unrest – can rapidly translate into higher resource prices in international markets. These price spikes in turn create macroeconomic pressures for governments, especially in consuming states. Political sensitivity to fluctuations could trigger overreactions or even militarized responses that exacerbate these tensions.

The political and social consequences of a resource price shock are most acute where the transmission mechanism is rapid and resilience is low. In 2011, high prices of staple foods and energy led to a doubling of inflation rates in low-income countries – where these staples make up half of consumer expenditure.[i]

Buffers are smaller than they used to be. The drive for efficiency through just-in-time production models continues to encourage low stockholdings. Global food stocks today remain close to crisis thresholds. The US Department of Agriculture predicted global pre-harvest corn stocks in 2012 falling to the lowest levels since 1974.[ii] Mounting environmental stress and continued market interventions by governments reinforce price volatility.

High and fluctuating prices are spurring new waves of resource nationalism and making unilateral and bilateral responses more attractive. For resources such as soybeans, iron ore or palm oil, increased market power in a few producer countries or corporations – whether through mergers and acquisition, nationalization or investments by state-owned enterprises (SOEs) – will limit options for consumers. Competition for critical resources, already acute in many parts of the world, may escalate, with the risk of a downward spiral of increasing competition – between sectors, communities and nation-states – and decreasing trust.

Measures to dampen the threats posed by volatility can serve as an insurance policy for the global economy. Past attempts to manage international resource price volatility through market interventions have, however, been costly and largely unsuccessful. Despite these failures, one key question for the future is whether better use of emergency stocks can be part of the solution. In the medium term, driving down resource intensity and encouraging sustainable use are the only remedies for high and volatile prices.

2. Environmental change and degradation are challenging traditional approaches

Environmental change and degradation are challenging business-as-usual approaches to resource extraction, production, processing and consumption, whether through scarcities of specific inputs such as water or indirectly through social-political opposition. Climate change is leading to shifts in long-run trends in, for example, temperatures and rainfall patterns. Most ominously, climate change is expected to increase the frequency and severity of extreme events such as heat waves and floods, with the potential to disrupt resource production and further destabilize tight international markets.

Freshwater scarcity stands out as one of the most pressing cross-cutting challenges. While global water withdrawals have tripled in the last 50 years, the reliable supply of water has stayed relatively constant during the same period.[iii]

i IMF (2011), *Managing Global Growth Risks and Commodity Price Shocks: Vulnerabilities and Policy Challenges for Low-Income Countries,* International Monetary Fund, http://www.imf.org/external/np/pp/eng/2011/092111.pdf.

ii Mayer, G. (2012), 'US predicts receding food price threat', *Financial Times,* 23 February 2012, http://www.ft.com/cms/s/0/54cf1176-5e40-11e1-85f6-00144feabdc0.html#axzz24wdVnrhu.

iii World Water Assessment Programme (2009), *The United Nations World Water Development Report 3: Water in a Changing World* (Paris: UNESCO and London: Earthscan).

There is, moreover, great geographical variation, with sufficiency depending on local conditions, quality and delivery mechanisms. The supply gap is already severe in many developing countries which are least capable of putting in place the necessary policies and infrastructure to capture, produce, treat and distribute water, as well as demand management policies and cross-boundary sharing agreements.

3. Trade as a frontline for resource conflicts

Trade is becoming a frontline for conflicts over resources – at a time when the global economy is more dependent than ever on trade in resources. Export controls intended to prevent sharp domestic food price inflation in many producer countries, for example, ended up magnifying price spikes in 2008 and 2011. A number of key raw materials suppliers (especially manufacturers), such as China and Indonesia, have resorted to export controls as part of a broader move towards more explicit and interventionist industrial policy. Brazil and India are also considering similar measures. However, even short-term export restrictions may backfire if they precipitate similar actions in other producing countries, driving up prices and creating a collapse in confidence that spreads from one resource to another.

With multilateral trade negotiations on hold, escalating trade wars over resources could overwhelm the dispute settlement regime at the World Trade Organization (WTO). There is an urgent need to develop confidence-building measures that will increase transparency and predictability on the use of export controls and other restrictions, especially in the midst of a commodity price crisis. It will also be critical to make a better distinction between environmentally sound and perverse subsidies for resources.

4. Resource politics matter

Resource politics, not environmental preservation or sound economics, are set to dominate the global agenda and are already playing themselves out through trade disputes, climate negotiations, market manipulation strategies, aggressive industrial policies and the scramble to control frontier areas. The quest for resources will put ecologically sensitive areas under continuous pressure unless a cooperative approach is taken, not least in the polar regions, major forests and international fisheries.

The markets for critical resources have always been political. States have often taken action to preserve access to resources for their own economies – whether through direct interventions or via proxies. But higher prices and higher volatility have increased the stakes within and between countries. Compulsory nationalization or the assumption of a controlling interest, the confiscation of foreign-owned assets, windfall profit taxes and similar measures may become more common in an era of fluctuating prices.

Many of the political and economic realignments are already under way. Middle Eastern importers of food and Asian importers of raw materials – keen to guarantee access in an era of potential resource scarcity – are building economic and trade relationships with the major producing regions. In turn, producer countries have responded with policy measures of their own. With production concentrated among a few major exporters, OPEC could be joined by new international cartels in other resource markets if high prices persist.

The proliferation of SOEs or sovereign wealth funds in overseas resource sectors has generated renewed fears that they will serve as blunt instruments for the interests of foreign governments. SOEs are criticized for having non-commercial objectives, such as tying up deals overseas to feed their domestic economies with cheap resources.

But the evidence so far is mixed, and the extent to which SOEs are or can be directed by governments varies considerably. Physical ownership of assets and supply chains could indeed be an advantage in times of major crisis. For most countries, however, access to functioning global markets remains the best source of resource security.

5. Collaborative governance is the only option

The political economy of natural resources is increasingly shaped by the large, structural shifts under way in the world – whether in the changing natural environment, in the deepening interrelationship between resource systems, or in the rebalancing of global income and power. The world must now contend not just with growing environmental threats such as climate change and water scarcities, but also with the shift in consumer power from West to East, the concentration of resource ownership and the rise of state capitalism. All these moving pieces are changing the rules of the resources game.

In this context, investment in the environmental and social resilience of developing economies will be critical to long-term global resource security. There is a window of opportunity for leadership by OECD countries to help tackle the challenges facing new producers such as Mongolia. These include weak infrastructure, low-skilled workforces, water scarcity and political instability – all adding up to an unfavourable investment climate that may threaten long-term production prospects. In addition, emerging economies such as China, India and Brazil must become partners with the OECD in these undertakings to avoid destructive, 'race to the bottom' competition.

Existing international institutions are not up to the task of dealing with volatile markets. There have been no credible international policy responses to volatile resource prices, even though this challenge requires urgent policy innovation. For example, in the case of food, no rules or agreements are in place to deal with export controls, coordinate stockholdings or reduce the impacts of biofuel mandates on food prices. Repeated attempts to discuss such approaches have been stalled by conflicting politics and the needs of individual governments to protect particular domestic interests.

The blindness of standard policy prescriptions to resource politics could worsen the future outlook and undermine sound economic choices. To help ensure the world is equipped to move towards a new resource equilibrium under stress conditions, it will be critical to manage perceptions, expectations and fears of resource scarcity in a collaborative manner. It will be equally necessary to mitigate excessive politicization of resource markets and trade that could bring about worst-case scenarios. New modes of engagement also become critical as the centres of key decision-making on resources become diffused beyond traditional powers. It is not just a question of depoliticizing the resources debate, but of creating new structures and dialogues to make the politics of strong resource governance and good economics easier.

Recommendations

To avoid sleepwalking into a prolonged era of resource-related strife, the report makes ten top-line recommendations.

Fostering new leadership

1. To galvanize innovative thinking and change the status quo, this report proposes the formation of a new club of the world's principal resource-producing and -consuming countries to fill existing governance gaps on resource and scarcities governance (see Table A). This 'Resources 30' or R30 grouping, conceived as a 'coalition of the committed', would comprise leaders and officials from thirty countries of systemic significance as resource producers, consumers, importers or exporters.

   The R30 could provide an informal but dedicated forum where governments and stakeholders can address specific resource-related issues, including tackling price volatility at the sectoral level, devising guidelines on the use of export restrictions, and encouraging transparency of state-owned enterprises. Other stakeholders could also be invited to engage in an expert or observer capacity. The findings of these meetings could feed into existing international institutions, such as the International Energy Agency (IEA), WTO and G20.

Reducing vulnerability to short-term shocks

2. Mechanisms to reduce the impacts of short-term commodity price shocks should be explored in existing international institutions or in newly formed groupings of governments.

   - ***Oil:*** Efforts should be accelerated to expand or link the IEA's emergency sharing mechanism to those in the emerging economies, especially China and India. Another idea would be to introduce a new system to enable the companies critical to fuel supply to access a percentage of national reserves in case of *force majeure* without prior government approval. This would help mitigate localized disruptions before they feed into international markets.

   - ***Food:*** Major grain-based and oilseed-based biofuel-producing countries could collectively purchase call options from their biofuel industries. This arrangement would act as a virtual global food reserve. These contracts could specify a trigger – based on a price index – which when activated would obligate the producer to release feedstock back into food chains.

   - ***Metals:*** Global data and transparency on metals production, trade and stock levels should be enhanced. Stockholding figures from traders could be collated by an escrow service and published in aggregated form. The work of the international commodity study groups for zinc, copper and other metals could also be brought together as a publicly accessible data hub and expanded to include production data for all key metals, in virgin and secondary markets.

3. Guidelines on forgoing the use of export restrictions in times of commodity price crisis could be adopted as either an informal pledge or a plurilateral agreement at the WTO.

Investing in sustainable production and resilience

4. Clear policy incentives, government procurement rules, market creation schemes and pricing structures that reflect the full environmental and social impacts are needed at the national level to incentivize higher resource productivity and efficiency.

5. It will be critical to engage the next wave of new resource producers and consumers in constructive dialogues and initiatives. R30 or G20 governments could provide support to improve transparency, manage export and import dependencies, and strengthen environmental resilience in infrastructural investment and climate adaptation, especially in low-capacity producer states.

6. The elimination of environmentally perverse subsidies must be a global priority; any multilateral plan of action will require a clear timeline, concrete support for poorer states to reform their resource pricing, as well as effective channels and fora to share experience and technical expertise.

7. Water-sharing agreements at catchment level need to provide flexibility and adaptability against future environmental changes. Also important are efforts to strengthen collection and monitoring of water-related data. Donors should support the roll-out of drip irrigation in rural areas, as should investors in land transfers.

Reinvigorating rule-based resource governance

8. Criteria should be established (including for moratoria) to govern resource production or extraction in areas of significant biodiversity or ecological sensitivity, such as the deep sea or the Arctic, where effective mitigation efforts or remedies are not available or affordable.

9. Extreme engineering options are likely to become increasingly popular in a resource-constrained world. For this reason, relevant ministries, businesses and industry associations should discuss and implement national or local governance mechanisms and best practice on extreme responses such as weather modification.

10. An annual 'State of the World's Resources' report or an international resources data bank could be launched to standardize in a transparent manner the collection and sharing of data on resource endowments, stocks and trade figures. Such an initiative would benefit from parallel efforts, supported perhaps by charitable foundations, to increase the capacity of civil society and local communities and media to monitor resource usage and extraction at the local level.

Table A: Candidates for the R30

R30	Key producer	Key consumer	Key exporter	Key importer	Description
Australia	●		●		Key mining country especially for coal and iron ore. Also an expanding gas producer and a large agricultural exporter.
Brazil	●	●	●		Key agricultural producer and iron ore exporter. Expanding oil producer with significant reserves in offshore pre-salt fields. Large consumer especially of agricultural products, with fast growing energy and metal consumption.
Canada	●		●	●	Expanding (mainly unconventional) oil and gas producer. Major farming and mining industry. Large importer of both unprocessed and intermediate oil and metal products.
Chile	●		●		Largest copper producer today. Responsible for a third of world production.
China (incl. Hong Kong)	●	●	●	●	Major and fast-growing coal, metal, and food producer and consumer. Top importer of metals and forestry products, and fast-growing importer of fossil fuels and some agricultural products. Large exporter of metals and agricultural and fishery products.
EU27	●	●	●	●	Key consumer and importer of fossil fuels and metals. Major producer, exporter, and importer of agricultural and fisheries products.
France				●	Large importer mainly of fossil fuels.
Germany				●	Large economy with significant industrial sector, which is dependent on imports especially of fossil fuels, metals and minerals.
India	●	●	●	●	Major agricultural producer as well as large iron ore, bauxite and coal miner. Large exporter especially of iron ore. Expanding economy with major growth potential and rapid growth in import demand, especially for fossil fuels.
Indonesia	●	●	●	●	Key producer and exporter for coal, selected metals and many agricultural and forestry products such as palm oil. Large importer of fossil fuels. Expanding consumer with large growth potential due to size of its population.
Iran			●		Key oil and gas producer and exporter, with second largest conventional gas reserves.
Italy				●	Large importer of metals, fossil fuels and agricultural products.
Japan		●	●	●	Key consumer and importer of fossil fuels and metals, mainly for its large industrial sector, as well as significant importer of agricultural products. Large fisheries sector.
Malaysia			●		Key producer, consumer and exporter of palm oil. Importer of metals, agricultural products, and petroleum products.
Mexico			●	●	Large exporter of fossil fuels and some agricultural products. Heavily reliant on imports, especially for select agricultural and forestry products.
Netherlands				●	Resource trading hub for Europe centred on the third largest port in the world. Significant importer of fossil fuels and selected agricultural commodities.
Nigeria			●		Significant producer and exporter of petroleum and petroleum products.
Norway			●		Large (mainly offshore) oil and gas producer. Large fisheries sector.
Russia	●	●	●		Key oil and gas producer with large, mainly Arctic and sub-Arctic reserves. Major producer and exporter of metals (such as steel and nickel) and agricultural products (especially wheat).
Saudi Arabia	●		●		World's largest petroleum producer and exporter with the world's largest oil reserves. Growing importer of agricultural products.
Singapore			●	●	Large fossil fuel refining and trading hub.
South Korea			●	●	Large and resource-intense industrial sector, heavily reliant in particular on fossil fuels and metal imports. Significant exporter of refined oil and processed metals and large importer of agricultural products.
Spain				●	Large importer mainly of fossil fuels but also some metals and agricultural products.
Switzerland				●	Large importer of fossil fuels and significant trading and processing hub for metals.
Thailand				●	Large and growing importer of metals and fossil fuels for its expanding manufacturing sector. Large producer and exporter of rice and other agricultural products.
Turkey				●	Large fossil fuel importer and growing importer of metals and agricultural products. World's largest iron and steel scrap importer as raw material for its expanding steel industry.
UAE			●		Key oil producer and exporter. Growing importer of agricultural products.
United Kingdom				●	Large but declining oil and gas producer. Large importer of fossil fuels and metals, especially gold.
United States	●	●	●	●	Key agricultural and fossil fuel producer and a large mining sector. Key exporter of agricultural products and large importer of metals. Key fossil fuel importer but with falling import dependence due to consumption peak and expanding (unconventional) production.
Venezuela			●		Large producer of oil and key oil and gas exporter.

Key Facts

Agriculture

- Average prices for agricultural commodities are set to rise. By 2050, global demand for food is expected to have increased by 70–100%. Global cereal demand is increasing at 1.3% per year; average yields are growing at 0.9%.
- Volatility in agricultural commodities markets will persist. Global cereal stock-to-use ratios are at crisis levels below 20%, and will struggle to recover as demand continues to outstrip productivity growth.
- Climate change and extreme weather will become a growing problem for global food security, triggering regional food crises and global price spikes whenever they hit key production centres. Agriculture accounts for 70% of freshwater withdrawals worldwide, and up to 90% in developing countries.
- Agricultural trade remains dependent on a small number of key export centres, increasing the risks of extreme weather. North and South America are the only two major export centres, while palm oil production is almost entirely concentrated in Indonesia and neighbouring Malaysia. Growing export capacity in the Black Sea region is highly variable and vulnerable to extreme weather.
- New trade flows are creating new interdependencies and new risks. Cereal imports for the MENA region from Russia and Ukraine have overtaken those from either the EU or the US, growing from 750,000 tons to more than 24 million tons – the risks of which became clear in 2011. Booming Chinese meat consumption has seen global soybean trade reorganize itself between China and South America.
- Concentration of production increases the risks of unilateral actions. During the 2008 crisis over 30 governments imposed export controls, bringing agricultural markets to the edge. In 2011, Russia's export ban on wheat drove up international prices and led to the initial protests in North Africa that became the Arab Spring. Emerging regional production centres for key commodities such as wheat, rice and soybeans also raise the prospect of cartels.
- The sheer scale of China's strategic food reserves and its levels of production and consumption mean that tight agricultural markets are highly sensitive to changes in China's net trade position. A critical uncertainty is how long China's policy of self-sufficiency in grains can be maintained, given the rising demand and environmental constraints it faces, and how any such retreat from this policy would be implemented.

Metals

- China is the dominant metals consumer. Its share of global metals consumption will increase from 40% today to about 50% in 2020, despite the current slowdown. Many mining countries –including Australia, India, Peru, Brazil and Chile – have become increasingly dependent on exports to China. Of all the metals traded worldwide, 45% goes to China – more than the sum total of the 20 next largest importers.
- Between 2000 and 2010, China increased its production in iron ore by 233%, bauxite by 293%, zinc by 150% and copper by 124%, becoming the largest iron ore, zinc and tin producer, second largest bauxite producer, and third largest copper producer in the world.
- Even with the largest mining industry in the world, China is increasingly import-dependent for most metals. Domestic sources, for example, provide only 37% of the aluminium, 29% of the iron and 26% of the copper its economy requires.
- Future availability is not in question and there have been large additions to global proven reserves over the past decade. But reserve data are a poor proxy for future supply. Many greenfield

projects located outside traditional mining countries face multiple challenges. Citigroup suggests that a quarter of these may not be developed before 2020, with a further 40% at risk.

- Adding to the supply challenge are declining ore grades. While iron and bauxite mining may remain stable, zinc, lead and particularly copper and nickel will be affected by declining ore grades, as will precious metals such as gold and platinum.
- Mining investments have increased more than fourfold in the last decade to nearly $80 billion per year. Sustained large-scale investment will remain necessary to meet future demand but is threatened by cutbacks related to the recent weakening of metal prices.
- A number of emerging economies such as Indonesia have either imposed or are considering new export restrictions on a variety of metals. China and India would be among the hardest hit by these bans.

Fossil fuels

- The last decade saw the share of global fossil fuel trade going to China and India more than doubling in value terms (from 4.4% to 10.8%) and tripling in weight terms (from 4.5% to 14.3%).
- Over the next 20 years, this trend will reinforce geostrategic interests between Asian consumers and energy exporters – particularly the Persian Gulf and sub-Saharan Africa for oil, Russia and Qatar for gas, and Indonesia and Australia for coal.
- Some of the traditional exporters of energy have also emerged as the fastest-growing consumers of energy over the last decade: e.g. Saudi Arabia for oil (6%), Indonesia and Vietnam for coal (9% and 12% respectively) and Egypt and Thailand for gas (10% and 8% respectively). This may affect the ability of some to maintain export volumes in future.
- With the dramatic growth of shale gas in the United States, global energy projections have been redrawn. China rather than Europe will be the next test case for unconventional gas development, with state companies directed to produce 30 bcm of gas from coalbed methane and shale by 2015 – more than double China's 2008 natural gas import volume.
- The global coal market is being reshaped by the import profiles of China and India – the world's largest and third largest coal producers respectively. With its expected increases in coal-fired power generation, India's demand is projected to be 20% of today's world coal trade and could overtake China's volume of imports after 2020.
- Heavier volumes of energy trade together with a changing climate, extreme weather events and water stress will increase the vulnerability of the global energy production and transportation systems. Much of existing and planned infrastructure will be at risk from storm damage, rising sea levels and the effects of melting permafrost.
- Water and energy provision will be increasingly interdependent. The hydropower sector will feel the effects of water stress most directly – leading to vulnerabilities in hydro-dependent regions in Latin America, South Asia and sub-Saharan Africa. Power generation and heavy hydrocarbons extraction and transformation processes (particularly coal and tar sands) are likely to compete with water resources in already water-stressed areas by 2030, e.g. in India, China and South Africa. The perception of unequal access to clean water will be a serious potential trigger of conflict and instability.
- Current mechanisms are inadequate to deal with oil supply shocks, particularly with the rise of new consumers not included in the IEA's emergency sharing mechanism. The 28 IEA member countries hold most of the world's strategic oil stocks but China and India have also begun to develop significant stockpiles, with China planning to expand them to 90 days' worth of imports (476 million barrels) by 2020.
- Flashpoints for competition and possible conflict over hydrocarbon resources include the East and South China Seas, the South Atlantic, the Arctic Ocean and East Africa.

1 Introduction

1. Introduction

Dramatic changes in the patterns of production, trade and use of natural resources – energy, water, agricultural products and minerals – are reshaping national politics and international relations. After a decade of rising and fluctuating resource prices, price spikes and supply disruptions, 'resource security' – here defined as *reliable access to the resources on which society and the economy depend, at affordable cost* – is now at the top of the global public agenda.

Resource security is a dynamic concept. Innovation in technologies, systems and practices, for example, can improve the availability and affordability of resources. It can also introduce new risks. Which resources are deemed critical and/or insecure changes over time, owing to evolving consumer preferences and technological changes. Domestic and international political contexts also shape consumer–producer relations, which in turn affect perceptions of supply security. Another key factor is the cost associated with (and capacities available for) securing access to resources. Broader environmental and social changes further affect resource production and use. Not all changes are evolutionary, however, as abrupt shifts can follow major supply disruptions or natural disasters.

Today, anticipation of future scarcities together with high and volatile prices have already influenced decisions by businesses and governments – despite slacker markets associated with the economic downturn. The consultancy company McKinsey presents resource productivity improvement as the seminal economic and environmental challenge for the years ahead.[1] The fear is that concerns over natural resource securitization and politicization risks will become self-fulfilling prophecies – that states and non-state actors will increase the militarization of resources in response to perceived threats and therefore create the conditions for conflict.

High prices and increased volatility suggest critical linkages between environmental sustainability, geopolitical stability and economic prosperity, making these goals harder to achieve in the absence of integrated and coordinated responses at the international level. Are we on the cusp of a new world order dominated by struggles over access to affordable resources?

The overall scale and speed of growth in demand for resources over the last ten years are unprecedented,[2] even though the pace of growth for individual resources differs. The use of coal, palm oil and iron ore has been growing at between 5% and 10% a year, while use of oil, copper, wheat and rice has grown at 2% a year (Figure 3.12). For a handful of resources such as barley or potatoes, global use has been falling.

Today, emerging economies have become new epicentres driving changes in multiple resource markets as both consumers and producers. The rapid industrialization and urbanization of these countries, especially China, India and Brazil, represent change an order of magnitude larger than the growth of Japan and Korea in the twentieth century. These three BRIC countries account for over one-third of the world's population and, as with Japan and Korea, change is taking place at a much faster rate than the analogous processes in Western Europe and North America. This in turn is creating opportunities for less developed countries, many of them in Africa, with increasingly valuable endowments of land, metals or fossil fuels.

It is anticipated that the current resource boom may last longer than earlier episodes. Large margins of uncertainty surround demand, supply and price forecasts for natural resources. But mainstream long-term forecasts are predicting high demand growth and continuing price volatility for most resources until at least 2030, despite recent signs of easing in some markets (see Table 1.1). The boom – driven by demand beyond the more affluent West – has also reshaped the landscape for resource trade and deepened global interdependencies.

Mainstream long-term forecasts are predicting high demand growth for most resources until at least 2030

Table 1.1: Outlook for natural resources by 2020 and 2030

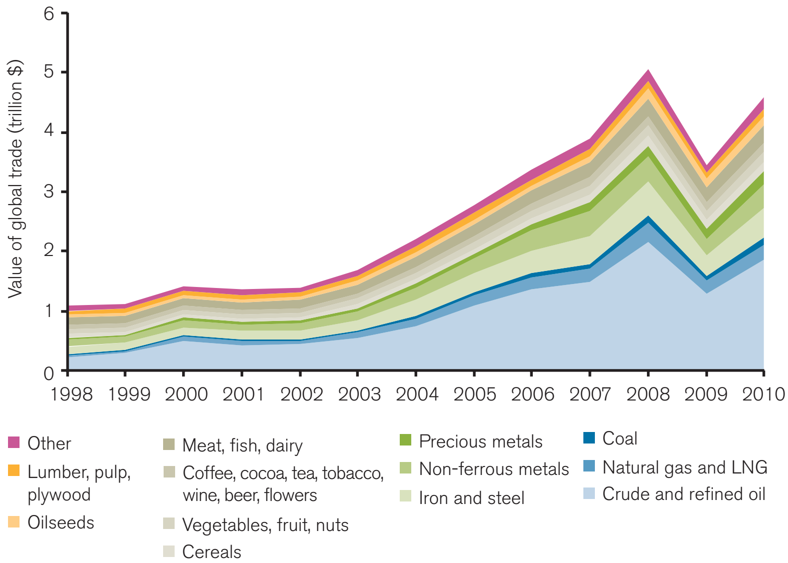
	By 2020	By 2030
Food	• Average crop prices increase by 15–20% against long-rate average, but lower than 2008–10 spike.[3] • Global food production grows by 1.5% per year.[4] • Stocks-to-use ratios remain at crisis thresholds. • Fish-as-food demand increases by 11–17% compared with 2010.[5]	• Cereal prices increase by 70–90% compared with 2010; up to 130–170% with climate change.[6] • Crop demand reaches 2.7 billion tonnes, from 1.9 billion tonnes in the 1990s.[7] • Meat demand growth between 2001 and 2030 estimated at 1.7% per year.[8] • Fish-as-food demand grows by 20–30% compared with 2010.[9]
Energy	• Demand for energy increases by 17% (from 2010) by 2020. • To meet oil supply in 2020, over $3 trillion of investment in the oil sector is needed. • Prices for oil are around $120 per barrel. Gas prices remain differentiated by regions, with Asia's being significantly higher than North America's.	• Demand for energy grows by 29%. Coal demand grows by 20% and gas by 44%. • By 2035 a total of over $37 trillion of investments is needed in the energy sector, half of which will go to the power sector. • Prices for oil are at $100–140 per barrel in real terms.
Metals	• 30–50% demand growth for major metals; rare earth demand doubles from 2010 levels.[10] • Copper faces a 30% supply gap in absence of considerable additional investment.[11] • Heavy rare earths remain in deficit until around 2018–20.[12]	• 90% demand growth for steel, 60% for copper (2010 baseline). Demand for aluminium more than doubles.[13] • Copper could face a 50% supply gap in absence of considerable additional investment.[14] • Potential for temporary shortages of speciality metals with wider deployment of novel technologies.

Sources: Prepared by Chatham House for the NIC. See US NIC (forthcoming, 2013), *US National Security Impacts of Natural Resources by 2020, 2030 and 2040*. Main data sources: FAO (food), IEA 2012 New Policies Scenario (energy), and industry sources (metals).

1.1 The interlinked resource systems

Resource systems are closely interlinked at the local level and – through markets, trade and the global environment – increasingly at the global level too. Resource trade, for example, has more than tripled between 2000 and 2010, from less than $1.5 trillion to nearly $5 trillion (see Figures 1.1 and 1.2). Many recent reports seek to analyse the interconnections among resource systems, placing energy, food and/or water at the centre of a resource 'nexus'. Some have advocated integrated resource management and governance across sectors and scale. Others have proposed cross-cutting targets on lowering resource use.[15]

Figure 1.1: Value of global resource trade, 1998–2010



Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

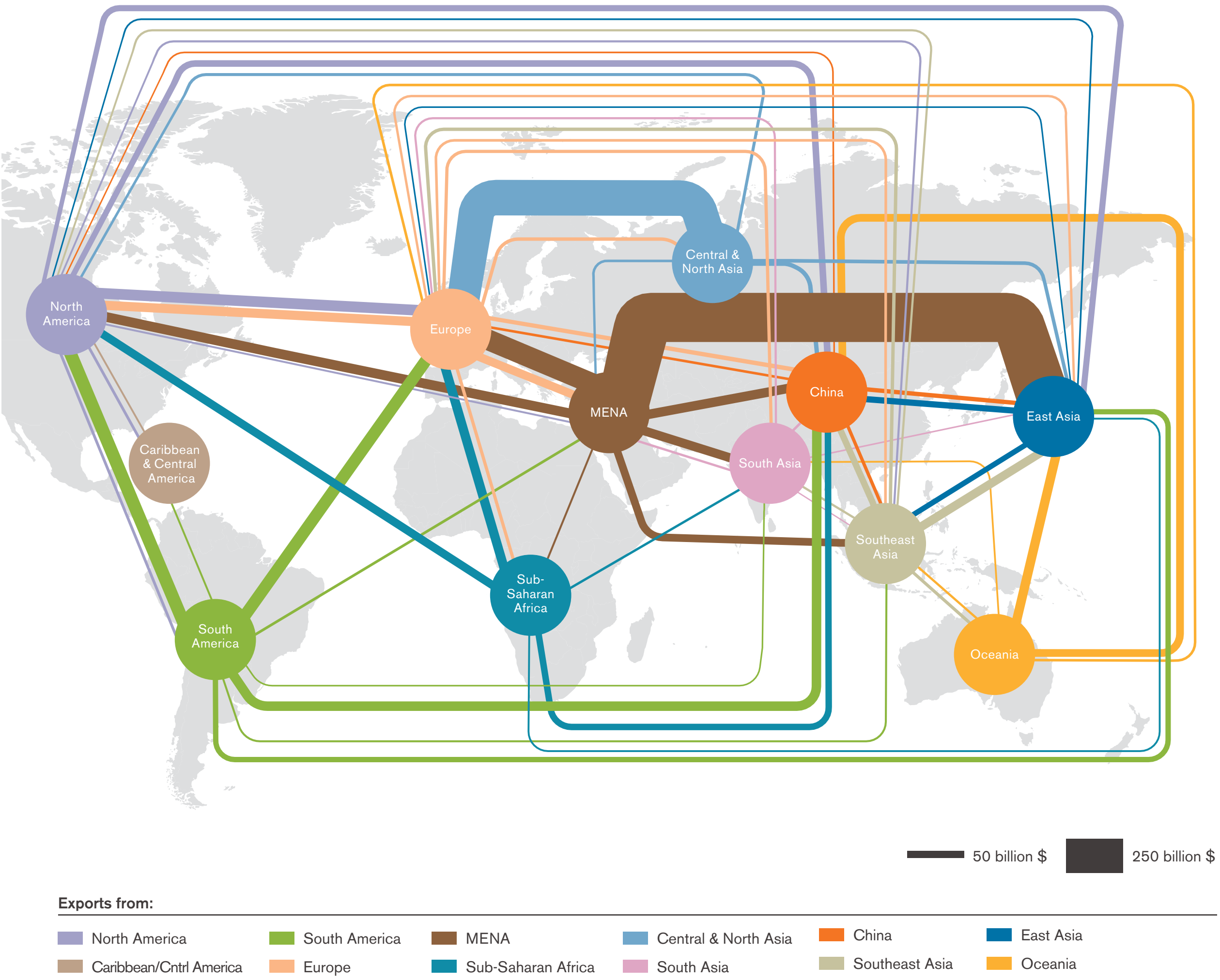
The availability and price of one resource have knock-on effects in the production of others

The availability and price of one resource have knock-on effects in the production of others. The energy sector, for example, is a significant user of water.[16] Mining, transport, processing and energy transformation account for around 35% of water use globally in the industrial sector.[17] Water is, of course, also essential to agriculture. Wheat production in Saudi Arabia, for example, relies entirely on fossil water. In 2009 the country abandoned its policy of wheat self-sufficiency because underground non-renewable aquifers were in precipitous decline.[18]

Land for food production is under pressure from competing uses, with cropland lost to urbanization and industrial use, or converted for biofuel production and reforestation.[19] As a result, agriculture is increasingly shifting onto marginal lands with poorer soils and weak infrastructure. This is particularly the case in sub-Saharan Africa, which still has the largest reserves of arable land.

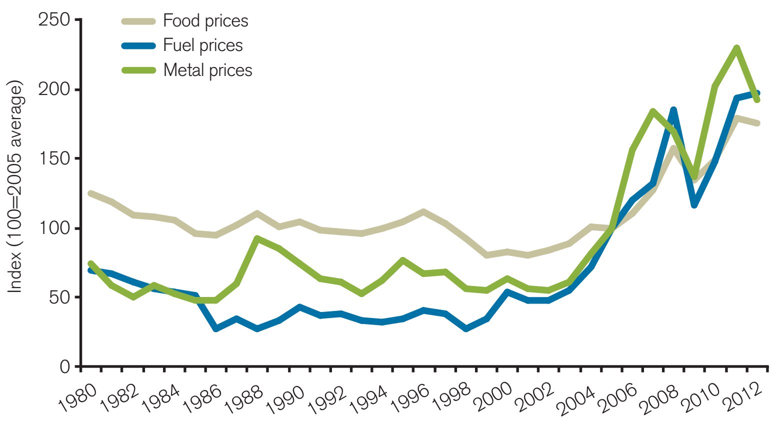
The interconnectedness of resource systems means that it is critical to explore unintended consequences when considering regulatory choices (such as biofuels subsidies) or supporting the development and deployment of new technologies. Getting this right, in turn, may generate co-benefits and win-win outcomes.

Figure 1.2: Resource trade between regions, by value, 2010



Sources: Chatham House Resource Trade Database, BACI, COMTRADE. Resource trade flows between regions worth more than 10 bn $ in 2010.

Figure 1.3: Resource prices: Indices for fuel, food and metal commodities, 1980–2012



Source: Chatham House based on IMF (2012).

Box 1.1: Today's concerns in historical perspective

Fluctuations in resource prices have long been the norm. Markets have always seen booms followed by busts – a typical feature of highly cyclical primary industries, such as mining and oil and gas, that require major capital investments with long lead times. Over the course of the twentieth century, despite increased consumption, the trend in real prices across the spectrum of resources has in general been downwards.

Many have sought to account for the upward pricing trends for these resources over the past ten years, each with different physical, production and market characteristics. Some put more weight on increasingly 'hard' limits, others on production bottlenecks and under-investment, unsustainable demand growth and increasing production costs. Many attribute the tight markets to demographic shifts and the explosion of demand from emerging economies. Others point to financial speculation as the source of volatility.

Fears of resource scarcity are not new. As far back as 1798, Thomas Malthus – noting that food production might not keep pace with exponential population growth – suggested the inevitability of famine.[20] In a precursor to today's discussion on self-sufficiency, Malthus supported duties on imported corn to boost domestic production and guard against dependency on foreign states.

Worries that the world would run out of oil or other resources also appeared at regular intervals. In 1956, the Shell geologist Marion King Hubbert estimated that world crude oil production would peak in 2000 and decline inexorably thereafter, even if this could be slowed somewhat by enhanced recovery techniques.[21] Paul Ehrlich foresaw a world in which famine would wipe out millions.[22] In the 1970s, against the background of two oil price shocks, concern about the availability and politicization of resources became widely popularized. The Club of Rome saw limits to finite resources becoming constraining factors on economic development within a matter of decades.[23]

In many respects, the current debate on resources is dominated by experience of tight and rigid resource markets in the past decade, which have recently shown signs of some easing. IMF data (see Figure 1.3) suggest a broad correlation in price increases across agricultural products, fuels and metals when presented as an annual average. McKinsey points out that this correlation is stronger than it has been for at least a hundred years, a reflection of the linkages between resource markets.[24]

With the global consumption growth and the anticipated supply-side challenges, the general contention is that the world has entered a period of intensified resource stress – with the potential for high and volatile prices becoming the norm, accelerated environmental degradation, greater risks of supply shortages and disruptions, as well as intensified political tensions over control and access to resources. Even though these developments may resemble previous episodes (see Box 1.1), the larger shifts under way – in the natural environment, in the relationship between resource systems and in the distribution of global income and power – are fundamentally changing the rules of the game. They are also undermining assumptions about the sustainability of wider resource-intensive economic growth.

1.2 Environmental risks and interdependencies – era of shocks and disruptions

The scale and pace of efforts to meet resource demands have also sharply affected the state of the global environment – from biodiversity loss, deforestation, soil erosion and land degradation to air and water pollution. Today, environmental change and degradation are presenting new challenges to business-as-usual assumptions about future resource extraction, production, processing and consumption – whether directly through scarcities of specific inputs such as water or indirectly through social and political opposition (see Chapter 4).

The principal challenge is global climate change. The World Bank estimates that by 2025 climate change will result in 1.4 billion people across 36 countries facing crop or water scarcities.[25] A recent study estimated that global temperature rises are already having significant impacts on cereal yields.[26] By 2050, 200 million people may be permanently displaced climate migrants, a tenfold increase over the current documented total of refugee and internally displaced people.[27]

The risk is that the knock-on effects of unmitigated climate change and environmental degradation may cause social instability, generate mass movements of human population and ultimately trigger political instability and conflicts over access to water and other increasingly scarce resources. Such insecurity will be driven not by single, linear changes but by complex interactions between multiple environmental, social, political and governance factors.

The knock-on effects of global climate change may cause social instability, mass population movements and, ultimately, conflict

Extreme weather events have become more common and this trend will intensify[28] – even in the best-case scenario. The potential disruptions that these and other environmental changes will bring to global trade and the production sites for many resources have not yet been comprehended.[29] The global energy transport system is particularly vulnerable to disruption at key maritime choke points (see Chapter 4) such as the Straits of Malacca and Singapore, Bab Al-Mandab, the Suez Canal, the Turkish Straits and the Strait of Hormuz.

As the volatility in the price of global resources increases and certainty about access decreases, the risks of militarized responses aimed at securing vital goods and assets will multiply. This will in turn increase the pressures on the institutions and conflict resolution mechanisms already in place and decrease the chances of further cooperation over shared resources.

1.3 Navigating the world of scarcities

In the coming decade, countries across the world will face enormous challenges in managing the transition to sustainable 'resource' equilibrium under extreme stress conditions, while keeping the lights on and putting food on the table. In some cases, investment and technology may bring temporary solutions to problems of resource availability and access. But on the global scale, the scope and size of these challenges may overwhelm the ability of states and markets to adapt.

Meanwhile, demographic shifts, environmental pressures and a rapidly changing global economy are exacerbating scarcities and sharpening resource politics. Fears of resources 'running out' and the complex, dynamic and adaptive nature of global markets are leading states to pursue poorly designed and short-sighted policies which are likely to undermine, not reinforce, the conditions for collective prosperity, sustainability and security.

Most zero-sum national strategies to hedge against scarcity and price swings typically make things worse, not better. High and fluctuating commodity prices are likely to spur resource nationalism and increase the attraction of unilateral and bilateral responses that erode trust and undermine multilateralism. Increasing concentration of producer powers – whether through mergers and acquisitions (M&A), nationalization or investments by state-owned enterprises (SOEs) – may limit options for many.

Competition for resources increases the risk of a downward spiral towards more competition, less trust and poorly designed policies

Competition for critical resources, already acute in many parts of the world, is likely to escalate, increasing the risk of a downward spiral towards more competition and less trust. These pressures will also continue to augment existing political and social stresses – between sectors, communities and nation-states. In such situations, politics usually trumps science and good economics.

It is the logic of zero-sum competition rather than cooperation and shared interest that now shapes increasingly dysfunctional multilateral processes. The G20's attempts to deal with food price volatility in 2011 were neutered by the unwillingness of some governments to provide assurances against the unilateral imposition of agricultural export controls, and of other governments to consider removing the generous subsidies afforded to their biofuel and agricultural sectors.

The failure to achieve an international climate agreement at Copenhagen in 2009 was similarly rooted in the special interests and dependencies organized around resources. In a cruel irony, the countries with the greatest interest in securing an international climate deal are those with the least bargaining power: poor, vulnerable states with small resource footprints. Power lies instead with the major resource producers and consumers, for which decarbonization implies a profound reconfiguration of both infrastructure and the economy.

Countries with significant fossil fuel resources ostensibly stand to lose most from a binding international agreement to progressively cut greenhouse gas emissions, and have accordingly adopted some of the most obstructive negotiating positions and disruptive strategies. Equity considerations dictate that the initial speed and extent of decarbonization should be greatest among developed countries. However, this encounters resistance from domestic resource-consuming industries such as energy and metals, which face higher short-term costs and increased competition from their counterparts in emerging economies. But in climate politics, a level playing field would be unfair: not only would it fail to incorporate the equity concerns of emerging economies; it would also penalize their more emission-intensive industries more heavily. With developed and developing economies unable to agree how the relative cost of decarbonization should fall across their respective patterns of resource consumption, the result is stalemate.

Governments, businesses and citizens must seek answers to some difficult questions. Can we collectively challenge vested interests to move towards a more constructive politics over global public goods? Are the right mechanisms in place to insulate consumers and producers from price swings, so creating more space for governments to pursue less reactive, more cooperative agendas? Relatedly, will the existing international architecture be robust enough to support the world as it moves towards an open and transparent trading system for resources? Can we pre-empt – or in the worst case, resolve – an explosion of resource-related conflicts?

Moving towards a more constructive politics of resources will mean governments, businesses and citizens have to answer difficult questions

This report aims to analyse this new global situation, as well as the stresses and implications of attempts to manage the production and consumption of key natural resources, and their international trade. Chapter 2 outlines the scale and speed of growth in demand for resources over the last ten years and mainstream projections for the coming decades. It also sets out the new geography of resources, facilitated by rapid growth in global trade. Chapter 3 is focused on the production of natural resources and how this is changing – including the key players and the needed investments. The chapter also explains how these production trends are creating new independencies. Chapter 4 highlights a set of critical uncertainties, including the impact of volatility and the role of innovation, as well as the key environmental fault lines. Chapter 5 examines how governments and other stakeholders are responding to actual and perceived shortages – and how this may be worsening the outlook for resources politics. The report concludes with a set of recommendations on how international institutions, governments and companies can pre-empt and manage future stresses on natural resources. These provide a framework for achieving the transition to a world where global resource consumption is environmentally, economically and politically sustainable.

2 More, More and More

- Growth for critical resources such as fossil fuels, steel and food over the last decade was driven by economic development in the large developing economies, primarily China and India. Nearly all demand growth is coming from the emerging economies.

- The value of traded resources tripled in the past decade to about $5 trillion. China and India lie at the centre of this expanded global resource trade. One in five tonnes exported worldwide goes to either China or India. Their growth rates over the next ten years will determine the state of global resource markets.

- The resources boom has reconfigured the contours of bilateral and regional trade and deepened economic ties. Rising fossil fuel demand will further increase China's and India's import dependence on – and geostrategic interest in – the Middle East, but also force both to seek greater imports from other exporting regions, such as South America and Africa.

- Beyond the BRICS and OECD countries, a wave of developing countries will become important resource consumers in the next decade. Iran, Vietnam, Turkey and Thailand are likely to be among them.

- Policy choices in key consumer regions will determine the scale of future demand growth. Without additional measures, such growth is a threat to economic stability in the medium term for some countries, including major oil exporters in the Middle East.

2. More, More and More

For most of the twentieth century, the political economy of resources revolved around the needs of a few advanced economies, in North America and Europe, as well as the Soviet Union and Japan, while the rest of the world had much lower rates of consumption as well as considerable net outflows of natural resources. This model is now changing.

Today, increasing globalization of supply chains – combined with higher incomes and population growth – has seen the shifting of processing and consumption hubs to developing-country regions. With the consolidation and expansion of regional production networks,[30] emerging economies such as China have switched from their traditional role as exporters of primary goods to net importers. This chapter explores the evolving geography of the global resource system, particularly the dramatic expansion of consumption. These changes are generating new dynamics for the resources sectors, leading to a structural shift in global resource trade, and creating new winners and losers. The specific dynamics of agriculture, metals and energy trade-related dependencies and politics are considered in separate sub-sections.

2.1 The consumption boom

Expanding populations and rising incomes will drive increasing demand for fossil fuels, steel, food and water

Driven by expanding populations and rising incomes, significant rates of growth are expected to 2040 across critical resources such as fossil fuels, steel, food and water. Rapid increase in resource consumption is often linked to greater industrialization and urbanization. In China, for example, after a long period of decline, energy intensity rocketed in 2002, driven by the growth of heavy industries. It has also been climbing in the Middle East over the past decade, largely owing to soaring electricity consumption in air-conditioned buildings. While technological improvements, changing economic structures and other factors have reduced the material intensity of the economy, the link between economic growth and resource consumption has not been broken.[31]

Growing wealth has also brought changes in consumer behaviour. Shifting diet patterns, for example, contribute significantly to the growing demand for key resources. Average per capita consumption of meat in high-income economies increased from 55.9 kilograms per annum in 1990 to 93.5 kg in 2002. Over the same period, there was a dramatic rise in China's annual meat consumption per capita, from 3.8 to 52.4 kg, and in Brazil's, from 27.8 to 82.4 kg. Whereas producing a kilogram of potatoes requires just 500 litres of water, producing a kilogram of beef requires 15,000 litres.[32] In addition to water stress, the production of meat has significant environmental implications for land degradation and greenhouse gas emissions. Globally, one-third of the world's land is currently experiencing desertification attributed to overgrazing, with livestock producing about 80 million metric tonnes of methane annually.[33]

The combination of these trends implies a continuation of the upward trajectory in resource demand in the coming decade, barring major shifts and disruptions. Clearly, one has to be cautious about the predictive power of these projections – since they are often relatively simple extrapolations of past trends – given the range of uncertainties over demographics, technological change and gross domestic product (GDP) assumptions as well as policy responses, among other factors. For example, UN population projections range from 8.1 to 9.7 billion in 2040, up from 7 billion today.[34] In real terms global GDP is expected to double between 2010 and 2030, according to the IMF, but projections of GDP per capita in different countries vary widely.[35] The pace of technological change and the relative costs of different demand- and supply-side options require a further set of assumptions (see Section 4.2). Examples of previous failures in predicting economic trends abound. The potential for transformative, disruptive shifts is particularly difficult to model, especially where technologies have not yet been commercialized (see Section 3.3.1.1) and where higher prices may prove an incentive to speed up innovation and diffusion of new technologies.

Resource-related projects over the next decade or more are particularly sensitive to developments in the emerging economies. There is a widely held assumption that China's GDP will grow at around 8–9% per year to 2015 and 7–8% from 2016 to 2020,[36] and that this will continue to drive the resource markets; but if a near-term slowdown becomes a reality, as some are predicting, there will be reverberations throughout resource markets.[37] These assumptions are already being challenged today by slackened growth figures in China in 2012. China's resource consumption growth is expected to flatten out in the 2020s,[38] and it is unclear whether the global markets will return to lower resource prices owing to excess production capacity, or tighten further in response to new demands from other emerging economies such as India.

Over the next decade, investments in resource-related projects will be driven by growth rates in China, India and Brazil

Chapter 2

Expectations of growth in resource consumption

Food demand

In this decade, demand for cereals is likely to increase by around 15%, for oilseeds, protein meals and meat by 20% and for sugar, vegetable oils and fresh dairy produce by roughly 25%, according to FAO-OECD projections (see Figure 2.1). By 2030 cereal demand is expected to reach 2.7 billion tonnes - compared with 1.9 billion tonnes in 2000.[39]

Most of this demand growth comes from resource use associated with rising incomes and those used to produce biofuels. Oilseeds (2.2% annual growth until 2030 – see Table 2.1) are used as animal feed, an ingredient in processed food or feedstock for biofuels. Coarse grain (1.4%) – also used as animal feed and in biofuels – is the fastest-growing cereal category. Of the major crops, rice is expected to exhibit the least change (0.9% rise), as higher incomes tend to result in a shift away from rice in favour of wheat and other food sources. Rice is not typically used as grain feed for animals. Meat demand (1.7%) will grow especially for poultry, which is set to overtake pigmeat as the world's most consumed meat by 2020.

Fish demand

Fisheries and aquaculture produced 128 million tonnes of food for human consumption in 2010. An additional 14 million tonnes of fish per year would be needed in 2020 (27 million tonnes in 2030) to maintain present levels of per capita consumption.[40] Developing countries will account for 97% of growth between 1997 and 2020.[41] China alone is expected to be responsible for just over half of global consumption expansion during that period, while Southeast Asia will add 15%. Most of the increase will be met by aquaculture production, as the share of capture fisheries in global production continues to grow (Section 2.3.4).

Forest and wood products demand

In much of the developing world biomass is an important fuel for heating and cooking. To the extent possible, local communities typically make use of broken branches and dead wood on their own land or in nearby forests rather than cutting mature trees. But in the absence of sustainable land management practices, the commercial production of wood fuel for urban markets (including charcoal) is often associated with forest clearance.[42]

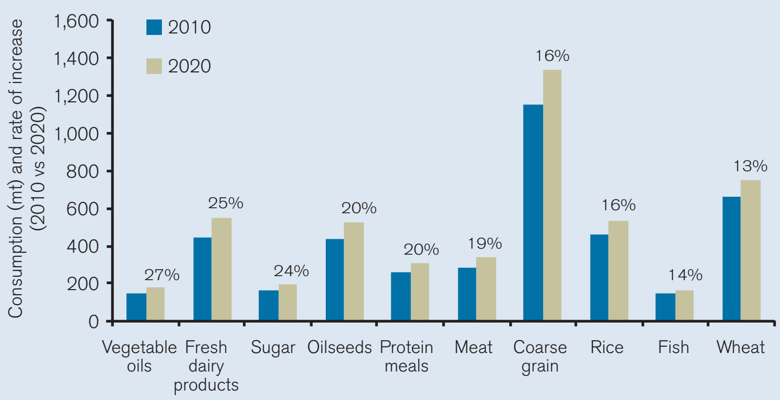
Growth in the use of wood as a source of energy is one of the most dramatic changes in timber consumption patterns. Global demand for wood pellets – a new and easily transportable low-moisture, high-density form of wood and wood residues – has grown more than fourfold over the last decade, mostly for use in energy production.[43] In Europe – a key growth market – per capita biomass energy use is projected to triple by 2020 in response to renewable energy targets. The extent to which this can be met by domestic wood production and non-wood sources (energy crops and agricultural residues) is largely unknown.[44] Large-scale commercial production of biofuel from wood sources could increase the demand for timber even more drastically, potentially increasing imports from North America and, within the region, from Russia to the European Union.

Table 2.1: Food product growth rates, 2001–30 and 2031–50 (%)

Commodity	Growth rate 2001–30	Growth rate 2031–50
Oilseeds	2.2	1.6
Meat	1.7	1.0
Coarse grains	1.4	0.8
Wheat	1.1	0.5
Rice	0.9	0.2

Source: FAO (2006).

Figure 2.1: Consumption of key crop products, 2010 and 2020

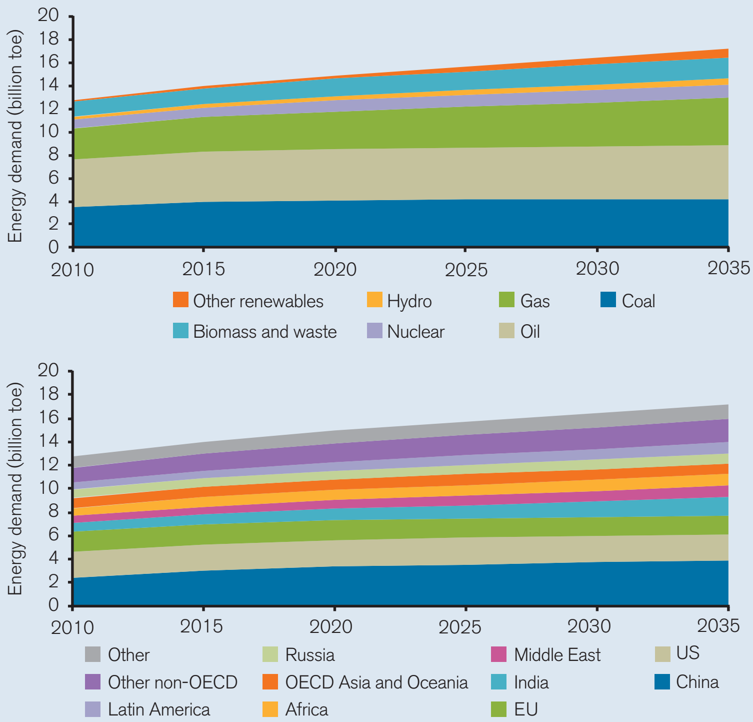


Source: Chatham House based on data from OECD-FAO (2012).

Fossil fuel demand

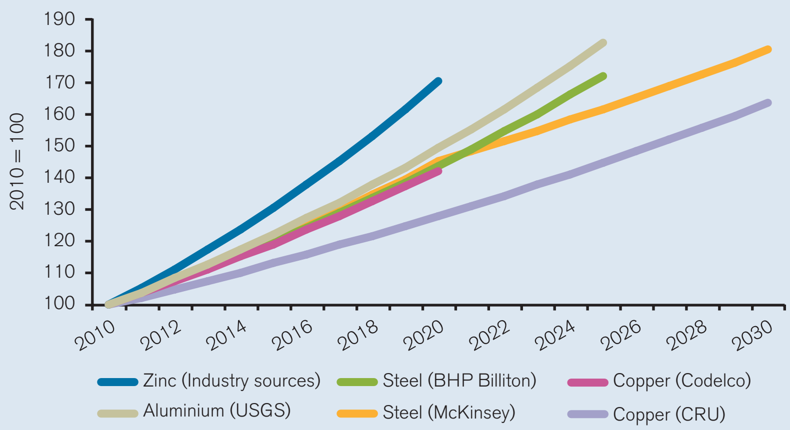
Demand for energy is set to increase by 35% by 2035 compared with 2010, according to the IEA new policies scenario. Fossil fuels will provide about 75% of supply at this time, with the gas sector seeing the largest growth. Much of this growth is expected to come from emerging economies, particularly China. Other mainstream forecasts offer a similar picture, although assumptions about the impact of energy efficiency policies in larger economies influence the overall demand trend. The mix of energy sources in these scenarios is partly determined by assumptions about the cost of (and policy support for) renewable energy, nuclear and electric vehicles as well as the availability of unconventional gas and oil (see Box 3.2 for definition of unconventional resources).

Figure 2.2: Global energy demand to 2035, by source and region



Source: IEA (2012).

Figure 2.3: Projections of metals demand



Source: Chatham House based on industry sources.

Metals demand

For metals and other minerals, comprehensive long-term demand projections are mostly unavailable outside the realm of resource companies and commercial consultancies. The few publicly available forecasts predict gradual but significant increases in consumption, based on GDP growth estimates. The OECD estimates that metal demand will grow by 250% from 2005 levels by 2030, or 5.1% per year,[45] while the Ellen McArthur Foundation suggests that global ore extraction will grow from an estimated 8 billion tonnes annually to 11 billion tonnes by 2020, an increase of 37%, or 3.2% per year.[46] Among major metals, aluminium demand is expected to grow the fastest (4.1% per year until 2020 according to USGS projections), followed by steel (see Figure 2.3).

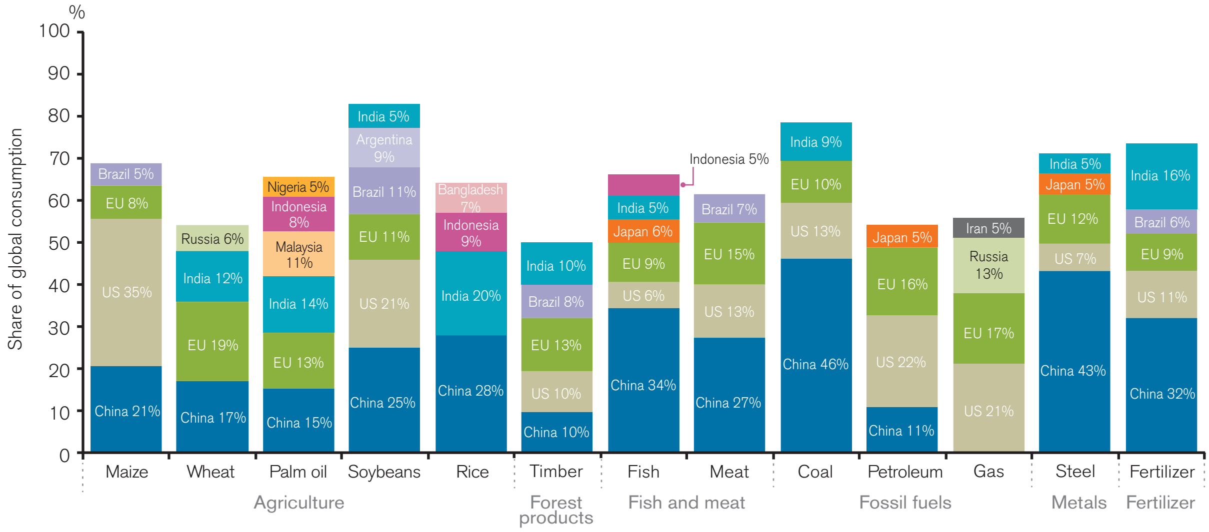
Fertilizer demand

Inorganic fertilizer demand is linked with energy as well as food markets; higher oil prices tend to push up food commodity prices, encouraging the more intensive use of fertilizers.[47] Overall, global demand for fertilizer nutrients is expected to grow at around 2–2.5% per year from 2011 to 2015.[48] There are three major fertilizer categories: nitrogen fertilizers are derived from fossil fuels, whereas potassium (potash) and phosphorous (phosphate) are mined. Annual demand for nitrogen, phosphate and potash will grow by 1.7%, 1.9% and 3.1% respectively to 2015.[49] The intensity of fertilizer usage (per tonne of agricultural output) varies considerably by crop and from region to region. China and India are the largest consumers of all three categories, accounting for about half of nitrogen and phosphate demand in 2009, for example.[50]

2.1.1 The rise of the rest

China and India are now major consumers in most resource markets. China is the world's largest consumer of steel, coal, wheat, palm oil and soybeans, to name a few (see Figure 2.4). India follows at some distance, but is among the top four countries in terms of demand for coal, steel, wheat and palm oil. Looking forward, the influence of these two countries over resource markets will continue to grow.

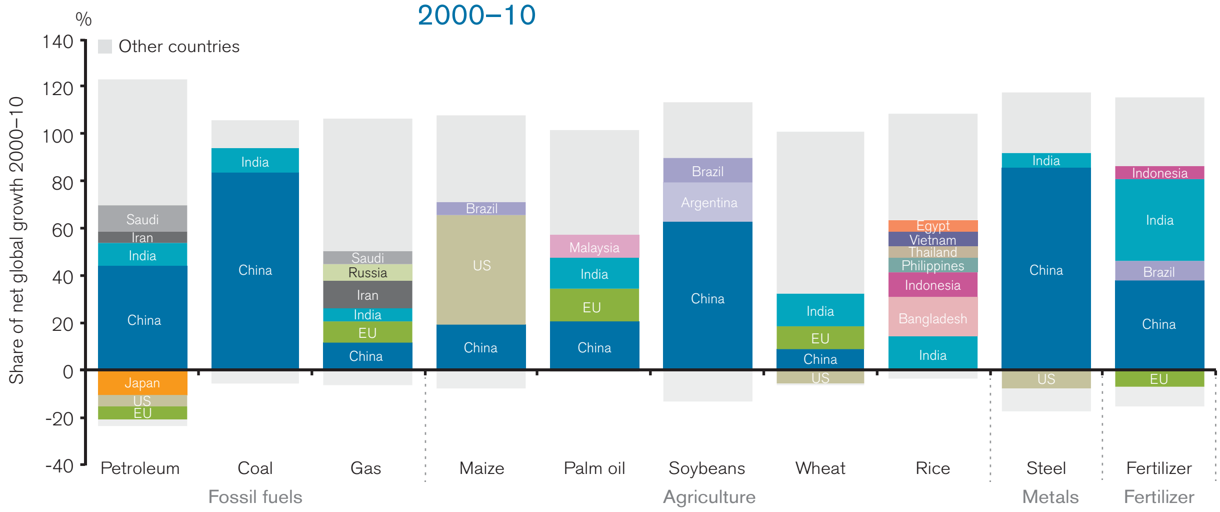
Figure 2.4: Major resource consumers, 2010 (>5% of global in 2010)



Source: Chatham House analysis of FAO, EIA and World Steel Association data. Data for the agricultural commodities refer to 2009, the latest year for which comprehensive statistics are available.

The majority of demand growth over the past ten years has come from the emerging markets; maize for the US – buoyed by biofuels subsidies – is the only major exception (see Figure 2.5). Over this period, China was responsible for 63% of the growth in demand for soybeans; 20% each for maize and palm oil; 44% for petroleum; and 83% for coal. India accounted for around 10% of growth in palm oil, wheat, oil and coal demand, while Argentina and Brazil together accounted for 25% of demand growth in soybeans. For steel and other metals, China's contribution to demand growth is especially pronounced (see Box 2.1).

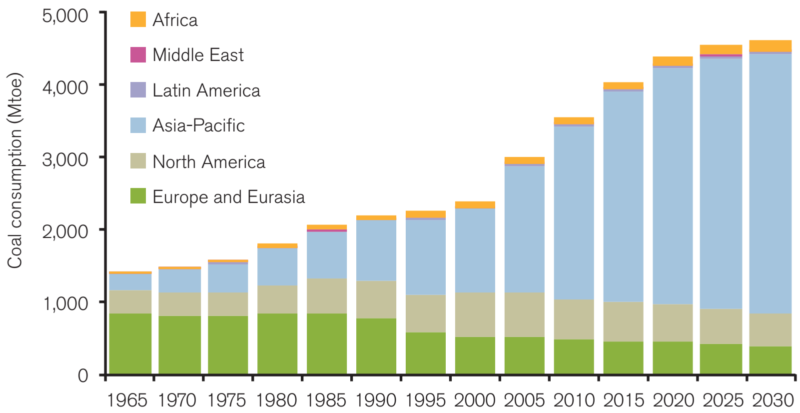
Figure 2.5: Major contributors to global consumption growth, 2000–10



Source: Chatham House analysis of data from FAO, FAO-OECD, EIA, and the World Steel Association. Data for the agricultural commodities refer to 2009, the latest year for which comprehensive statistics are available.

The case of coal best illustrates the changing roles. While China and India lay claim to the world's third and fifth largest coal reserves respectively, they are consuming coal faster than they can develop domestic mines. In the last seven years, China has gone from being a significant exporter of coal to a net importer.[51] The resurgence in coal demand (see Figure 2.6), as the result of coal-fired power generation in Asia, is now driving massive investment in new mining in Australia and Southeast Asia as well as in India and China themselves (see Section 2.1.2).

Figure 2.6: Coal consumption to 2030, by world region



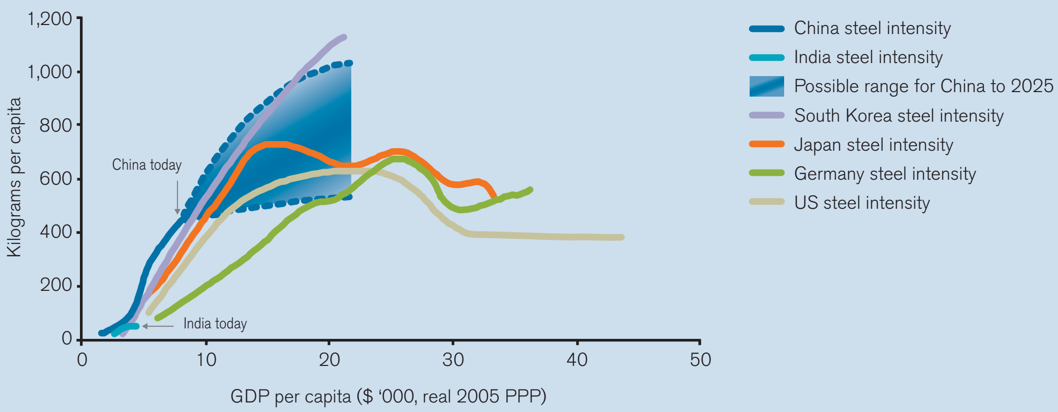
Source: BP Statistical Review of World Energy 2011.

Coal-fired power generation in Asia is driving massive mining investments in Australia

Box 2.1: China's heavy metal addiction

China's metal intensities are unusually high given its level of economic development. For steel, its per capita consumption today already exceeds per capita consumption in the US and is rapidly catching up with that in Germany and Japan, despite the income differences (see Figure 2.7). For copper, where consumption growth typically occurs at higher income levels, average per capita consumption has also increased steeply and is beginning to catch up with US levels.

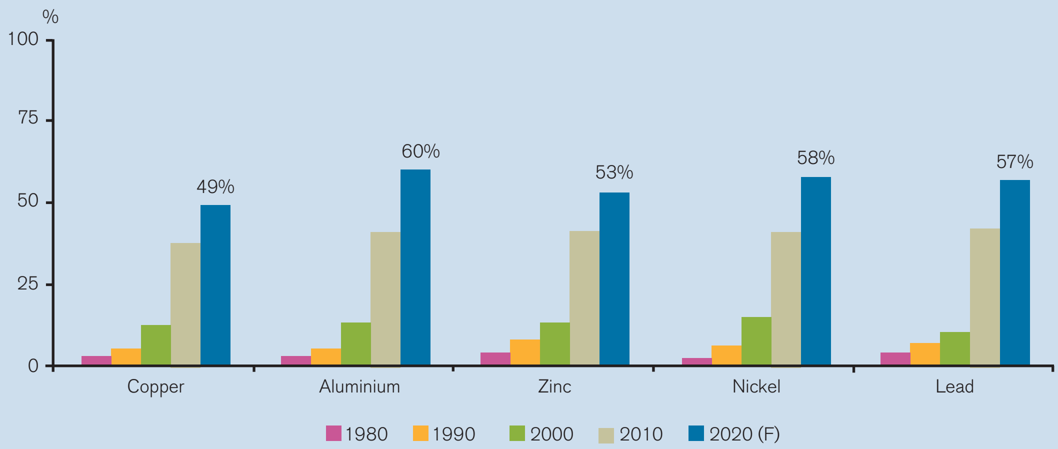
Figure 2.7: Which trajectory will China follow?



Source: BHP Billiton (2011).[52]

GDP-per-capita levels and urbanization rates alone do not provide a satisfactory explanation for China's extremely high metal consumption. For example, per capita incomes and urbanization rates in Latin American countries such as Brazil and Argentina are higher but their per capita metal consumption is a fraction of China's. Demand growth in China has been slowing, but even if this trend continues, its share of global consumption will increase further, from around 40% today to well over 50% by 2020 (Figure 2.8).

Figure 2.8: China's growing share in global base metal consumption, 1980–2020



Source: Lennon (2012).[53]

One explanation for China's unusually high metal intensity lies in its development trajectory, which resembles those followed by Japan and South Korea at a similar stage of development.[54] An unusually large manufacturing sector and booming construction industry driven by state-led infrastructure building contributed to this demand for metals.

But aggregate numbers conceal enormous regional disparities in China, where development in eastern coastal regions is considerably ahead of that in many western provinces. Per capita copper consumption in the east already rivals South Korea's, while in the west it is comparable to consumption in other developing economies. Similar regional differences exist for other metals. A key question is whether the rest of the country will follow the resource-intense development of the coastal regions over the coming decades.

A second generation of emerging economies will become significant resource consumers in the next 10–20 years

2.1.2 The next wave of consumers

Beyond the next decade, a number of developing countries could become significant resource consumers at the global level in the next 10–20 years. Many of these are medium to large by population size and belong to the booming second generation of emerging-market economies (see Table 2.2). The list is based on growth rates over the past ten years and the share of global consumption today, with consideration of the potential for growth – given the level of economic development, stage of industrialization and population size.

Countries that feature in several categories include India, Iran, Russia, Thailand, Turkey and Vietnam. Others are already major consumers for several resources, but have rapidly growing demand in new areas (natural gas in China, for example). (See Annex 4.)

Table 2.2: Existing and emerging resource consumers

Resource	Major consumers	Share of global consumption, 2010 (%)	Annual growth 2000–10 (%)	Emerging consumers	Share of global consumption, 2010 (%)	Annual growth 2000–10 (%)
Maize	US	35	4	Indonesia	2	6
	China	21	3	Nigeria	1	3
	EU	8	0	Philippines	1	4
	Brazil	5	3	Iran	1	10
				Vietnam	1	10
Wheat	EU	19	1	Pakistan	4	2
	China	17	1	Egypt	3	3
	India	12	2			
	Russia	6	1			
Rice	China	28	0	Vietnam	5	2
	India	20	1	Thailand	3	3
	Indonesia	9	2	Philippines	3	3
	Bangladesh	7	3			
Soybeans	China	25	10	Russia	1	14
	US	21	0	Paraguay	1	6
	EU	11	-1	Iran	1	10
	Brazil	11	5	Ukraine	0	34
	Argentina	9	8	Egypt	0	19
	India	5	7	Syria	0	24
Palm oil	China	15	17	Pakistan	4	6
	India	14	8	Thailand	3	9
	EU	13	11	Bangladesh	2	28
	Malaysia	11	8	Iran	1	25
	Indonesia	8	3	Russia	1	17
	Nigeria	5	8	Vietnam	1	19
				South Africa	1	36
				UAE	1	45
Timber	EU	13	1	Chile	1	3
	India	10	1	Ghana	1	6
	USA	10	-4			
	China	10	1			
	Brazil	8	1			
Steel	China	43	16	Brazil	2	5
	EU	12	-1	Turkey	2	7
	US	7	-4	Iran	1	6
	Japan	5	-2	Thailand	1	8
	India	5	8	Vietnam	1	16
Crude oil	US	22	0	India	4	4
	EU	16	0	Saudi Arabia	3	6
	China	11	7	Iran	2	4
	Japan	5	-2	Russia	3	2
				Brazil	3	2
Gas	US	21	0	China	3	15
	EU	17	1	India	2	11
	Russia	13	1	Saudi Arabia	3	6
	Iran	5	9	UAE	2	7
				Mexico	2	4
				Egypt	1	10
				Thailand	1	8
				South Korea	1	9
Coal	China	46	12	Kazakhstan	1	6
	US	13	0	Indonesia	1	9
	EU	10	-1	Turkey	1	2
	India	9	6	Vietnam	0	12

Source: Chatham House analysis of data from FAO, IEA, EIA, IFA and the USGS (See Annex 6 for details). Data for the agricultural commodities refer to 2009, the latest year for which comprehensive statistics are available.

Box 2.2: Consumption growth in producer countries

In many countries, the politics of production and consumption are closely interrelated. From one perspective, countries with large domestic consumption often actively encourage domestic production, often with the aim of improving security of supply or providing local employment opportunities. This tends to create strong lobbies in favour of production subsidies, price support or other trade-related measures, so that more resources are produced in these countries than would otherwise be the case (see Chapter 3). Examples abound, from the US biofuel mandate, Japanese rice production or the EU common agricultural policy to the coal and steel sectors in China.

Looked at from another angle, key producer countries have made a disproportionate contribution to global demand growth over the past decade. Saudi Arabia, the world's largest oil producer, accounted for about 10% of global petroleum demand growth. Russia and Iran, which together control nearly a quarter of global gas supply, accounted for nearly a fifth of global gas demand growth. China has made a larger contribution to demand growth for steel and coal than for any other resource and is at the same time the largest producer for both. Argentina and Brazil, representing 45% of global soybean production, also accounted together for 25% of the growth in soybean demand. The world's largest maize producer, the United States, is responsible for nearly 40% of the global demand growth in the last decade. Malaysia, the second largest palm oil producer, is also responsible for 10% of global demand growth.

Resource producers and regions are often powerful constituencies in the domestic politics of major producer countries, and have frequently secured subsidies that promote consumption of their products. For example, extensive policy support for corn-based biofuels in the United States is closely tied to the political expediency of stimulating a market for the powerful farm sector there.

Abundant production also makes it politically difficult to remove subsidies on domestic consumption. The risk is that low prices lead to rapid growth in domestic consumption, adding to global pressure on international resource markets and the environment, but also creating large inefficiencies that can hinder economic development and lead to substantial fiscal pressures in producer countries.

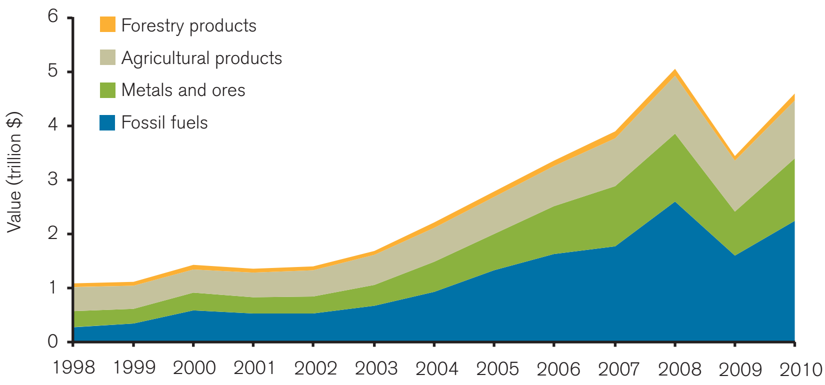
2.2 Expansion of resource trade

The resources boom has reconfigured bilateral and regional trade and deepened economic interdependencies

Much global attention focuses on the role of emerging economies' consumption in driving the resource boom.[55] This is not surprising, as emerging countries from Asia alone have doubled their share of global output in the past two decades.[56] The rise in the manufacturing competitiveness of economies such as China, India, and Korea[57] has led to the expansion of regional production networks, which are themselves becoming new demand centres. Less attention has been paid to how the resources boom has reconfigured the contours of bilateral and regional trade and deepened economic interdependencies.

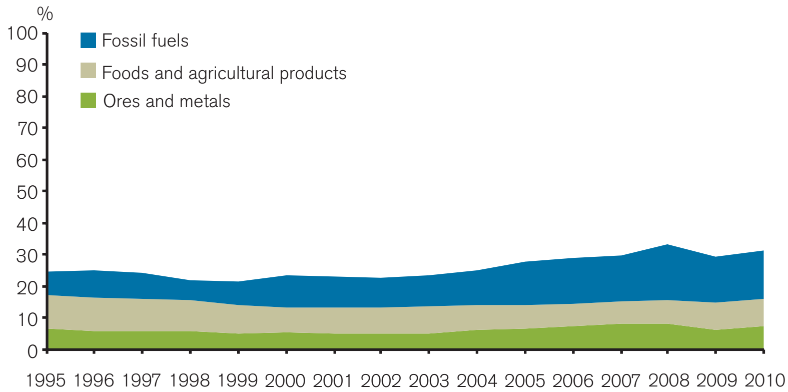
Resource trade has grown in response to emergence of new consumption hubs as well as the spread of global supply chains. China lies at the epicentre of this new web of interdependencies among countries and regions. Driven in part by higher oil prices, the value of traded resources has more than tripled in the past decade, amounting to nearly $5 trillion today (see Figure 2.9), or just under a third of the global merchandise trade (see Figure 2.10).[58] In weight terms, trade has grown nearly 50% from a decade ago. This is mainly due to expanding trade in oil, iron and steel, coal, oilseeds and cereals (see Figure 2.11) – feedstock for China, the factory of the world. The growing bulk of resources trade has also helped spur significant growth in global transport infrastructure connecting new centres of consumption and production – especially in energy and metals (see Box 4.8).

Figure 2.9: Global resource trade, by value, 1995–2010



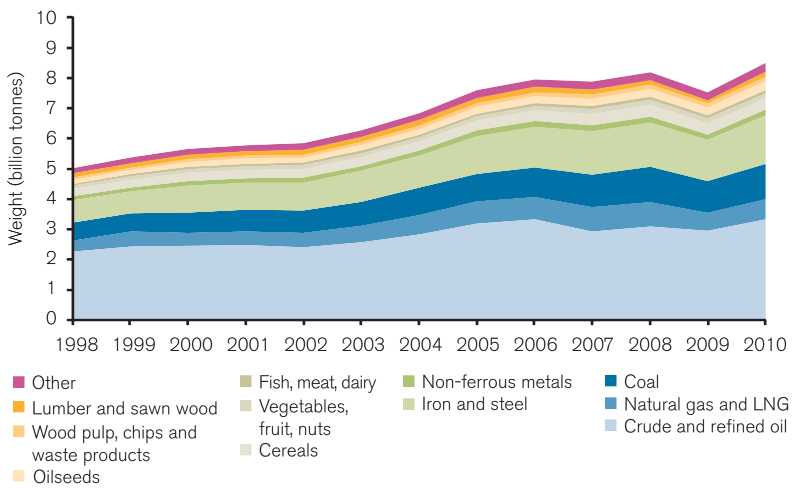
Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

Figure 2.10: Resource trade as share of global merchandise trade, by value, 1995–2010



Source: Chatham House based on data from UNCTADSTAT.

Figure 2.11: Global resource trade, by weight, 1998–2010

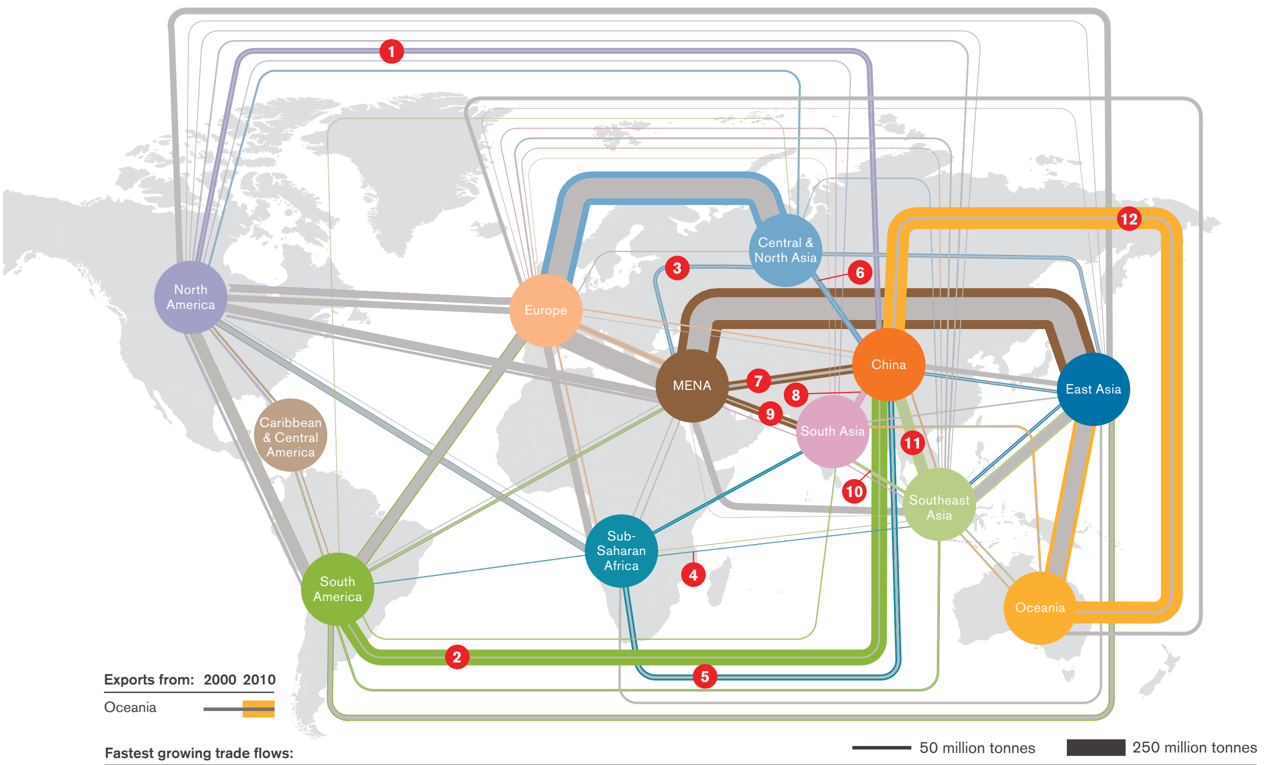


Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

It remains challenging to track and decipher the dynamics of these growing resource flows owing to the dearth of accurate bilateral trade data. To strengthen understanding of the changing trading patterns in critical resources, Chatham House compiled an extensive new dataset, covering bilateral trade in natural resources between over 200 countries and territories over the period 1998–2010 (see Annex 1).

Resource trade over long distances is increasing particularly fast. In 2010, over three-quarters of traded resources by weight (67% by value) crossed regional boundaries, up from 67% by weight (58% by value) in 2000. Trade barriers and cross-border infrastructure affect the degree of integration in different parts of the world. In Europe and North America, countries exchange a large proportion of trade with others in the region. In contrast, around 90% of African, Middle Eastern, South American and South Asian resource exports go to countries outside their region. Only in Southeast Asia is intra-regional resource trade growing significantly faster than extra-regional trade, reflecting the rapid economic integration of the region over the past decade.

Figure 2.12: Key resource trade relationships (by weight), 2000 and 2010



Fastest growing trade flows:

1. North America to China: Soybeans, forestry products, coal, copper, cotton
2. South America to China: Copper, iron ore, soybeans, crude oil
3. Central & Northern Asia to MENA: Steel, wheat, sawn wood, coal
4. Sub-Saharan Africa to South Asia: Crude oil, coal and gold
5. Sub-Saharan Africa to China: Crude oil, copper, non-ferrous and speciality metals, iron ore, coal
6. Central & Northern Asia to China: Crude oil, iron ore, coal, logs and sawn wood, non-ferrous metals
7. MENA to China: Crude oil
8. South Asia to China: Iron ore, cotton
9. MENA to South Asia: Crude oil, refined petroleum, gold, LNG
10. Southeast Asia to South Asia: Palm oil, coal, refined petroleum
11. Southeast Asia to China: Metallurgical and thermal coal, refined petroleum, palm oil
12. Oceania to China: Iron ore, metallurgical coal, non-ferrous metals

Sources: Chatham House Resource Trade Database, BACI, COMTRADE. Resource flows between regions exceeding ten million tonnes.

Figure 2.12 depicts the expansion of trade flows between world regions. The strongest interdependency stems from oil trade from the Middle East and North Africa (MENA) to East Asia. Others fast-growing flows include:

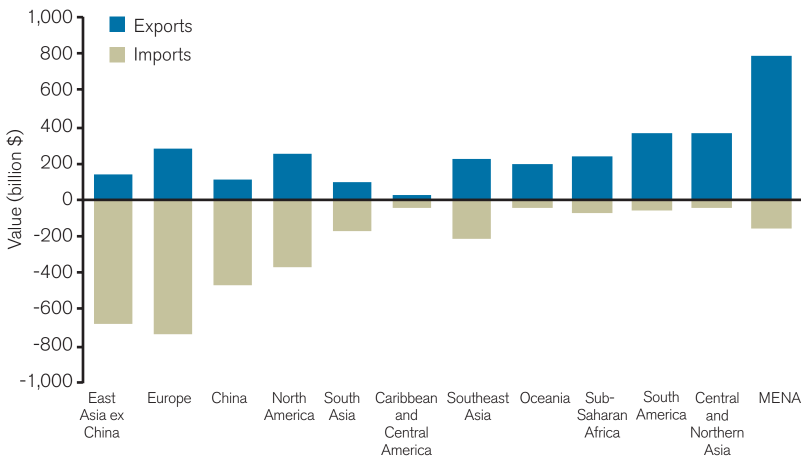
- Oil from MENA to China and India;
- Wheat from Russia and Ukraine to MENA; gas from Russia to the EU;
- Oil from Sudan and Angola to China;
- Iron ore from India and Australia to China;
- Soybeans from Argentina, Brazil and the US to China; and
- Palm oil from Malaysia and Indonesia to China, India and the EU.

The centrality of China (followed by India) is clear. The share of India and China in resource imports in 2000 was 4.9% in value terms and 5.8% in weight terms. In 2010 it was 12.4% in value terms and 19.9% in weight terms. In other words, one in five tonnes exported worldwide goes to either China or India.

2.3 Tilting eastwards?

On the back of rapid import demand growth from China, East Asia (including China, Japan, Korea and Taiwan) has now overtaken Europe as the top import region for natural resources (see Figure 2.13). Meanwhile, imports to the Middle East (MENA), Southeast Asia and South Asia are also growing rapidly.

Figure 2.13: Resource imports and exports by region in order of net exports, by value, 2010



Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

The traditional demarcation between resource importers and exporters could be misleading. Major Middle Eastern oil exporters have also become large importers of agricultural produce. The emergence of processing hubs such as Thailand – embedded in complex global supply chains – adds another layer of complication. Thailand imports large quantities of refined metals from Japan and South Korea, which produce the metals from imported ores and concentrates from South America, Australia and elsewhere. Multinationals such as car companies that use Thailand as a manufacturing hub then process a large share of these metals into products, which are subsequently exported again and sold across the region.

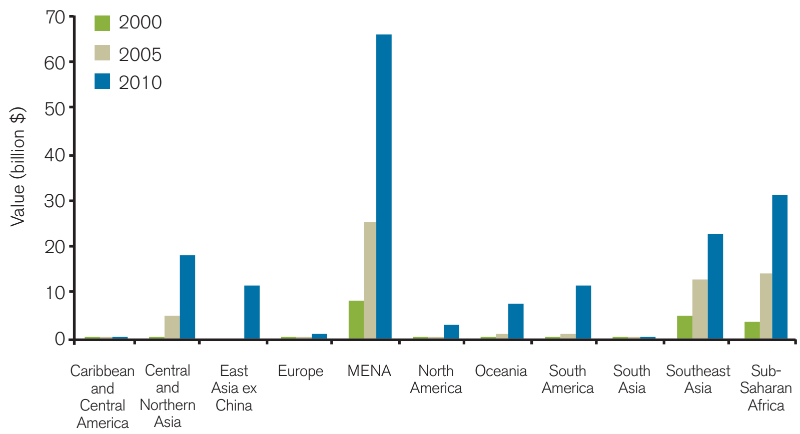
The traditional demarcation between resource importers and exporters is misleading. Processing hubs, for example, are embedded in complex global supply chains

The following sections outline how the resource consumption boom in emerging economies has redrawn patterns of trade in critical resources.

2.3.1 Energy

The share of global fossil fuel imports going to China and India more than doubled in value terms from 4.4% to 10.8% and in weight terms more than tripled from 4.5% to 14.3% between 2000 and 2010 (see Figure 2.14). Looking forward, China and India are likely to escalate their fuel imports rapidly, in the footsteps of more affluent East Asian economies such as Japan, Korea and Taiwan, as well as Europe.

Figure 2.14: Energy imports by China from other regions, by value, 2000–10



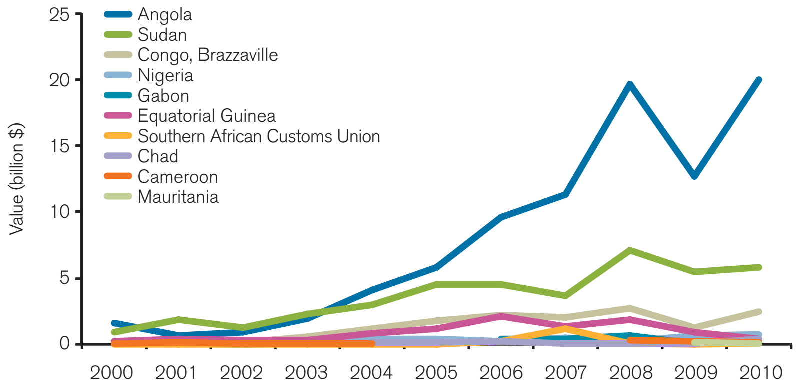
Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

Despite surging energy trade to emerging economies, the largest energy importers remain North America, Europe and the advanced economies of East Asia (Japan, South Korea and Taiwan). They account for two-thirds of global fossil fuel imports, which will, however, be likely to decline to these economies over the next twenty years, though differences in growth rates, policies affecting consumption and domestic energy production trends are likely to magnify differences in import profiles. For some, greater energy efficiency (and the economic downturn) are likely to keep energy demand growth in check, while alternative and non-conventional energy sources will play a larger role in their energy mix. The growth of domestic non-conventional and shale gas production in the US is likely to accelerate the trend to lower imports. In contrast, rapid reductions in fossil fuel imports are less likely in Europe owing to falling domestic production.

Rising fossil fuel demand in China and India will increase their geostrategic interest in the Middle East

Rising fossil fuel demand in China and India will increase their import dependencies over the next 20 years (unless domestic production of unconventional energy sources significantly exceeds current expectations). This in turn will increase their geostrategic interest in the Middle East and encourage stronger relations with other exporting regions, such as Russia and Central Asia, West and East Africa, South America and Australia (Figure 2.15 shows the growth of oil imports from sub-Saharan Africa to China).

Figure 2.15: Oil exports from sub-Saharan Africa to China, by value, 2000–10

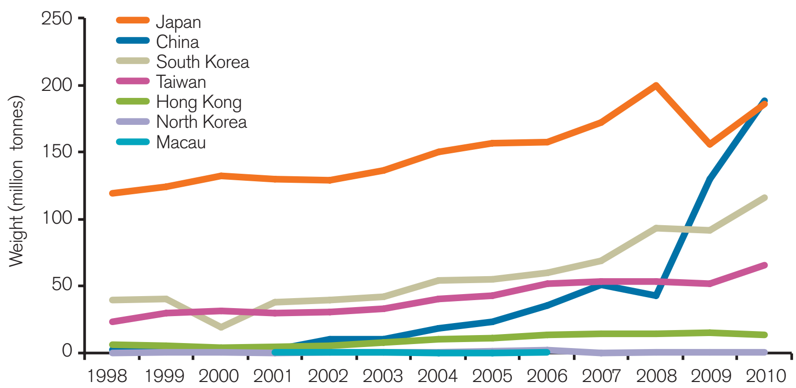


Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

These intensifying global energy ties will not only require extensive investment in producer countries (see Section 3.4) but also entail expensive and strategically vulnerable infrastructure, including pipelines, deep-sea ports, oil and gas terminals, and storage facilities. The image of 'all roads leading to China' could become a reality for energy resources with the construction of thousands of kilometres of oil and gas pipelines from Russia and South Asia and an expanded shipping fleet bringing coal, oil and liquefied natural gas (LNG) to China's ports. To meet China's ambitions in its 12th Five-Year Plan, 14 LNG terminals and 65 LNG carriers are needed by 2015, according to risk management company DNV,[59] unless negotiations with Russia for a gas pipeline reach a successful conclusion before 2014. Within a decade or less, there could be a similar convergence of routes to India.

The image of 'all roads leading to China' could become a reality with the construction of oil and gas pipelines and the expansion of shipping fleets bringing other fuels

Figure 2.16: East Asia's coal imports, 1998–2010



Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

The global coal market is also reshaped by the import profiles of China and India, the world's largest and third largest coal producers. China became a net importer of coal less than ten years ago, but overtook Japan's imports in 2010 (Figure 2.16). The government of India expects coal imports to grow by 35% between 2012 and 2017 – which would be equal to almost 20% of today's volume of international coal trade.[60] With its expected increases in coal-fired power generation, India could overtake China's volume of imports after 2020.[61] Both countries' hunger for coal will not only spur greater demand for Australian and Indonesian exports but also lead to expanding production in countries such as Mozambique, Colombia, and Vietnam. The growing availability of coal in the US, resulting from falling demand and the supply boom of shale gas, may also increase that country's coal exports to East Asia.

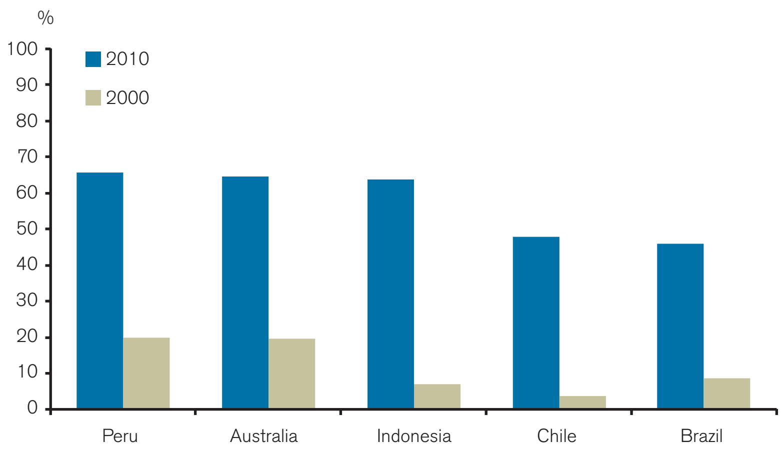
2.3.2 Metals and ores

China's growth has also reconfigured the global metals trade; the value of its metal and ore imports increased almost tenfold between 2000 and 2010 (from 17.2 billion to 171.7 billion dollars), while the weight increased nearly sevenfold (from 109.1 million tonnes to 720.9 million tonnes) (see Figure 2.17). Today, almost one in two tonnes (45%) of metals traded worldwide goes to China – more than the combined imports of the next twenty largest importers. China's import demand has pushed up international metal prices and triggered a global mining boom. Even with the largest mining industry in the world, in 2011 China produced from domestic sources only 37% of the aluminium, 29% of the iron and 26% of the copper its economy requires.[62] It is self-sufficient only in the production of a number of speciality metals, most famously rare earths.[63]

The economic fortunes of many exporting countries are tied to China's import needs

Key metals-producing countries have become increasingly dependent on exports to China – now the destination for more than half of the metals exported by Australia, Indonesia and Peru and well over a third of those from Brazil and Chile (Figure 2.17). Given the importance of the mining industry for these exporting countries – which has grown during the resource boom – their economic fortunes are becoming increasingly tied to China's import needs.

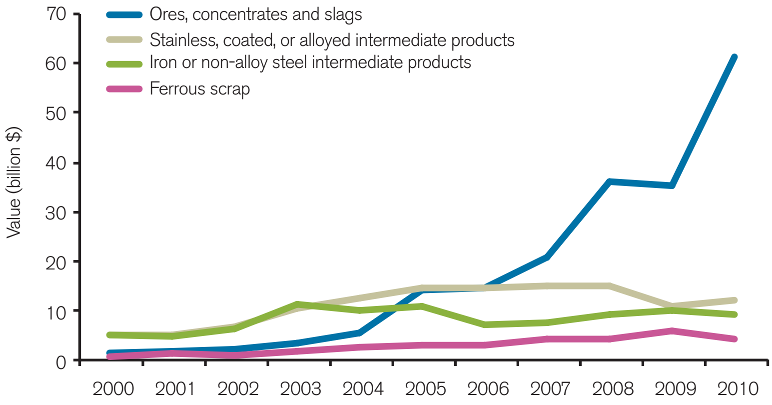
Figure 2.17: Share of mineral exports to China for selected mining countries by weight, 2000 and 2010



Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

A large and growing share of China's imports is made up of relatively cheap, unprocessed mineral ores and concentrates. The rapid build-up of its smelting and refining industry means that it can now produce intermediate goods. Steel is a typical case: China's imports of iron ore have soared since the early 2000s, but its imports of intermediate steel products are roughly the same today as they were a decade ago (Figure 2.18). While this shift up the value chain reduces China's import bill, the country has also 'imported' a significant share of the global environmental degradation associated with the metals industry.

Figure 2.18: China's imports of iron ore and steel, by value, 2000–10



Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

The emergence of new trade links between China and its suppliers has not been without friction (see Chapter 5).[64] Allegations that Rio Tinto executives had accepted bribes from Chinese steel companies during price negotiations resulted in long jail sentences and a diplomatic row with Australia.[65] The incident contributed to the breakdown of the decades-old global benchmark pricing system in iron ore markets. China is also locked into an ongoing dispute with Brazil's state-backed Vale, the world's largest iron ore producer, over a new class of 'Valemax' or 'Chinamax' dry-bulk carriers (see Section 4.5). Chinese shipping companies have successfully lobbied the central government to ban the vessels from docking in Chinese ports. Indonesia imposed an export ban on unprocessed nickel in 2012 to encourage the development of domestic refining and processing of the metal. This has hit its Chinese refiners particularly hard, as they are deeply import-dependent (over 80%) and Indonesia is China's largest supplier.

Other emerging economies are also rapidly increasing their metal imports. Thailand's metal imports have risen eightfold in value (nearly threefold in volume) over the past ten years. Turkey has become the world's fifth largest metal importer as a result of rapidly growing demand for steel scrap used in its recycling-oriented steel industry. Jindar Steel projects that India will be importing 40–50 tonnes of steel by 2020 – on current trends India will be producing about 150 million tonnes of steel at this time, while its demand will be 200 million tonnes.[66]

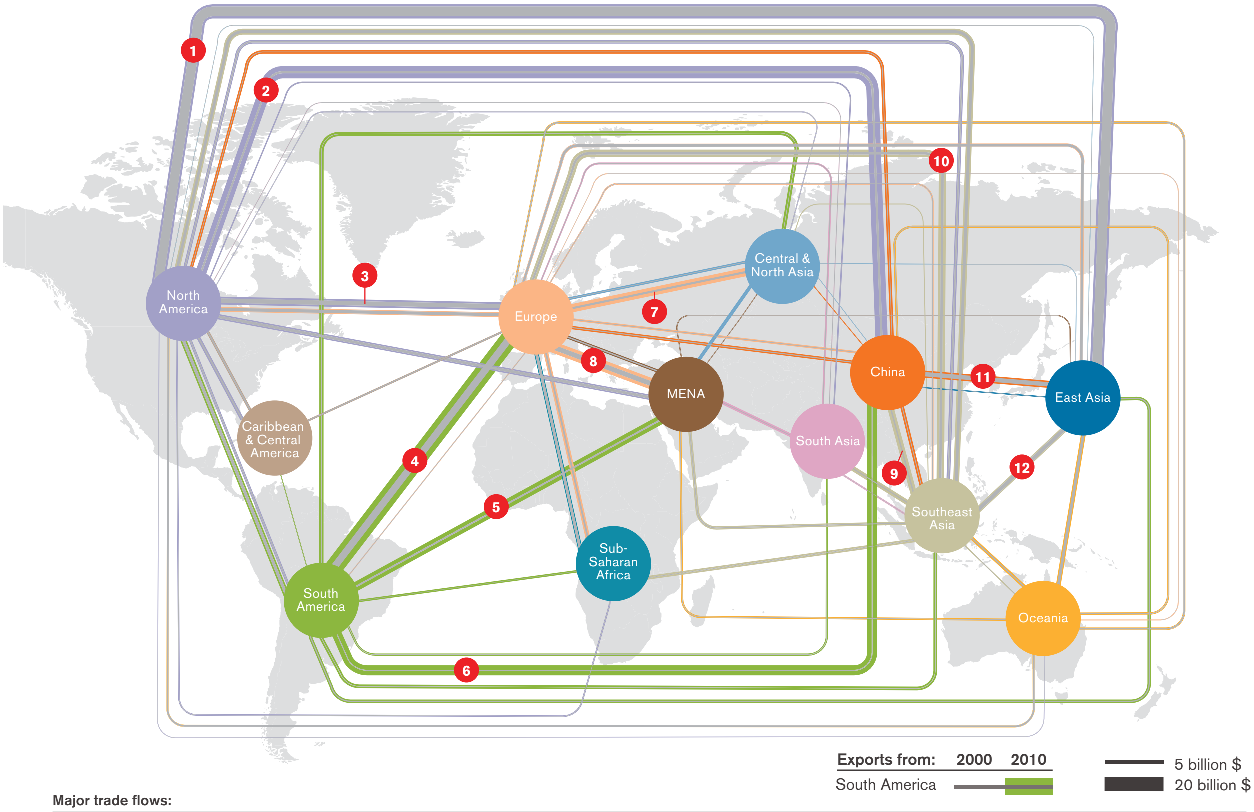
Thailand and Turkey are also rapidly increasing their metal imports

Among developed countries, Japan, South Korea and the EU's member states are also large importers, especially in the higher-value segment of global metal markets such as copper or speciality metals, rather than simple iron and steel or bauxite/alumina.

2.3.3 Agriculture

International agricultural trade has also undergone major structural changes in response to the changing consumption patterns (Figure 2.19). Underpinning this shift are the changing role of emerging economies, rapidly growing demand for meat and biofuels, as well as tightening environmental regulations and emerging geophysical constraints (such as water availability, extreme weather events and land degradation).

Figure 2.19: Snapshot of global food trade (value) in 2000 and 2010



Major trade flows:

1. North America to East Asia ex China: maize, wheat, soybeans, potatoes
2. North America to China: soybeans, meat
3. North America to Europe: nuts and fruit, soybeans and rapeseed, maize, fish
4. South America to Europe: soybeans, fruit, meat
5. South America to MENA: soybeans, cereal, meat
6. South America to China: soybeans, meat
7. Europe to Central and Northern Asia: vegetables, meat and dairy, fish
8. Europe to MENA: cereals, meat and dairy, vegetables, oilseeds
9. Southeast Asia to China: palm oil, fruit and vegetables, rice
10. Southeast Asia to Europe: palm oil, fish and seafood, vegetables and fruit
11. China to East Asia ex China: rice, fish and seafood, vegetables
12. Southeast Asia to East Asia ex China: palm oil, rice, vegetables, fish

Sources: Chatham House Resource Trade Database, BACI, COMTRADE. Regional trade flows above $1 bn.

Export growth in Southeast Asia and South America has been focused mainly on oilseeds. Brazil and Argentina have rapidly increased soybean production, mainly for export to China and Western Europe, where the protein-rich bean is used as feed in livestock industries. Between 2000 and 2010, soybean exports from Brazil to China grew over tenfold to roughly 19 million tonnes per year, worth more than $7 billion annually.

In Southeast Asia, export growth has been focused mainly on palm oil to meet rising demand in India and China, but also in Europe, the Middle East and Africa. In both regions, export growth has so far been achieved mainly through expanding the area under cultivation, making export-oriented agriculture a key driver for deforestation in the Amazons and the tropical forests of Southeast Asia.

If current trends persist, the volume trade in oilseeds and animal products will overtake that of cereal crops before the end of the decade. So far, biofuel policies have tended to favour national production and consumption (though this may be beginning to change, for example with the expiry of the US ethanol import tariff at the end of 2011). Large agricultural regions such as the US, Brazil and the EU have seen significant areas of land dedicated to the production of 'energy crops' to supply national consumption mandates. So while biofuel policy is having a significant impact on global agriculture and prices, the most important effect on agricultural *trade* has been indirect. For example, growing biofuel production has acted as a powerful drag on export growth from the US, the world's largest agricultural exporter, while the increasing diversion of European oilseeds to biodiesel production has indirectly led to higher European imports of other vegetable oils for traditional uses.

Trade in oilseeds and animal products could overtake cereals trade before the end of the decade

Looking to the future, biofuels' impact on trade is likely to grow, as governments continue to increase mandated consumption levels, and high oil prices help to keep production economically viable. Second-generation technologies, which may offer greater energy yields from biomass, are not expected to make a significant contribution to production in the next decade, so continued biofuel expansion will have significant implications for global food security.

Environmental factors and water stress are likely to transform global food trade patterns. Australia has not profited from the boom in global agricultural demand and prices – its nearly decade-long drought has constrained production. China has so far managed to sustain its self-sufficiency policy for cereals despite increasing water stress, the effects of soil erosion, and competing pressures for land use, which have reduced the amount of land available for agriculture since the late 1990s. But the country has been unable to ramp up domestic production of animal feed to satisfy its burgeoning meat demand.

Rapidly escalating water stress in MENA has left countries ever more reliant on imports. As mentioned earlier, the growing threat of aquifer depletion has led Saudi Arabia to abandon its large wheat cultivation programme, which had guaranteed self-sufficiency for nearly three decades. This leaves it precariously dependent on large-scale cereal imports, for instance from Europe and, increasingly, Russia and Central Asian countries. Import dependency is growing in other regions already facing significant food security challenges, such as South Asia and sub-Saharan Africa – regions with some of the highest population growth rates and some of the lowest per capita incomes in the world. In Africa, examples include the Democratic Republic of the Congo (DRC) and Equatorial Guinea.[67]

2.3.4 Fisheries

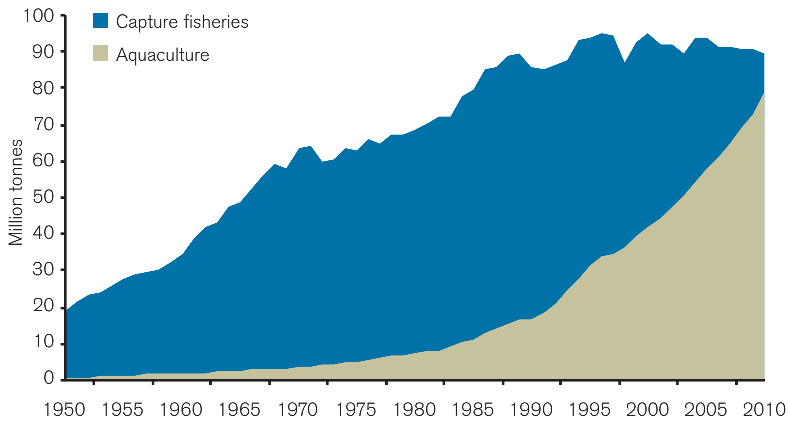
Production of wild caught fish has been largely stagnant since the mid-1980s. Just 14% of world production is thought to come from underexploited or moderately exploited stocks while the rest is fully exploited, overexploited or depleted.[68] One widely cited study predicts that all currently fished seafood will be extinct by 2048.[69] While such estimates need to be treated with some caution, the overall message is valid – fish stocks are seriously under pressure from excessive, wasteful, illegal and un- or poorly regulated fishing. Other factors such as coastal developments, pollution, invasive species and climate change are placing further stresses on inland and marine ecosystems.

Aquaculture, especially in Asia, will remain the main source of growth in global fish production

In the light of capture fisheries' performance, aquaculture has been and will remain the main source of global fish production growth. By 2020, the share of farmed fish in global production is projected to reach 45%, up from 38% in 2008–10 (Figure 2.20).[70] As a result, competition for land and water is set to become more severe. Also, as aquaculture farms expand, their vulnerability to environmental changes, climatic shocks and diseases increases. In China, for instance, aquaculture producers lost an estimated 1.7 million tonnes of their 2010 production through natural disasters, diseases and pollution.[71] Aquaculture expansion will also heighten environmental impacts, such as mangrove destruction to make way for fish farms, and the degradation of land and aquatic environments from effluent discharges and the contamination of abandoned ponds.

Asia dominates fisheries production, accounting for over two-thirds of global output in 2010.[72] Much of this comes from fish farming, which contributed almost 90% of global aquaculture production. China – the world's largest producer since 2001, ahead of Norway and Russia – generates 38% of all fisheries products and over 60% of farmed fish.

Figure 2.20: Global fisheries production, 1950–2010



Source: FAO FishStat Plus.

Asia consumes much of what it produces but alongside Europe (notably Norway) it remains a leading importer and exporter of fish. China is the largest exporter, but its share fell to 12% in 2010. In 2005, China also overtook Japan as the world's leading importer in terms of volume, importing mainly low-value fresh or frozen fish for processing and fishmeal. Thailand has also become an important fish processor in the Asian region. The main markets for high-value products are the US, Europe and Japan.

2.3.5 Timber

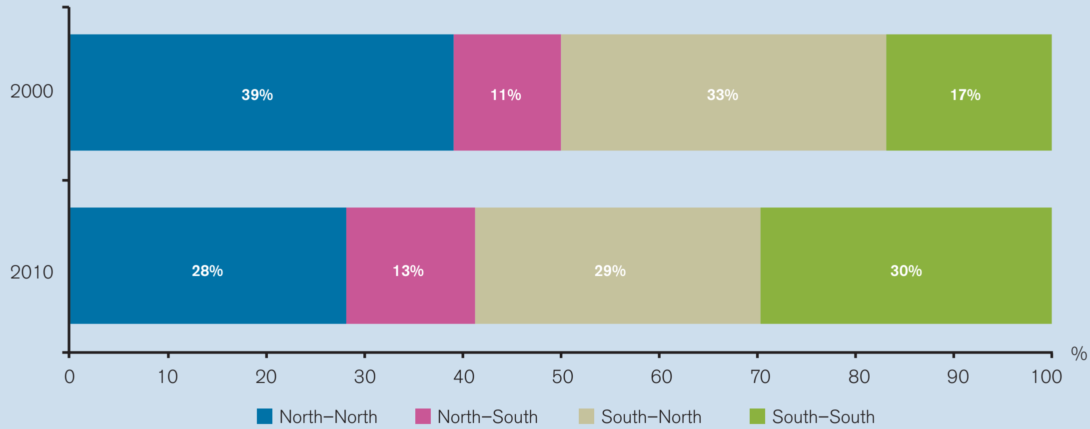
More than half of the world's forests – about 2 billion hectares (ha) – are primarily or partially used for the production of wood and non-wood forest products. Data on the latter category – plants, nuts, berries, oils and resins, mushrooms and animals harvested from the forest – are largely lacking, and its approximate global value of $18.5 billion in 2005 (compared with the value of wood of $100 billion) is certainly an under-estimate, possibly a substantial one.[73]

Box 2.3: Growth of South–South resource trade

Until the late 1990s, over 70% of trade in resources either took place among advanced economies, or consisted of cheap exports from developing countries to advanced economies (see Figure 2.21). South–South trade (i.e. trade between developing countries) made up less than 20% of global flows; the remainder (11%) comprised relatively high-value exports from advanced economies to developing countries.

Today, South–South trade constitutes around 30% of global trade in natural resources (see Figure 2.21), having overtaken South–North resource flows for the first time in 2010. The nature of North–South flows has also evolved. Emerging economies have developed sophisticated processing capabilities and infrastructure, allowing them to import large volumes of unprocessed resources from advanced economies such as Australia, the US or Canada (instead of mainly importing expensive processed products such as refined oil, alloyed steels and processed foods as they did ten years ago). Increasingly, the emerging economies are also supplying developed countries with higher-value processed resources.

Figure 2.21: The growing role of South–South trade in natural resources



Sources: Chatham House Resource Trade Database, BACI, COMTRADE.

While many poorer developing countries remain suppliers of cheap and unprocessed natural resources, these trends challenge the simplistic North–South logic that has framed international policy debates about natural resources.

Overall, timber and wood products form an important component of international trade, reaching a value of just over $600 billion in 2008, about 4% of total world merchandise trade.[74] Global timber trade doubled in the six years from 2001 to 2007. After a levelling off in 2007–09 owing to the world recession, the trade recovered strongly in 2010 and is forecast to grow further in the next decade. The bulk of the increase is due to the growth in trade in higher-value secondary-processed products – furniture, millwork (windows and doors), mouldings, etc. – and to a lesser extent in pulp and paper.

These developments are primarily due to growth in demand in China, the 'timber workshop of the world', processing raw timber into finished and semi-finished wood products for export to Japan, the EU and the US, and also for growing domestic consumption. About 70% of the Chinese demand for timber is met from domestic sources, but the remainder is imported, mainly from Russia (about two-thirds of the total) and from tropical developing countries. Since 2006 China has been the world's biggest timber importer, and it is now also the biggest exporter of furniture and other secondary-processed products; total Chinese wood product exports grew fivefold over the last ten years and experienced no downturn during the recession.

Consumption is also beginning to increase strongly in India and the Middle East. Europe has remained a major exporter of all categories, including in particular panels and paper products; total European exports doubled over the period 1999–2008. North American exports failed to show any significant increase over the same period.

2.4 Understanding new interdependencies

A decade ago, advanced economies accounted for nearly 80% of metal imports, over two-thirds of agricultural imports, and over 60% of oil imports. Today, their share of imports has dropped to less than half for metals, less than 60% for agricultural imports and to just over half for oil imports. Much of this change stems from growing imports in China, especially in the case of metals where China has become the world's largest importer, buying more than the US, Japan, Germany and South Korea combined.

Following in the footsteps of middle-income countries, low-income countries are rapidly becoming more integrated into the global economy, though they are expanding from a small base. The share of low- and lower-middle-income countries in global imports grew from 7.5% to 12.4% for agricultural goods and from 5.4% to 9.3% for metals between 2000 and 2010.

There are also many new interdependencies arising from the last decade, whether oil from MENA to China and India, wheat from Russia and Ukraine to MENA, or palm oil from Malaysia and Indonesia to China and India (see Figure 2.12).

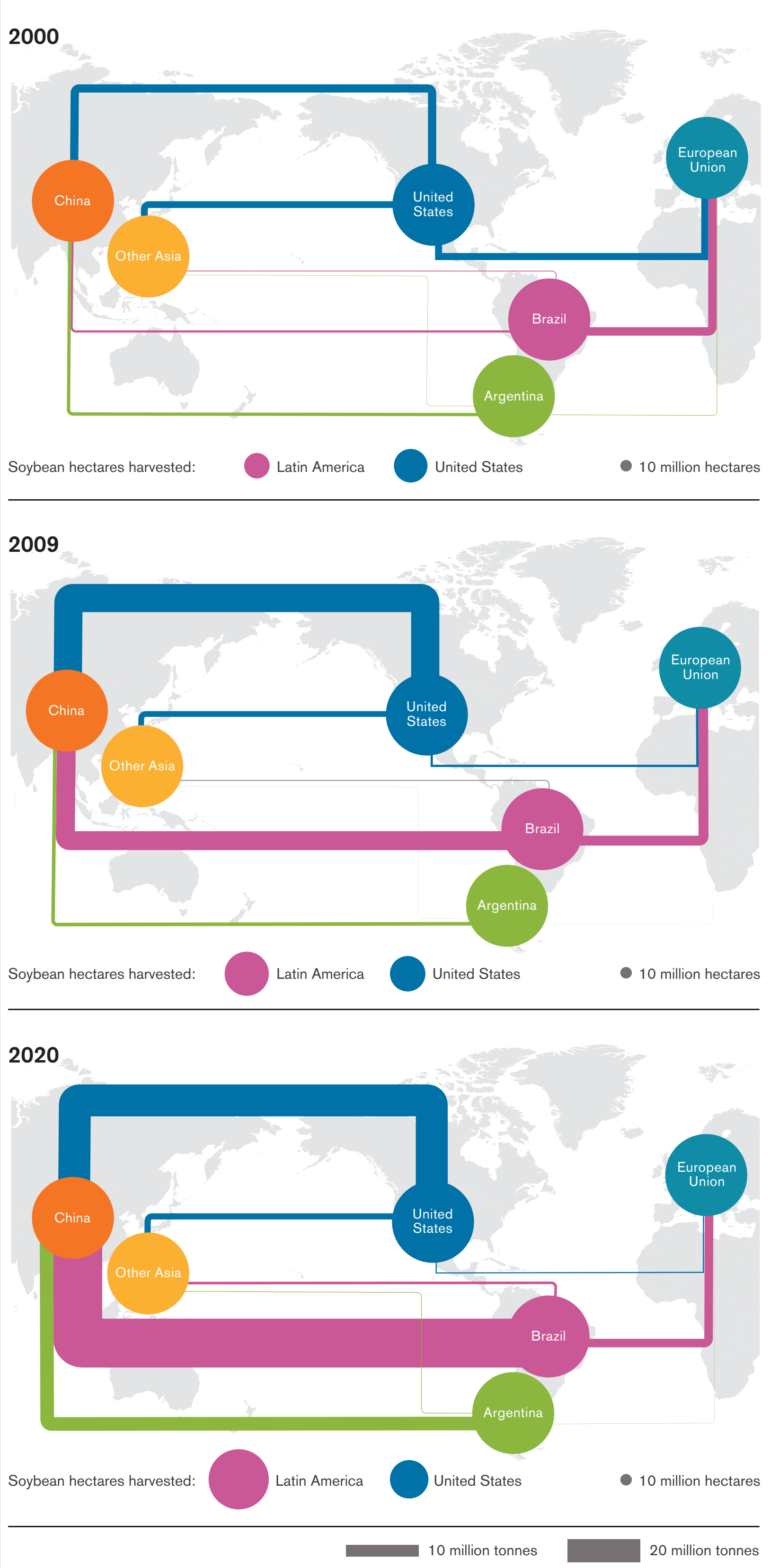
The integration of Asia into the global economy has reinforced the region's global interdependencies, but the OECD countries remain important actors and drivers of change

The integration of Asia into the global economy has reinforced the region's global interdependencies, notwithstanding growth in intra-Asian trade.[75] But the OECD countries remain important actors and drivers of change. Nearly 40% of goods produced in Asia are destined for the US, the EU and Japan. In any case, nearly 70% of intra-Asian trade comprises intermediate goods used for processing and assembly in vertical global supply chains. The collapse in demand from advanced economies can be felt throughout Asia, where the economies are particularly vulnerable to external shocks.

The case of soybeans (see Box 2.4) demonstrates how uneven consumption and production growth across the world is reshaping interdependencies. It also highlights the impact of policy choices. China is not pursuing self-sufficiency in soybeans, and there has been rapid growth in imports to meet the growing demand for animal feed and to build a strategic reserve. The implications for global soybean production and trade have been profound. Soybean markets have completely reconfigured around Chinese growth over the past 20 years. Brazil has emerged as the product's most important exporter, while the US has been slow to respond to Chinese demand owing to its strong domestic policy support for maize ethanol.

The next chapter will look at critical issues related to scaling up production to respond to changes in consumption and trade.

Box 2.4: The evolution of soybean trade



Key policy decisions

2000: Global soybean trade begins to expand beyond US–EU exchange. About 10% of US corn used to make ethanol. About 20% more land dedicated to soybeans in US compared with Latin America.

2004: US ethanol tax credit of $0.45c per gallon increases incentive for US corn production at expense of soybean.

2005: US Energy Policy Act sets Renewable Fuel Standard (RFS1) mandating 7.5 billion gallons of ethanol by 2012. Area dedicated to soybeans in Latin America grows level with US.

2006: 2-year moratorium on soybean farming in Brazilian Amazon agreed, to slow deforestation.

2007: US Energy Independence and Security Act sets RFS2, mandating 9 billion gallons of biofuels by 2008 and up to 15 billion gallons of ethanol from corn starch by 2022.

2008: Food price crisis triggers requests for US ethanol mandate to be waived. They are rejected. 35% of US corn production used to make ethanol. In the wake of the global food price crisis, China begins building a strategic soybean reserve. Moratorium on soybean farming in Brazilian Amazon extended.

2010: Moratorium on soybean farming in Brazilian Amazon extended.

2011: Ethanol accounts for 40% of US corn harvest. Ethanol blenders' tax credit expires in face of budgetary constraints.

2012: Worst US drought in 50 years sees new calls for US ethanol mandate to be waived. They are rejected.

To 2020: Area of land used for soybeans in the US remains static. US corn harvest grows by 15% compared with 2010, while 40% share for ethanol continues in order to meet the mandate. 75% more land dedicated to soybeans in Latin America than in US. Exports from Brazil and Argentina to China continue to grow.

Sources: Chatham House Resource Trade Database, BACI, COMTRADE. Additional data from USDA (2012) and Masuda and Goldsmith (2009). Shows key players in global soybean trade that collectively account for 75% of global soybean trade.[76]

3 The Coming Resources Crunch

- Reserve data for energy and metals are a flawed guide to what is available. Policy, price and technological innovation all influence what counts as a ‘proven' reserve, while poor data availability in some of the major producer countries hampers any assessment

- The future availability and price of food, energy and metal resources will be shaped by a combination of above-ground factors – including accessible reserves, transportation routes, technology and the input costs (such as water and energy) as well as the political conditions in producer and consumer countries.

- Hundreds of billions of dollars of new investment in new production are needed to meet expected demand, yet long lead times and uncertainty over future markets, investment terms and climate threaten the prospects for delivery.

- The dramatic growth of shale gas in the United States has led to global energy projections being redrawn and shows the potential impact of long-term policies to promote technology innovation and deployment on resource production. At the same time, the shift to unconventional production in energy and other resource sectors creates new environmental pressures and uncertainty for conventional resource investment.

- Large-scale resource extraction remains concentrated in a handful of countries: China, the US, Australia, Brazil, Russia, India and Indonesia, and in the EU. Most of the new production capacity has come from the emerging economies, Russia and the US.

- Africa remains a small player in global resource production – despite the attention it receives as a major destination for foreign energy and mineral resource investment and land acquisitions.

- Reducing losses and waste at the production/extraction stage could have profound implications for the availability of food and metal resources and for the resilience of developing-country economies. Yet only a small share of R&D is currently focused on this problem.

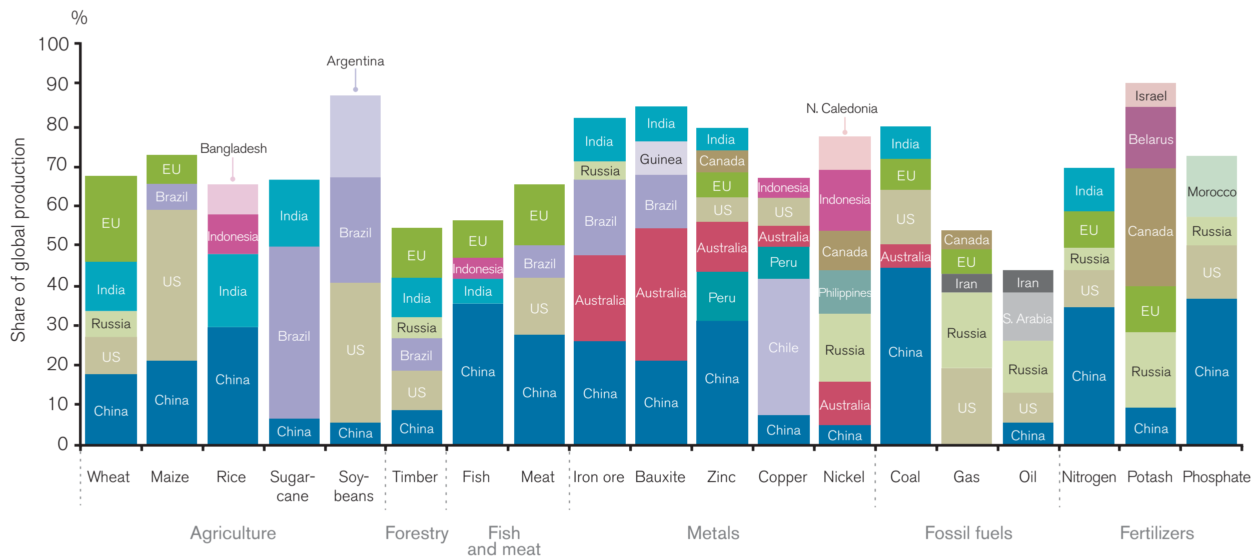
3. The Coming Resources Crunch

This chapter examines the evolving structure of global resource supply and the forces that are shaping trends in different sectors. While depletion – at least for most types of resources – is not a threat in the near to medium term, serious obstacles would have to be overcome for a continued rapid expansion.

3.1 Concentration of resource production

Large-scale resource extraction remains concentrated in a handful of countries. Across 19 resources (crops, timber, fish and meat, metals, fossil fuels and fertilizers) the three largest producers on average account for 56% of global production. Just eight players dominate the picture: China, the US, Australia, the EU, Brazil, Russia, India and Indonesia (see Figure 3.1 and Figure 3.2). Others with significant production capacities for one or two major resources include Argentina (soybeans), Thailand (sugar cane), Bangladesh (rice), Saudi Arabia (oil), Iran (oil and gas), Canada (gas, zinc and nickel), the Philippines (nickel), Peru (zinc and copper) and Chile (copper). For resources with smaller production volumes, such as palm oil or many speciality metals, the concentration among producer countries is even higher.

Figure 3.1: Major resource producers (>5% of global total in 2010)



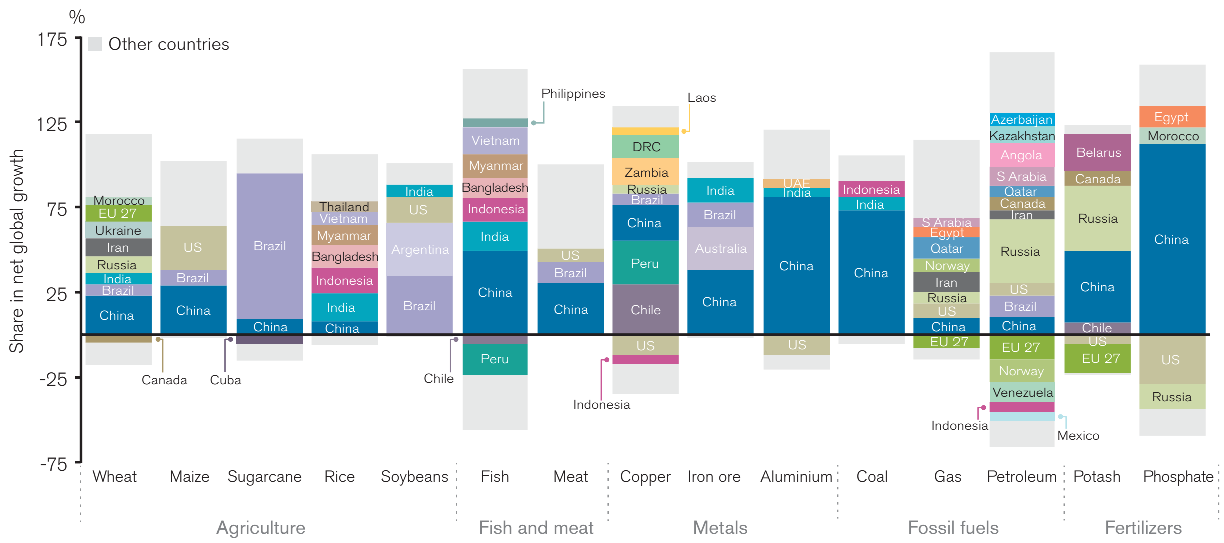
Source: Chatham House analysis of data from FAOSTAT, EIA, IFA and the USGS.

Why do so few countries dominate the global supply of resources? Size (both in terms of landmass and population) certainly plays a role. The countries mentioned above account for over half of the world's population. Unequal resource endowment (in terms of mineral reserves, fertile soils, water and climatic conditions) is also a key factor, but the largest producers need not be those with the greatest reserves. The ability to attract large-scale, long-term investments in new production depends just as much on the policy direction, governance capacity, regulatory environment and access to the global market (which is more difficult, for example, for land-locked countries), as mentioned in Chapter 1.

3.2 The emerging producers

Much of the new global production capacity has been added by emerging economies, but these additions are more diversified than on the demand side. Advanced economies such as the US or Australia have also helped expand global production of maize or iron ore, for example. Poorer countries taken as a group – including Angola for oil, the DRC, Zambia and Peru for copper and Burma (Myanmar) for rice – have also added significantly to global output (see Figure 3.2 and Table 3.1).

Figure 3.2: Major contributors to global resource production growth, 2000–10



Source: Chatham House analysis of FAO, EIA, IFA and World Steel Association data.

Although emerging economies will remain significant producers with sizeable growth, other resource-rich countries could join them over the next two decades. For all the potential agricultural productivity gains available in sub-Saharan Africa and talk of 'land grabs' (see Section 4.7.2.2), indications are that new players in terms of the major cereals and energy crops are likely to be found elsewhere – such as Eastern Europe (especially Ukraine) or South America (for instance Paraguay for soybeans). Nearly all the growth in fisheries production is to be found in Asian aquaculture. Looking beyond China and India, several smaller Asian economies (Vietnam, Burma, Bangladesh) have been experiencing double-digit growth.

Table 3.1: Major producers and new players for various resources

Resource	Major producers	Production share (%)	Annual growth (%)	Emerging producers	Production share (%)	Annual growth (%)
Maize	US	38	2	Indonesia	2	7
	China	21	5	Ukraine	1	12
	EU	7	1			
	Brazil	7	6			
Wheat	EU	21	1	Iran	2	6
	China	18	2	Brazil	1	14
	India	12	1			
	US	9	0			
	Russia	6	2			
Rice	China	28	0	Myanmar	5	5
	India	21	1	Cambodia	1	7
	Indonesia	10	3			
	Bangladesh	7	3			
	Vietnam	6	2			
Soybeans	US	34	2	Paraguay	3	10
	Brazil	26	8	Ukraine	1	75
	Argentina	20	10	Uruguay	1	39
	China	6	0			
Timber	EU	12	1	DRC	2	2
	US	10	-4	Chile	1	3
	India	10	1	Ghana	1	6
	China	9	0	Uruguay	0	8
	Brazil	8	1			
	Russia	5	1			
Aluminium	China	40	19	India	4	9
	Russia	10	2	Brazil	4	2
	Canada	7	2	UAE	3	12
	Australia	5	1	Bahrain	2	6
				Iceland	2	13
				Mozambique	1	26
Iron ore	China	26	16	Ukraine	3	3
	Australia	21	10	South Africa	3	6
	Brazil	19	5	Iran	1	8
	India	11	12	Guinea	0	n/a
	Russia	5	2			
Copper	Chile	34	2	Zambia	4	11
	Peru	8	8	DRC	2	34
	China	8	7	Brazil	1	21
	US	7	-3	Iran	2	7
	Indonesia	5	-1	Laos	1	21
	Australia	5	0	Mongolia	1	0
Crude oil	Saudi Arabia	12	1	Brazil	3	6
	Russia	12	4	Angola	2	10
	US	11	1	East Africa	–	–
	China	5	2			
	Iran	5	1			
Gas	US	19	1	China	3	13
	Russia	19	1	Saudi Arabia	3	6
	EU	6	-3	Egypt	2	13
	Canada	5	-2	East Africa	–	–
	Iran	5	9			
Coal	China	44	11	Indonesia	5	16
	US	14	0	Colombia	1	7
	India	8	5	Vietnam	1	14
	EU	7	-2	Mongolia	0	17
	Australia	6	3	Mozambique	0	9

Source: Chatham House analysis of data from FAO, IEA, EIA, IFA and the USGS (see Annex 6 for details).

For copper, countries such as Iran, Mongolia, Laos or even Afghanistan could play a growing role, in addition to expanding production in the DRC and Zambia. Colombia and Vietnam are likely to become more important coal exporters, as may Mozambique, where new world-class mines are nearing completion. West African countries are likely to emerge as a major new export region for iron ore, and production has also been growing rapidly in other countries including Iran and South Africa.

Yet joining the club of global producers is by no means assured for any country. In the energy and metals sectors in particular, many of these prospective suppliers suffer from a combination of weak infrastructure, a low-skilled workforce, water scarcity and political instability – adding up to an unfavourable investment climate. This translates into high capital costs, long lead times as well as substantial political risks, which often cause costly delays and investment disputes, further deterring potential investors (see Chapter 5).

3.3 Hitting the limits?

The future availability of food, energy, timber and metal resources (and their associated costs) will be shaped by a combination of factors – including management of reserves, the terms of investment for resource development, transportation routes, environmental considerations, technology and the input costs (such as water and energy) as well as the political conditions in producer and consumer countries alike. Reserve figures – for energy or metals, for example – are imperfect guides to what is available. Increased investment, resource prices and technological advances continually redefine what is economic to extract and therefore what counts as a 'proven' reserve, while poor data availability in some of the major energy and metals producer countries hampers any assessment.[77] The recent shale gas phenomenon illustrates the difficulty of predicting resource limits as new technologies emerge.

Ultimately, the future of natural resources will not be decided in a vacuum free of economic context, vested interests and political careers. Large sums of money are being invested in new technologies both to provide more resources for the existing infrastructure and to create new systems that could replace or compete with these. Sectors or industries will naturally try to protect their interests by gaining political support for their particular form of production over others. In this context, how much more can be extracted or produced becomes a function of who can win over the policy-makers and whether the public acquiesces.

How much more can be extracted or produced becomes a function of who can win over the policy-makers and whether the public acquiesces

Shocks rarely happen because a resource physically runs out but rather when one country hoards or prevents exports or there is a supply chain failure, whereupon others rush in to fill the gaps. In any case, near-term economic decisions rarely recognize long-term costs to society. It is the responsibility of the policy community to provide the economic and commercial context – through taxes or regulation – that will force business decisions to consider these social costs.

3.3.1 Uncertain fossil future

On the basis of available data, oil would appear the most geologically constrained of the fossil fuels. According to the IEA, production from conventional oilfields is declining at an average annual rate of over 4%. This amounts to 47 million barrels per day – the equivalent of twice the current Middle East production in the Organization of Oil-Exporting Countries (OPEC).[78] The biggest declines in production to 2035 are projected to take place in China, the UK, Norway and Russia.[79] The question is whether large reserve holders in OPEC and the former Soviet Union (FSU), and new production from unconventional and geologically challenging oil sources, can not only replace declining production elsewhere but also keep up with rising demand from the developing world. Whether they manage this feat will be a function of politics, financing and institutional capabilities in key countries including Saudi Arabia, Iran, Iraq, Russia and the US.

The IEA expects over 80% of growth in oil production between 2010 and 2035 to come from just six OPEC countries, where state oil companies play the leading role (Saudi Arabia, Iraq, Kuwait, Iran, Qatar and Abu Dhabi). The IEA's projections show that, by 2035, most of the oil produced will come from new fields – those that have been found but not developed, and those that are yet to be discovered. Among non-OPEC countries supply is forecast to come mainly from Canada (mostly oil sands), Brazil (deepwater pre-salt) and Kazakhstan (mainly the giant Kashagan field). Relatively new oil producers such as Ghana and Uganda, shale oil from the US, offshore production in some Arctic states, coal-to-liquids and increased natural gas liquids (NGLs) from gas production are also likely to add to the global hydrocarbon liquids balance, but are not of the order needed to offset the decline of conventional fields in the short term.

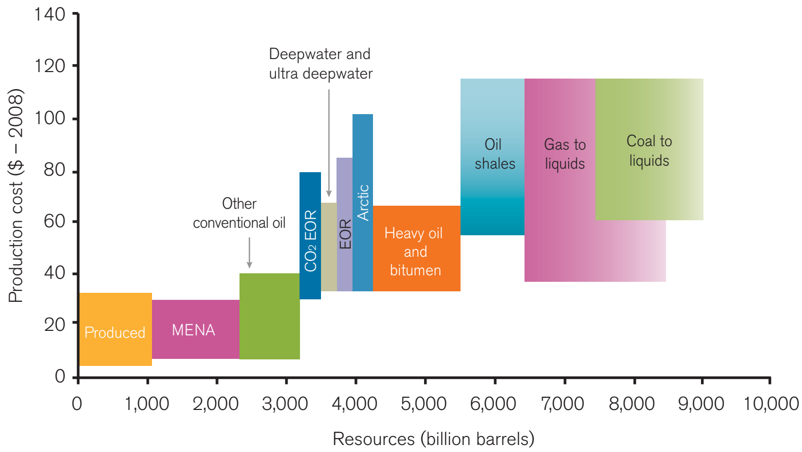
Unless demand for oil is radically reduced or replaced by alternative fuels, markets will continue to rely on Saudi Arabia and Iraq, where political turmoil persists

Rather, unless demand for oil is radically reduced or replaced by alternative fuels, the global market will continue to rely on OPEC, with the greatest expectation on Iraq and Saudi Arabia. But production and capacity to export in these countries are far from assured. Iraq, while holding the world's second largest proven conventional oil and second largest gas reserves,[80] remains in political turmoil, with the status of producing regions and the legislative environment contested. While the Kurdish Regional Government (KRG) is relatively stable and several major oil companies have signed exploration and production (E&P) contracts with it, the federal government continues to challenge the legality of these in the absence of a nationwide petroleum law.

This has led to several warnings of a supply gap for liquid fuels if new reserves are not exploited rapidly enough and OPEC cannot meet targeted capacity increases in the face of growing demand.[81] Given the combination of such projections for oil demand growth and the expectation of a continuing per barrel price of $90 or more, investment is accelerating in non-conventional liquid fossil fuels and deepwater and Arctic oil. Indeed, upstream investment in oil more than quadrupled between 2000 and 2008, although this was mainly due to higher costs of labour, exploration, construction materials and equipment.

The shifting pattern in oil supply means rising oil production costs. These vary significantly by region – lowest in the Middle East, and highest in Europe and North America – and also by type. Many resources such as oil shales, bituminous sands and the Arctic offshore oil are complex and expensive to develop in comparison with conventional fields – with prices as low as $5 per barrel in Saudi Arabia and as high as $112 per barrel for production from kerogen and coal. The potential range for less exploited resources is wide given that it is hard to predict how future costs will be influenced by the policies, technology and human capacity (see Figure 3.3).

Figure 3.3: Estimated per barrel production costs of global oil resources



Source: IEA (2008).

Meanwhile, established oil producers face the double challenge of maintaining export levels and the associated revenue stream while meeting booming domestic demand (see Box 3.1). Without significant increases in investment levels and energy efficiency improvements, several producer countries are likely to become net importers over the next 20 years.[82] This happened to Indonesia, for example, in 2004,[83] and the IEA expects Malaysia to become a net importer of oil and gas in 2017.[84] Even major producers face significant challenges – meeting growing domestic and international demand for Russian energy will require some $100 billion per year in investment in new oil, gas, coal and electricity infrastructure.[85]

With the growing variety of importers and exporters and further diversification of the energy mix, traditional consumer and producer blocs such as the IEA and OPEC will be less able to influence energy markets over the medium to long term, a development that could potentially increase price volatility.[86] As the role of OECD countries falls in relative terms, their power as rule-setters and underwriters of international fossil fuel markets may decline correspondingly.[87] Many powerful oil exporters will themselves form increasingly important energy consumer blocs whose political stances on a 'fair' price for oil will change according to their differing budgetary pressures. This was in evidence in mid-2012 as OPEC members disagreed over proposed volume increases to compensate for lost Iranian exports in the face of falling prices.[88] In future, it may inhibit their ability to stabilize markets effectively.

Keeping up with domestic and international demand on Russian energy will require $100 billion per year in investment

Box 3.1: Increasing tension between domestic demand and export dependence in oil- and gas-exporting countries

Governments in many oil- and gas-exporting countries struggle with energy waste and rapidly rising consumption encouraged by low or heavily subsidized domestic prices. Venezuela, with the lowest fuel prices in the world, is one example.[89] Producer governments are often reluctant to tackle the issue, fearing political backlash from entrenched interests and restive citizens.

The experience of Nigeria, where attempts to cut subsidies triggered a national strike and violent protests (see Section 4.7.1.1), is a cautionary tale about taking measures hastily without putting comprehensive social safety nets in place. Iran is one of the few recent examples where sudden substantial cuts to fuel subsidies have been sustained. Initial public acquiescence in fuel and electricity price rises was achieved by blanket cash hand-outs to families and a large-scale administrative strategy. Subsequent reports suggest this was inadequate in providing a safety net for the poor and compensating power providers.[90] More gradual fuel price rationalization has been achieved in China and India over the last decade.

Rapidly growing domestic energy demand could even affect Saudi Arabia's ability to maintain a cushion for the global oil market and a Chatham House study has shown that current trends could begin to affect spare capacity by 2022. [91] Saudi Aramco has warned that the country's crude export capacity would fall by about 3 million barrels per day to under 7 mb/d by 2028 unless the growth of domestic energy demand is checked.[92] Saudi Arabia, like several other countries in the MENA region with an inflexible oil- and gas-based energy mix, will need to choose between enforcing policies to rationalize fuel use and importing gas in the next decade to fulfil growing demand from the power and petrochemicals sectors, in addition to planned diversification of the energy mix.

The availability of gas from the MENA region will also be affected by this trend. For example, in spite of substantial gas reserves, domestic demand in Iran, Iraq and several GCC countries is likely to limit potential export volumes to the global market.[93]

Powerful oil exporters will form energy consumer blocs, whose political stances on prices will depend on their national budgetary pressures

3.3.1.1 New gas: golden opportunity or market distraction?

For gas, producer–consumer relations and the perceptions of future markets for different types of gas are more important than the proven and potential global reserves. While the latter seem ample, at least within a 20-year timeframe, gas is not yet a fungible resource. This means that the deals made between importers and suppliers of gas (for pipeline gas and, in some cases, LNG) and some confidence in future markets (for LNG) are crucial in bringing new supplies online. The prospect of unconventional gas changing the import balances or demand profiles of major consumers such as the EU and China – as it has done for the US – presents a risk to potential exporters of LNG in particular. Prospective investors in new LNG facilities and some pipelines will carefully track the progress of unconventional resources in their target markets. The main resource crunch concern is that caution over price destruction could deter investment and limit future availability if unconventional supplies fail.

Decisions by governments also affect the supply potential of gas *vis-à-vis* other energy sources. Many Asian governments – like those in the West – are planning to increase gas as a share of the national energy mix, but it remains uncertain how this aim will be met. For example, the Chinese government plans to triple the share of gas in the country's energy mix between 2010 and 2030. Given the lengthy negotiations over routes from Russia's Far East gasfields, it is hard to gauge how much will be politically or economically feasible via pipeline and how much China will rely on the LNG market. The rate of domestic development of coal-bed methane and shale gas will also affect this balance. Likewise, the potential gas pipelines from Bangladesh, Burma, Iran and Central Asia into India are all fraught with political difficulties.

The so-called shale gas revolution in the US in recent years has served as a reminder that production costs can fall as well as rise, with dramatic consequences for resource production and trade (see Box 3.2). The story illustrates the role of long-term government energy and investment policy in changing a country's supply mix. Advances in fracking technology were stimulated by government funding for R&D and demonstration since the 1970s.[94] Tax breaks then provided incentives for the multi-billion-dollar capital investment in shale plays.[95] The result was an abundance of cheap gas. As President Barack Obama put it in the 2012 State of the Union Address, 'It was public research dollars, over the course of 30 years, that helped develop the technologies to extract all this natural gas out of shale rock – reminding us that government support is critical in helping businesses get new energy ideas off the ground.'

This has had knock-on effects on energy resource availability and market prices more generally. It has prompted a large reduction in the share of coal in the US power sector (from 49% in 2007 to 42% in 2011), as well as in actual volumes (down 11%) as plans to increase gas imports were scrapped and coal surpluses exported.[96]

In terms of gas markets, the 'shale gas revolution' has created an oversupply of LNG and a general downward pressure on gas prices. However, the current uncertainties over how far resources will translate into actual production are having a serious impact on investment. If the shale gas hype turns into reality, then world energy markets can look forward to floating on clouds of cheap gas, at least up to 2030. If the hype remains hype, however, current investor uncertainty will limit future gas supplies. This will lead in the next five to ten years to much higher gas prices, assuming gas demand continues to increase.[97]

The prospects for cheap gas also affect the development of cleaner alternatives. Concern is growing in many importing countries including the US and the UK that the cost of relying on renewables to try to mitigate climate change is too high and likely to rise even higher. The argument is that gas provides an obvious transition fuel to a lower carbon economy, displacing coal, especially if the shale gas revolution increases supply and keeps prices low.[98] For example, in 2011 emissions of carbon dioxide (CO_2) in the US dropped to their lowest levels since 1995. Although the economic downturn will have played a role, the decline is mainly due to falling gas prices.[99] However, if this argument convinces policy-makers, then gas could well end up substituting not for coal but for renewables – and the opportunity of installing the infrastructure to create a more competitive renewables market will be delayed.

If gas continues to be seen as a transition fuel to a lower carbon economy, it could end up as a substitute not for coal but for renewables

Box 3.2: Shale gas

What is shale gas and how much is there?

Shale gas is a source of unconventional gas. Other sources include tight gas, coal-bed methane (CBM) and hydrates. Conventional gas is produced when a well is drilled and the gas flows naturally. When additional applications and techniques are required to get the gas to flow, the gas is referred to as 'unconventional'. The technologies applied to produce gas from shale rocks are horizontal drilling and hydraulic fracturing (fracking). These enable water, sand and chemicals to be pumped at very high pressure into the well bore to fracture the shale rock and allow the gas to flow. Neither technology is new; for example, the first hydraulic fracture of a well was carried out in 1947.

In 2007, the National Petroleum Council in the US estimated global technically recoverable shale resources at 16,112 trillion cubic feet (tcf), compared with proven conventional gas reserves of 6,609 tcf. In 2011, the US Energy Information Administration estimated shale gas resources for 32 countries at 6,622 tcf, compared with conventional gas reserve estimates for those countries of 1,274 tcf. While such estimates should be treated with great caution (and scepticism),[100] there is a great deal of potential to produce shale gas where the economics support it.

What has the story been on production so far?

To date, the only success story has been the 'shale gas revolution' in the United States. This revolution appears to have happened rapidly. In 2000 shale gas accounted for less than 1% of domestic US gas production and by 2011 it had reached over 20%.[101] However, although it was only after 2005–06 that there was a real impact on production, the 'revolution' had in fact been over 20 years in the making. Outside the United States, hype about an impending shale gas revolution[102] is not yet reflected in field development and production. However, shale has already had an impact on gas markets. It led to significant overcapacity[103] in global LNG. This had been expanding in anticipation of greater import demand from the US. Partly as a result, there has been a downward pressure on gas prices internationally.

What are the future prospects for shale gas production?

The future of shale hangs on two questions. Can the 'revolution' continue in the US? And can it be replicated elsewhere? Two factors could inhibit shale gas production in the US. The first is the current domestic gas price. In 2011, according to the EIA, the average wellhead price was $3.95 per thousand cubic feet and in February 2012 it was $2.46.[104] At these prices the economics of all gas operations are looking weak, a fact reflected by the collapse in the number of rigs in operation. In May this was down over 30% on an annual basis. However, assuming gas demand does not collapse, prices will rise as the reduction in drilling tightens supplies. Growing buy-in from the larger oil and gas companies, which have deeper pockets and can weather short-term cash-flow problems, should also tide the sector over a slack period.

The second factor concerns the negative environmental effects of fracking.[105] Some states have declared moratoria on fracking, awaiting the outcome of environmental impact assessments. The signs are that fracking will ultimately be given a clean bill of health,[106] not least because it is transforming the production of liquids and helping the US to achieve the long-standing national goal of 'energy independence'. One source has suggested that after 2030, 50% of domestic gas consumption will come from shale.[107]

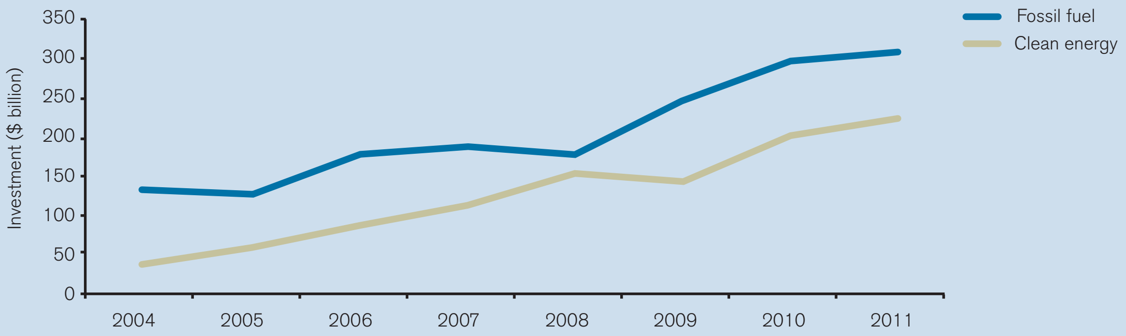
Source: Stevens (2012).[108]

Box 3.3: Will renewable energy displace fossil fuel production?

A mix of policy instruments has successfully boosted investment in renewable energy and to a lesser degree nuclear power in European countries, Japan, the US and China – this last now accounts for the lion's share of both investment and technology deployment. While global investments in fossil fuel power generation more than doubled between 2004 and 2011, investments in renewables more than quadrupled over the same period (Figure 3.4).

Renewable energy technologies will compete on cost with fossil fuels in some markets in the near to medium term. In some countries (Germany, Denmark, Italy, Spain and parts of Australia) solar power is already competitive with conventional fuel options, and by 2015 this will be the case in several other major markets including Japan, France, Brazil, Turkey and the US state of California.[109] Because of expected cost improvements, the average onshore wind farm coming online in 2016 will be competitive with fossil fuel options.[110] China aims for renewable energy to meet 15% of demand by 2020, which would avoid 1.8 billion tonnes of CO_2 emissions.[111]

Figure 3.4: Investment in renewable and fossil fuel power generation, 2004–11

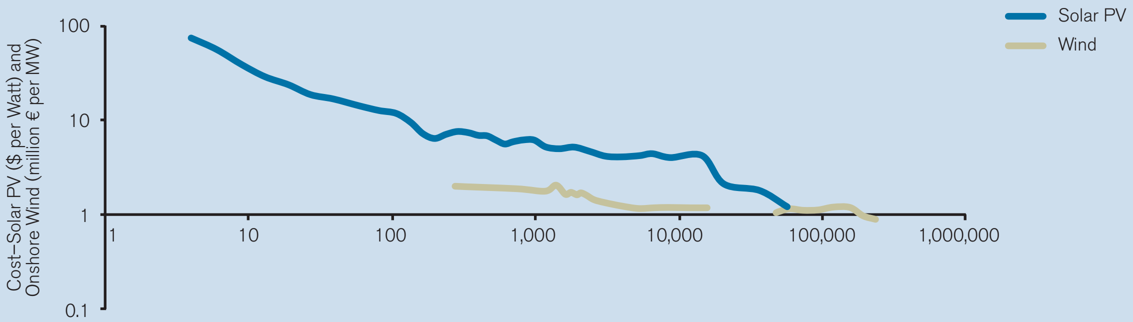


Source: Bloomberg New Energy Finance (2012). [112]

The improving competitiveness of renewables will help to reduce pressure on fossil fuel extraction as well as greenhouse gas emissions, but in the short term it creates uncertainty over both high carbon and low carbon energy investments. For relatively high-cost fossil fuel producers, there is a risk of stranded assets.

For the oil sector, the long-term uncertainty relates mainly to the use of electric vehicles (and alternative fuels such as biofuels, hydrogen and natural gas). In the short term, however, the impact will be minimal: the IEA expects sales of electric vehicles and plug-in hybrids to amount to only 400,000 vehicles in 2020, reducing oil demand by just 20,000 barrels of oil per day.[113] The fuel efficiency of oil-consuming vehicles, particularly in fast-growing markets such as China and India, will have more impact on fossil fuel demand in the short term.

Figure 3.5: Cost curves for renewable energy



Source: IPCC (2011).

The problem with mineral resources is the time taken to bring new supplies on-stream; this is often lengthened by the negotiation of terms between investor and government, fulfilment of environmental and other regulations and the contract and transit agreements involved in building pipelines. As the shale gas story illustrates, a key factor in bringing new supplies on-stream is the long-term commitment of a government to a policy promoting the development of certain fuel types or geographical areas. Yet it is difficult for governments to avoid revisiting such policies when a change in market conditions is anticipated – for example, owing to a glut of new gas production – or where there are growing concerns over the environmental impacts of extraction.

3.3.2 Land, water and agriculture

Assessing how much arable land remains is a key challenge for researchers and policy-makers

Agricultural output depends on a number of variables. The basic factors of production include land (and soil), water and fertilizers. However output is also highly dependent upon farm practices and climate. On the input side of the equation, a key challenge for researchers and policy-makers is to assess how much arable land remains. Estimates depend upon assumptions of future land use as well as value-based judgments about such issues as acceptable levels of land-use change emissions, biodiversity loss and community displacement. A recent report by the UK government on the future of farming, having reviewed the evidence, concluded that one 'should work on the assumption that there is little new land for agriculture' at the global level.[114]

Agriculture also faces increasing competition for water. Currently, it accounts for about 70% of total global water use and up to 90% in developing countries, including India.[115] By 2030, agricultural demand for water may have increased by 30%.[116] At the same time, however, there is growing demand for industrial, energy and municipal uses, particularly in poorer countries as societies urbanize and develop. This is likely to increase tensions over water both between countries that share transboundary water sources, and within countries where sectors or communities find themselves in increasing competition.

Fertilizer use, alongside new higher-yielding crop varieties and the expansion of irrigation, has underpinned the yield improvements of the green revolution but poses serious sustainability challenges. The decomposition of nitrogen-based fertilizers is one of the most significant sources of agricultural greenhouse gases – 2 Gt of CO_2 equivalent per year, according to one estimate. Fertilizer production is also energy-intensive. Ammonia accounts for 80–90% of energy use in the fertilizer industry, representing 20% of all energy used in the chemical industry.[117]

Phosphorous fertilizers are critical to long-term agricultural production. While some have argued that phosphate production could peak by 2030, recent assessments have suggested that known phosphate rock reserves could sustain current production rates for several centuries. The highly concentrated nature of inorganic fertilizer production and reserves has nevertheless raised supply security fears. Over 80% of phosphate rock reserves are in Morocco and Western Sahara, which together with the US and China control over 65% of production.[118] Similarly, 80% of potash reserves and over 50% of production are located in just two countries, Canada and Russia.

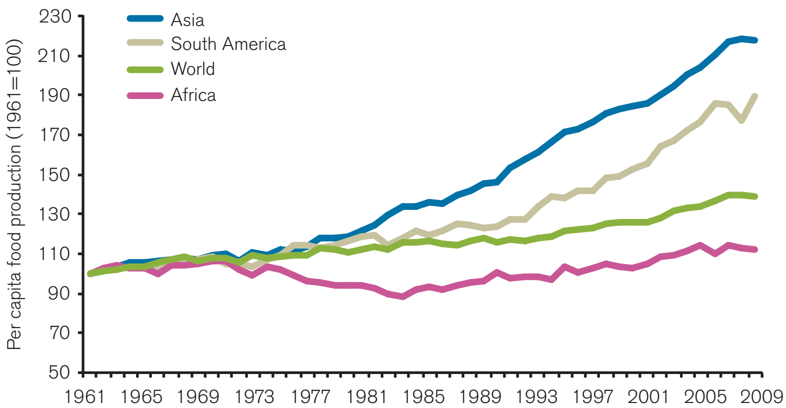
As well as being a driver of climate change, agriculture is also increasingly a victim. Rising temperatures and shifting precipitation patterns may already be reducing output: one study estimated that between 1980 and 2008, global maize and wheat production had declined by 3.8% and 5.5% respectively, compared with a reference case without climate change.[119] Meanwhile increasingly extreme weather is likely to result in more frequent and severe harvest losses. Without rapid investment in adaptation, climate change is expected to result in sharp declines in yields of key crops in many regions, with South Asia and Africa giving particular cause for concern. Maize yields in southern Africa, for example, could fall by 30% by 2030.[120]

In sum, agriculture must be radically reformed if production is to keep pace with demand, remain resilient to climate change and stay within environmental limits relating to the use of land, water and fertilizers. There are, however, significant opportunities to improve farm practices and improve water management and fertilizer application.

Agriculture must be radically reformed to keep pace with demand, remain resilient to climate change and stay within environmental limits

The biggest opportunities exist in sub-Saharan Africa, where significant yield gaps exist. Over the last half-century, notable improvements in production per capita have been achieved in Asia (200%) and South America (150%), while Africa has only recently returned to 1970s levels (Figure 3.6). Increasing agricultural productivity in Africa presents a major opportunity to boost and diversify global production, as well as to address regional poverty and enhance food security.

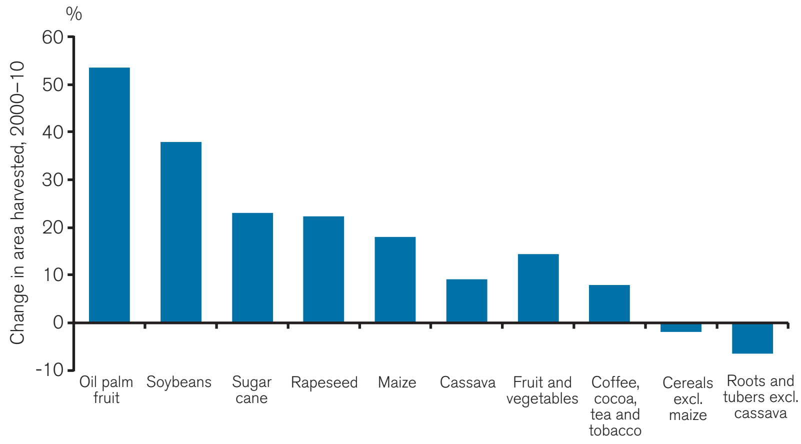
Figure 3.6: Changes in per capita agricultural production, 1961–2005



Source: Royal Society (2009).[121]

Globally, fully closing yield gaps could raise crop production by 45–70% for most major crops.[122] Much of this could be achieved simply through increasing irrigation and fertilizer use in poorly performing regions such as sub-Saharan Africa and Eastern Europe. Importantly, increasing fertilizer application in these areas can be offset by eliminating inefficient and profligate use in developed and emerging economies. One recent study found that closing yield gaps to 75% of attainable yields could increase global cereal production by 30% and could be achieved with only a 9% increase in nitrogen-based fertilizer use, assuming inefficiencies in developed and emerging economies were eliminated. For phosphates and potash, the net change would be -2% and +34% respectively.[123]

Figure 3.7: Growth in global area harvested for selected crops, 2000–10



Source: Chatham House analysis of FAO data.

The challenges of achieving this, however, should not be underestimated. It requires significant expansion of precision agriculture practices, access to high-yielding seed varieties, expanded irrigation and improved farm management practices in many countries with poor enabling environments for agricultural development, little rural infrastructure and weak governance and institutions. The overuse of fertilizers in developed and emerging economies will also need to be addressed.

Even then, the increases in output will not be sufficient to meet projected demand in the longer term. This is unlikely to be achieved with existing technologies and approaches alone, and will require further innovation. R&D for sustainable agricultural technologies represents a significant public good; however, public funding has stagnated in recent decades, particularly in developing countries where the needs are greatest. The current rates of return in excess of 40% for R&D investments in developing countries are indicative of the extent of underinvestment and scope for increasing the number of projects.[124]

In developed countries, waning public funding has led to greater reliance on private-sector R&D. This means the direction of R&D is increasingly dictated by immediate commercial interests and incremental technologies for industrial farming systems, rather than a longer-term public goods agenda. For example, post-harvest losses in developing countries (which may reach 20–30%) are not only major sources of inefficiency. They also represent the bulk of food waste, accounting for $14 billion of losses in 2007 alone.[125] Reducing losses could greatly improve the availability of food in developing countries as well as boosting poor farmers' incomes and resilience. Yet one estimate suggests only 5% of agriculture R&D is dedicated to this issue.[126]

North and South American countries continue to be the dominant producers and exporters, responsible for over 50% of global food exports. But the regional balance is shifting south, with the value of exports from Brazil and Argentina combined now equalling those from the US, up from just half of US exports a decade ago. Meanwhile, net exports from Southeast Asian countries such as Indonesia and Malaysia, and from states of the former Soviet Union, are fast catching up. They have overtaken Oceania (primarily Australia and New Zealand) as the most important export region after the Americas. Africa remains a small player in global food trade – despite the attention it receives as a major destination for land acquisitions.

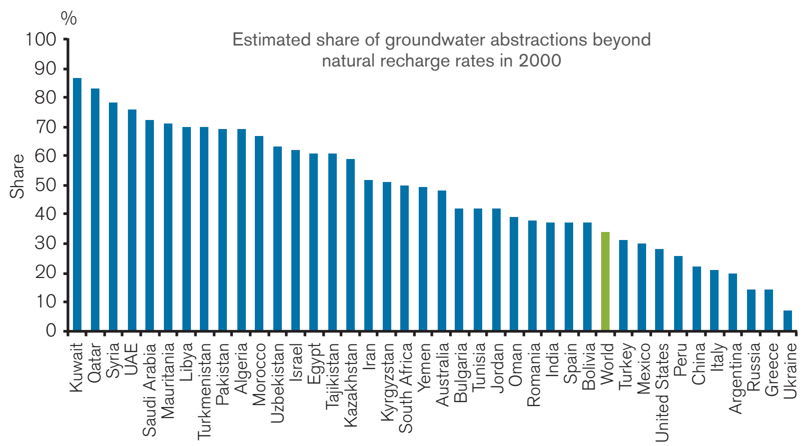
North and South America account for for 50% of global food exports, but the balance is shifting to the south of the continent

The revitalization and modernization of Soviet-era agricultural production has transformed Russia and countries of the former Soviet Union into one of the fastest-growing export regions – a more than sevenfold increase since the late 1990s.[127] This growth has mainly come from lower-value agricultural products such as wheat, barley, sunflower seeds and cotton, with the largest customers being Europe and increasingly MENA countries, as well as South Korea.

Tightening water constraints in many parts of the world are already affecting agricultural production, which, as noted above, uses around 70% of global freshwater.[128] According to UNESCO, without large-scale efficiency improvements water consumption for agriculture would have to increase by 70–90% to feed the projected world population by 2050. Some regions at greatest risk from water shortages are also significant agricultural centres: northwest India, northeast China, northeast Pakistan, California's Central Valley and the midwest of the United States.[129] Intensifying water scarcity therefore has the potential to curtail future yield growth and lead to increased incidence of crop failures, exacerbating global food insecurity and malnutrition.

Of particular concern are water-use patterns in regions that are reliant on groundwater resources to sustain large-scale irrigated agricultural production, including parts of the United States and Mexico, Saudi Arabia, Libya, Egypt, Australia, northern China, India, Pakistan and Iran. More than 50% of groundwater withdrawals from large parts of the MENA region and Central Asia come from depleting aquifers as large annual groundwater withdrawals far exceed natural recharge rates (Figure 3.8).

Figure 3.8: Reliance on non-renewable groundwater resources, 2000



Source: Chatham House based on estimates by Wada et al. (2012).

Chapter 3

Box 3.4: Desalination

Desalination technologies can produce freshwater in coastal regions but also in areas where brackish water – such as saline groundwater, drainage water and treated wastewater – is abundant. Today, the process of desalination is problematic in terms both of costs and of environmental impacts. In addition to high capital expenditure requirements and the challenge of safe disposal of brine waste, current technologies have high energy requirements, resulting in steep operational costs and large greenhouse gas emissions.

In water-stressed regions, desalinated water is becoming more competitive for urban uses – especially in countries with access to a cheap energy supply. For example, it already plays a critical role in many cities in the Middle East (especially in Saudi Arabia) and North Africa.

Desalination for the agricultural sector – responsible for two-thirds of global demand for potable water – has proved an even greater challenge, even though desalinated water is typically less damaging for soils than the direct use of brackish water. Israel is an exception: it has become the world's largest user of desalinated water in the agricultural sector. But the high costs often make it an unattractive proposition for large-scale agriculture in other countries, even for high-value crops.[130]

Today's technology is unsuitable for remote regions with no access to the electricity grid and expensive delivery costs for fuel, yet desalination facilities normally need to be located close to the point of use. Innovation is taking place to couple desalination with renewable energy sources, especially solar. The renewable energy could be integrated with the desalination plant, or renewable power generation could be used to drive a traditional desalination process. If these efforts successfully drive down costs, solar desalination could become a viable prospect for agricultural production of specific crops in some remote areas.

In India, the world's largest groundwater user, more than 60% of irrigated agriculture and 85% of drinking water supply rely on groundwater withdrawals.[131] Even as early as 2004, 29% of India's groundwater blocks were in a semi-critical, critical or overexploited condition.[132] Unsustainable groundwater use also afflicted Saudi Arabia, which abandoned its 30-year policy of large-scale irrigated wheat cultivation (in pursuit of its self-sufficiency policy) in 2008 after decades of unsustainable water withdrawals. As a result, domestic wheat production declined by over half between 2005 and 2010 and could end completely by 2016. Water scarcity in the Middle East and North Africa has also led countries in the region to ratchet up investments in desalination (see Box 3.4).

3.3.3 Metals

The global distribution of mining has been redefined in the past decade. China, seeking to meet its fast-growing domestic demand, has emerged as the most important mining country in the world. Between 2000 and 2010, it increased production of iron ore by 233%, bauxite by 293%, zinc by 150% and copper by 124%, and it is now the world's largest iron ore, zinc and tin producer, second largest bauxite producer, and third largest copper producer. Other countries – such as Australia and a number of resource-rich emerging economies including Brazil, Peru, Indonesia and India – have also experienced rapid, export-oriented growth in the mining sector.

Seeking to meet its fast-growing domestic demand, China has become the most important mining country in the world

Other key mining regions have declined in importance. Dwindling reserves and competitiveness issues in the US and Canada have led to falling North

American output for many metals, including iron ore (-15%), copper (-25%) and zinc (-16%). South Africa and Russia have also become less significant, although they still play a key global role in the supply of nickel, chromium and platinum group metals, among others.

Looking to the future, for most metals and minerals, reserve figures suggest that future availability is not in question. Rising metals prices have led to intensified exploration efforts and significant additions have been made to global proven reserves over the past decade (see Table 3.2).

Table 3.2: Production reserves and reserve ranges, 2000–10 ('000 tonnes)

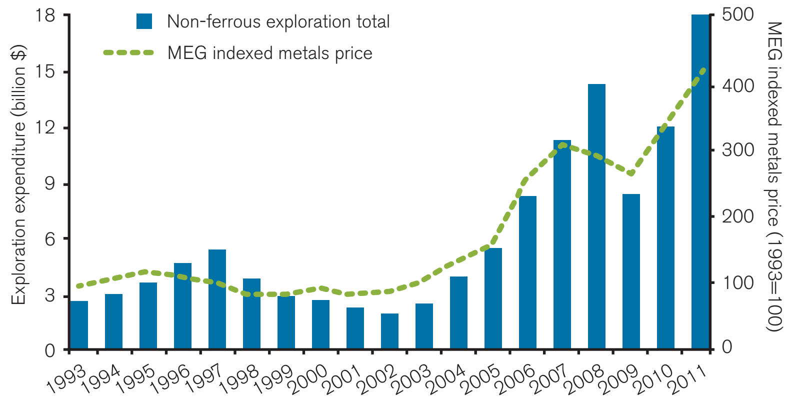
	Mine production			Reserves			Reserve ranges	
	2000	2010	Growth (%)	2000	2010	Growth (%)	2000	2010
Iron ore	1,060,000	2,590,000	144	140,000,000	170,000,000	21	132	66
Potash	25,300	33,700	33	8,400,000	9,500,000	13	332	281
Bauxite	135,000	209,000	55	24,000,000	29,000,000	21	178	139
Copper	13,200	15,900	20	340,000	690,000	103	26	43
Zinc	8,730	12,000	37	190,000	250,000	32	22	21
Nickel	1,250	1,590	27	58,000	80,000	38	46	50
REEs	84	133	59	100000	110000	10	1198	827

Source: Chatham House calculations based on USGS data.

The problem is that metal reserve figures are poor proxies for future supply. Reserve data convey only limited information about the quality of reserves, and give no indication of when, if ever, they will be mined. Despite intense exploration efforts, large-scale world-class discoveries have become less frequent (see Figure 3.9 and Figure 3.10). Copper supplies have been tight over the past decade, yet proven reserves more than doubled between 2000 and 2010. At current consumption levels, rare earth reserves would last for centuries, but the world has experienced a severe supply shock in the past few years. For bauxite, reserve ranges have been falling, while its supply growth continues.

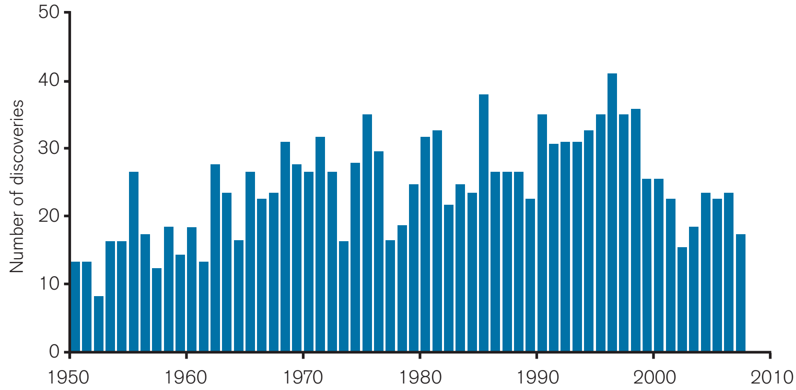
Metal reserve figures are poor proxies for future supply because they do not detail the quality of reserves or indicate when, if ever, they will be mined

Figure 3.9: Non-ferrous exploration spending and against metal price index, 1993–2011



Source: Metals Economics Group (2012).

Figure 3.10: Major discoveries of non-ferrous metals, 1950–2008



Source: MinEx (2010).

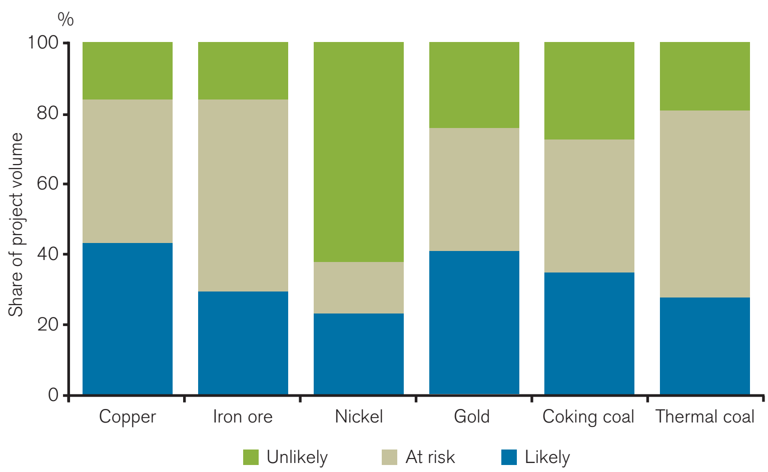
Chapter 3

Mature mining countries, such as Chile and South Africa, are struggling to maintain their output

In practice, meeting future demand for metals will depend on the successful expansion of existing mines and completion of new mining projects in a timely fashion, yet there are complex challenges in both areas. Mature mining countries such as Chile and South Africa are struggling to maintain output owing to declining ore grades, infrastructure constraints, labour unrest and limits to power and water supply. Despite tens of billions of dollars of investment over the past decade, for example, Chile's copper output has remained at roughly 5.4 million tonnes since 2004.[133] Planned investment of $80 billion over the next eight years is projected to increase the country's output by 40% until 2020,[134] but there are serious doubts about the industry's ability to meet this ambitious target.

Challenges for greenfield projects include planning processes, environmental management, inadequate infrastructure and more complex geologies. A 2011 survey of over 400 such projects found that nearly 25% were unlikely to be developed before 2020, with a further 40% at risk (see Figure 3.11).[135] Roughly half of these projects are being planned in developing regions rather than in the traditional mining countries such as Australia, Canada, the US, Chile, South Africa and Russia.

Figure 3.11: Greenfield projects, by commodity and estimated likelihood of completion



Source: Citi (2011).[136]

A decline in ore grades will affect individual metals to different extents. In iron and bauxite mining they are likely to remain relatively stable over the coming years. Zinc, lead, and particularly copper and nickel mining will be affected by declines, as will precious metals such as gold and platinum.[137] Geophysical constraints are therefore likely to be more important for the future production of these metals. Declining ore grades may lead, for example, to a substantial increase in the amount of energy and water needed to extract metals. Equally important are issues related to the 'social licence to operate', whether these stem from concerns over the environmental impacts or about the social consequences of extraction, particularly of lower-grade sources.

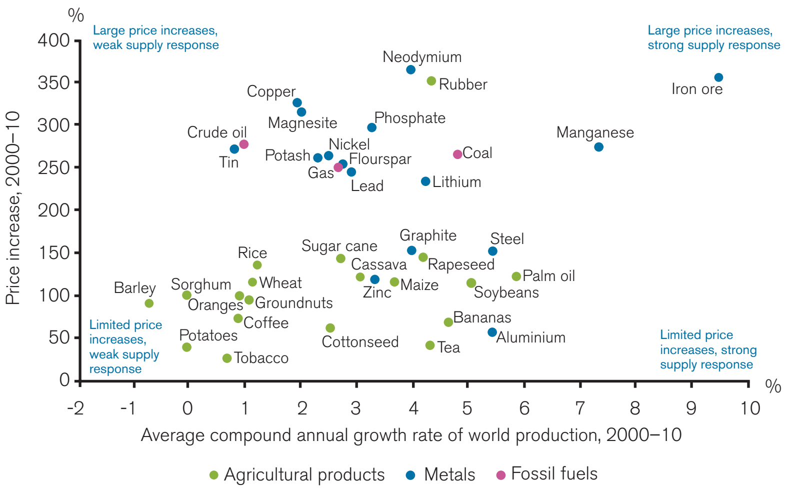
3.4 The looming investment gap

To meet expected demand, investment in production will need to climb to unprecedented levels. The FAO estimates an annual gross investment of $209 billion is needed in developing countries to keep on track with feeding the world in 2050 – roughly a 50% increase on current levels. The IEA estimates that cumulatively some $37 trillion is required for investment in energy supply infrastructure by 2035;[138] for oil supply alone $430 billion of investment every year is needed, 90% of which is in the upstream sector. For natural gas, the figure is $184 billion per year. For metals, long-term investment needs are unlikely to be considerably less than at present, even if demand from China turns out to be lower than currently anticipated. Mining investment has increased more than fourfold in the last decade, from less than $20 billion to roughly $80 billion per year. The five largest mining companies are planning to invest $200 billion over the next five years.[139]

Investment of $209 billion a year is needed in developing countries to keep on track with feeding the world in 2050, roughly 50% more than current levels

Experience over the last decade suggests that higher prices do not necessarily trigger fast production growth or response (see Figure 3.12). This is due to a complex mix of factors, from differing lead times and market structures to substitutability and varying political and environmental constraints.

Figure 3.12: Price increases and supply growth for various commodities, 2000–10



Source: Chatham House calculations (2012).[140]

Chapter 3

Because of the large capital investment required and long operating lifetimes, investment horizons in the energy and minerals sectors (especially for larger mines and processing facilities) can be as long as 40 years. This means investment decisions today will have repercussions for decades, and that stable investment frameworks are critical to encourage investment, especially if price volatility persists (see Section 4.1). Existing frameworks in producer countries (especially for unconventional energy) and demand-side policies in consuming countries make the prospects for delivering upstream investments highly uncertain in the short term.[141] In agriculture, investments by larger firms are based on a shorter (5–10-year) horizon. Millions of small investments by farmers and cooperatives will form the bulk of agricultural investments.[142] Especially in developing countries, small farms operate on even shorter investment timescales, partly owing to a lack of available credit at reasonable interest rates.

Attracting sufficient investment in sustainable resources production remains a major challenge, not least as a result of the weak governance or regulatory conditions in many resource-rich countries, the quality of infrastructure, and access to local and international markets. Agricultural development often falters because of the dearth of rural infrastructure as well as weak institutions. For other resources, unreliable power supplies and high energy costs for production and transport are serious barriers to investment. The World Bank identified a $50 billion investment gap in sub-Saharan African infrastructure, but meeting this would require a doubling of current spending levels.[143] Water availability is also likely to affect prospects for growth in many areas (see Section 4.3).

3.5 Responding to new challenges

Large emerging economies are not always aligned with the West and challenge the current international order and management of the global economy

In the past it has been possible to accommodate new and growing centres of resource demand – from Japan, Korea and Taiwan, for example. The growth seen in the last decade, however, is on a far larger scale. Moreover, any potential political implications of previous accommodations were alleviated by the countries' (relative) economic and political alignment with the West. In contrast, today's large emerging economies may view their interests differently and develop mechanisms to manage resource scarcity that challenge the existing international order and the current management of the global economy.

While the effects of resource shortages and price shocks will often be global, resilience will vary by country, and in larger countries by region. Traditional large import-dependent consumer countries within the OECD – alongside emerging consumer countries such as China – would all be affected by rising prices and supply disruption. But poorer developing countries are often far more vulnerable to resource price hikes despite being small consumers at the global level. And while producers such as Saudi Arabia may benefit from improved terms of trade for their particular exports, these same countries may be dependent on imports by others for their prosperity and stability (see Section 4.1). New risks associated with climate change and water scarcities are also reshaping the landscape for what is feasible and sustainable. These issues are explored in the next chapter.

4 Critical Uncertainties and Environmental Fault Lines

- Volatility in resource markets is likely to persist over the next decade with adverse consequences for both consumers and producers; globalized supply chains amplify the impact of local disruptions; and land and water are becoming increasingly scarce in many key regions.

- Climate change acts as a threat multiplier to resource production and trade, affecting the availability of water, food and other raw materials and – with the increased likelihood of extreme events – compromising production and transport infrastructure.

- The political and social consequences of a resource price shock are most acute where the transmission mechanism is rapid, substitution difficult and resilience low. The impact of price rises in staple foods and petroleum is more acute in poorer countries because these account for a large share of incomes.

- Escalating demands from agricultural, industrial and municipal water users will run into tight supply constraints in many parts of the world. Water rights, prices and pollution are set to become increasingly contentious and in some regions may erupt into social disruptions, political instability or open conflict.

- Trade flows between production and consumption centres are increasing, via a limited number of ports and shipping channels. A disruption to these critical routes from, for example, extreme weather events or conflict would affect prices and potentially even physical access to resources.

4. Critical Uncertainties and Environmental Fault Lines

The world's resources – whether in terms of production, consumption or trade – continue to face a wide range of critical uncertainties with the anticipation of expanding demand and potential supply bottlenecks. As recent events have shown, the rapid transmission of price increases to poorer consumers can lead to political unrest and instability, and potentially to large-scale migration. Price increases also undermine the macro-economic position of importing countries, affecting not only their stability but also their regional influence. Conversely, a price collapse can undermine the stability of countries and regions that depend on resource exports for a large share of their export income.

Countries that are resource-rich but suffer from weak governance and poor financial resilience can also be afflicted by the classic 'resource curse' – a mixture of soaring exchange rates and labour movements which dampen the prospects for other sectors of the economy (Dutch disease); increased opportunity and incentive for rent-seeking over productivity and corruption; and the income volatility that makes efficient and sustainable public spending difficult. Without effective institutions and financial instruments that stabilize windfall revenue and limit uneven wealth distribution, they can also be particularly vulnerable to the effects of a commodity price fall. In addition, there is strong evidence linking resource politics to the recurrence of civil war,[144] and of such conflict being prolonged in resource-abundant areas, with diamonds, timber, rubber and other resources being used to fund rebel groups and militias.[145]

Poorer resource countries are particularly vulnerable to shocks such as environmental disasters, political unrest, violent conflict or economic crises

Structural pressures from population growth, water scarcity, environmental degradation and climate change often intersect geographically in poor countries with fragile states and weak institutions. These multiple stress factors render countries vulnerable to different types of shocks such as environmental disasters, political unrest, violent conflict or economic crises – increasing both local and systemic risks. Such factors can create new tensions and flashpoints as well as exacerbating existing conflicts and divisions along ethnic and political lines. Rather than this being a matter of straightforward competition rising to a level of open conflict, these shocks are likely to interact with other social and political trends, often in complex ways. Recent research has pointed to the ways in which environmental scarcity and factors such as ethnic population pressures interact, finding that the probability of civil armed conflict increases across higher population levels of large minority groups as their ecological footprint increases and key resources, especially water, become scarce.[146]

Environmental factors, especially climate change, are likely to create increasing uncertainties over the patterns of production and consumption of key resources. The problems associated with the rapidly increasing consumption of resources are exacerbated and multiplied by the effects of climate change: availability of water, food and other raw materials is reduced, conflict over rapidly vanishing resources increases, and communities made vulnerable by their lack of resources face mounting environmental hazards. Water and agricultural land are already scarce in many parts of the world, and are coming under pressure from competing uses, as urbanization and industrial development continue.

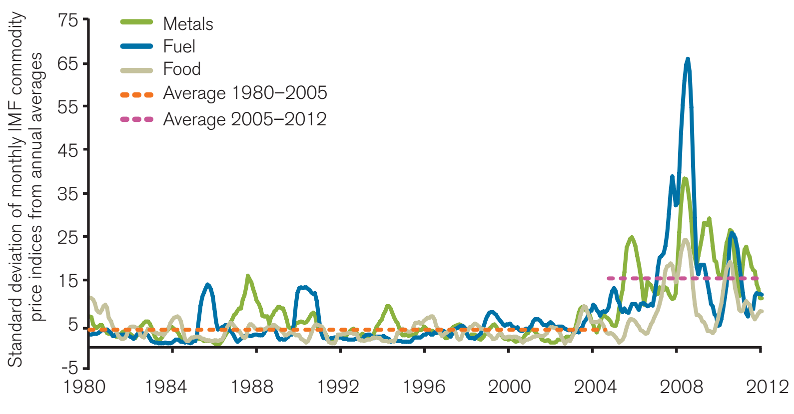
This chapter outlines some of the emerging fault lines and major uncertainties that could constrain future production, generate political instabilities or destabilize the global trading system in key producing or import-dependent states.

4.1 Volatility as the new normal

Responding to volatile resource prices is one of the most urgent – and politically sensitive – challenges confronting governments and businesses today. After a period of relatively low volatility in the 1990s, annual price volatility is now higher than at any time in the last century, with the exception of the 1970s for energy prices.[147] While brief periods of volatility are not uncommon, the sustained high levels of volatility across the commodity markets since the early 2000s mark a new trend (Figure 4.1).

Responding to volatile resource prices is one of the most urgent and politically sensitive challenges confronting governments and businesses today

Figure 4.1: Volatility in commodity markets, 1980–2012



Source: Chatham House calculations based on IMF commodity price data (see Annex 10).

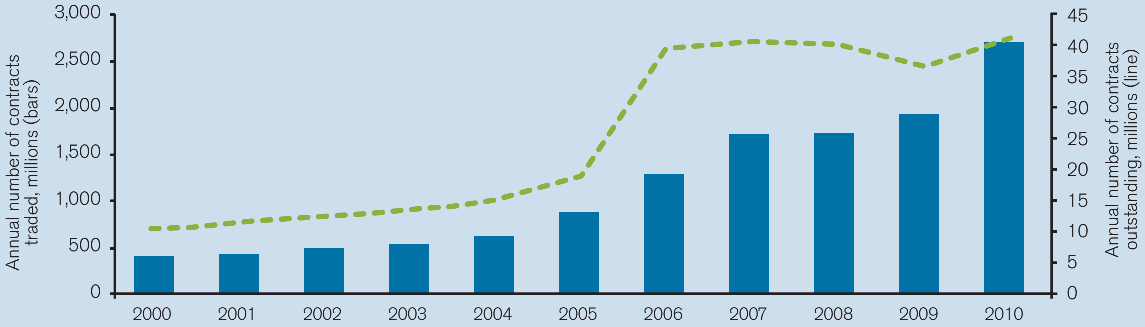
As events over the past decade have shown, short-term fluctuations can result in large costs for societies and economies, and may trigger significant domestic and international tensions and instability. Yet past attempts to minimize price fluctuations have been costly and largely unsuccessful; and in many cases they exacerbated the problem (see Chapter 5). To date, there have been no credible international policy responses, even though this area requires urgent policy innovation (see section 5.1).

Box 4.1: Why price volatility?

Experts disagree on what caused the high price volatility over the past decade. Many consider that a combination of tight supply and demand shock from emerging economies was an important contributor. Others attribute it to the higher incidence of government interventions (e.g. export restrictions) and intensified financial speculation. For agricultural products, biofuels have been blamed for faster price transmission from energy markets, and for creating a large and inelastic demand for maize or palm oil that would otherwise be consumed as staple foods.

Some question whether the increasing impact of financial investors in commodity markets contributes to excessive price volatility in physical markets.[148] Hedge funds, institutional investors, sovereign wealth funds and investment banks have increasingly taken positions in commodity markets to diversify their portfolios and gain exposure to rising commodity prices. This has led to substantial capital influx into derivative markets for natural resources (see Figure 4.2).

Figure 4.2: The evolution in commodity trading on world exchanges



Source: UNCTAD (2011).

Another question is whether new investments in derivative markets distort commodity prices. Expert opinions diverge on the extent to which these types of investments contribute significantly to excessive price volatility. For oil, the IEA argues that market fundamentals are the primary drivers behind oil price changes, though it does not rule out price-setting by financial traders as a contributing factor.[149] The reality is that it is difficult to disentangle empirically the impact of increased financial trading from the effects of low stocks and volatile demand and supply. It may also be misleading to distinguish traders focused on the underlying commodities from those investing purely for financial gain, as it is unclear whether they differ significantly in actual market behaviour in oil markets.[150]

With the contributing factors of price fluctuations remaining largely in place, volatility in resource markets is likely to persist. The drive for efficiency in just-in-time production models continues to encourage low stockholdings by market participants. Stock levels for food have also remained low as supply struggles to keep pace with demand growth. The US Department of Agriculture (USDA) predicted global pre-harvest corn stocks in 2012 to fall to the lowest levels since 1974.[151] Mounting environmental stress and continued market interventions by governments are also likely to create shocks that reinforce price volatility.

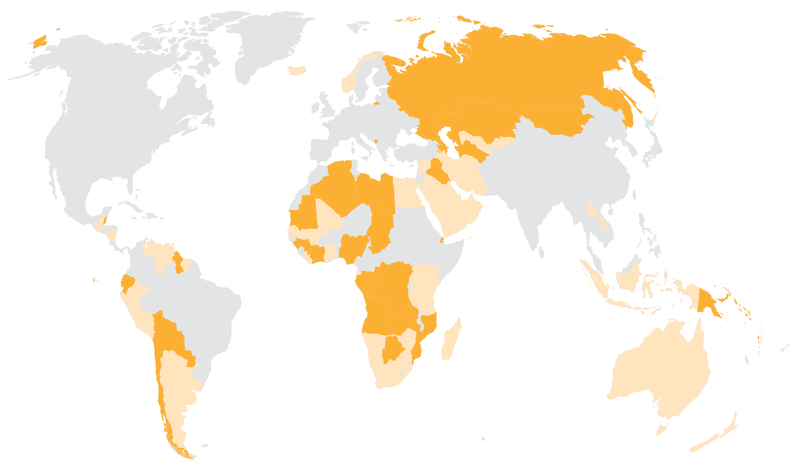
High price volatility has adverse consequences for both consumers and producers. For producers, it translates directly into fluctuation in revenues, especially for resource-dependent economies that rely mainly on the export of a limited set of resources, and this can feed into economic and political instability. Manufacturers and retailers are similarly vulnerable to short-term price volatility, which can cause sudden jumps in import bills, eat significantly into profit margins, and lead to tensions over long-term supply contracts.

For producer countries, price swings translate directly into revenue fluctuation – which can in turn cause economic and political instability

Poor populations – which spend most of their income on basic resources such as staple foods and fuel – are often particularly hard hit by strong price fluctuations. Better-off consumers tend to spend a smaller part of their income on resources[152] and typically consume them as processed products in which raw material prices amount to a small share of the product costs. At the same time, the fact that poor rural populations often largely rely on resource production for their livelihood, for instance as smallholder farmers or artisanal miners, means that international resource price fluctuations quickly feed through to their incomes. Small incomes, and lack of both savings and access to financial services also leave both poor consumers and producers with limited means to hedge against price fluctuations. Figure 4.3 highlights countries with open economies and where resources make up a large share of exports.

Short-term but frequent price fluctuations can – through indirect means – aggregate and lead to higher long-term prices and greater insecurity of global supply. Price volatility increases risk margins, which can act as a powerful deterrent to adequate long-term investment into supply – thereby translating into future resource constraints. This is a problem not only for smallholder farmers but also for extractive industries where large-scale and long-term investments require careful planning of cash flows and future revenue.

Figure 4.3: Producer countries exposed to resource price fluctuations based on openness of the economy and resource share in total exports



Exposure of resource-exporting countries to price fluctuations

- High
- Medium

Source: Chatham House analysis based on data from UNCTAD and the World Bank.[153]

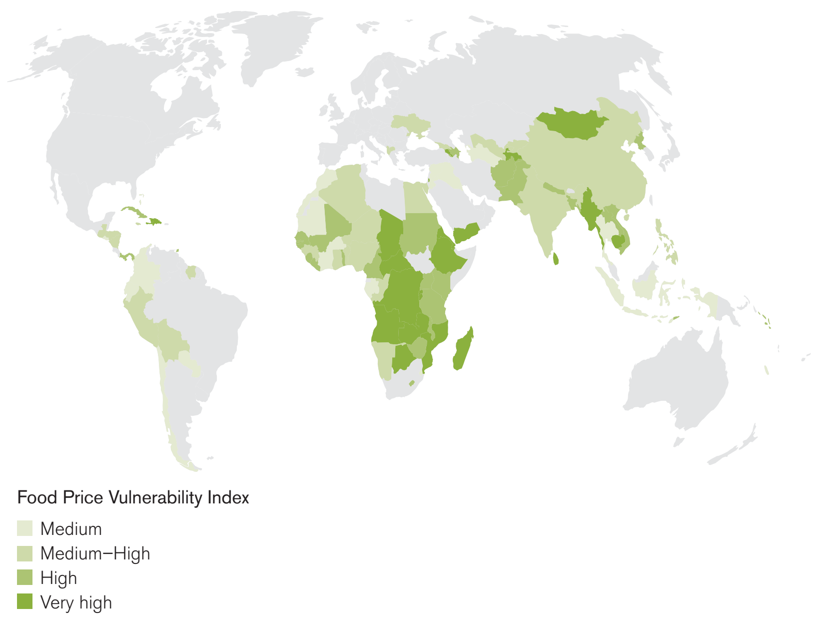
Chapter 4

Price volatility can cause trade and investment disputes as well as triggering diplomatic tensions

More immediately, price volatility can cause trade and investment disputes as well as triggering diplomatic tensions (see Chapter 5). Large price fluctuations create pressures for renegotiating (or reneging on) contracts such as revenue-sharing agreements between host governments and foreign investors or supply agreements between consumers and producers. Chinese importers of iron ore and coal, for example, have frequently been accused of defaulting on supply contracts during price slumps to negotiate lower prices on new contracts.[154] Extreme price volatility in cotton markets in India in 2011 similarly resulted in record numbers of defaults and arbitrations.[155] Price spikes also create incentives for governments to increase their tax take to capture windfall profits, increasing the likelihood of investment disputes.

Analysts have linked high wheat prices in 2011 with social unrest in North Africa and subsequently the Middle East. This region remains particularly vulnerable to high wheat prices, which are expected to remain volatile for the foreseeable future. Metrics such as food import dependency, share of income spent on food and prevalence of undernourishment are used by agencies such as the Food and Agriculture Organization (FAO) and World Bank to indicate vulnerability to price spikes. Using a combination of these, Figure 4.4 highlights countries that are particularly exposed. Those in sub-Saharan Africa and parts of Asia stand out. Both regions are already characterized by relatively high levels of social unrest and political violence[156] ranging from civil conflict (Sri Lanka, Mali, DRC) to insurgency (Naxalite rebellion in India)[157] and terrorism (Al-Shabaab in Somalia and Boko Haram in Nigeria). No set of indicators can be expected to fully reflect local political dynamics. Mexico – which does not appear on the map – is vulnerable to price rises in white maize which may spill over from yellow maize markets, where price is driven by US biofuel policy and oil prices. The 2007 Tortilla crisis demonstrated the potential for social unrest that could result from these dynamics.[158] Rapid urbanization is another factor increasing the scope for urban protest.

Figure 4.4: Vulnerability to food price spikes

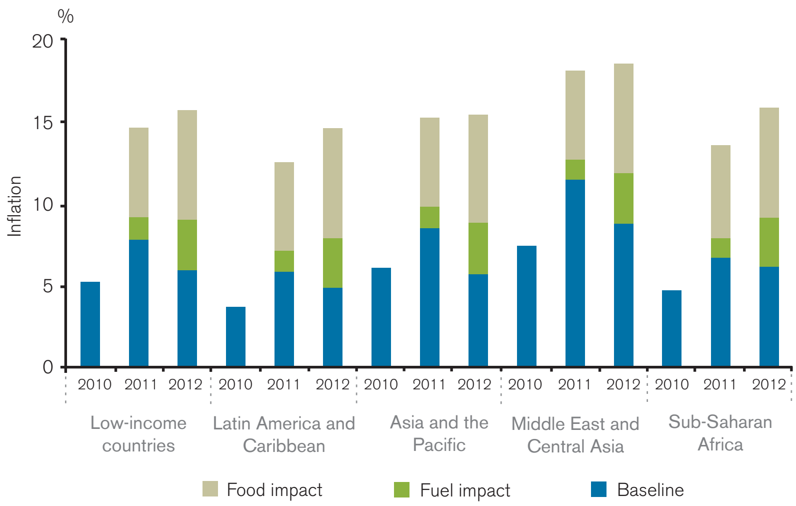


Source: Chatham House analysis – index based on data from World Bank and FAO.[159]

The political and social consequences of a resource price shock are most acute where the transmission mechanism is rapid and resilience is low – including staple foods and oil. The political uprisings across the Middle East and North Africa that began in 2010 have demonstrated the degree to which price volatility can interact with other factors to create political instability and even conflict.[160] As the World Bank has noted, these two resources pose the greatest threat to economic recovery in poor countries following the 2008 financial crisis.[161] Food and fuel together make up about 50% of consumer expenditure in low-income countries.[162] Price rises for these resources led to a doubling of inflation rates in these countries in 2011 (Figure 4.5).

Volatile prices of staple foods and oil pose the greatest threat to economic recovery in poor countries

Figure 4.5: Estimated impact of higher food and fuel prices on inflation in low-income countries



Inflation: Impact of higher commodity price in 2011 and 2012 (percentage points, median).

Source: Bredenkamp (2011).[163]

A sharp increase in energy prices would particularly afflict importing states with weak governance regimes or high inequality – India, China, Pakistan, Afghanistan, Indonesia, Ukraine and countries in sub-Saharan Africa including Kenya and Somalia. In developing countries where the market sets the energy price, a further substantial increase in oil prices can quickly lead to civil unrest. Countries that maintain artificially low consumer prices will face longer-term structural problems that will eventually make such policies unsustainable. This is especially true for countries with weaker balance sheets; yet rapid reductions in subsidies are fraught with political risk.

Oil prices also hit the transportation sector, affecting the movement of goods and, in turn, economic activity.[164] The transmission of prices in resources such as other minerals, metals and natural gas is less direct – for example, the price effect is often felt first by industry and the power sector. Mineral and metal resources therefore tend to be a lower priority for governments.[165]

4.2 Technological responses

Much of the debate about future resource scarcities hinges on assumptions about technological progress – whether innovation can keep pace with soaring demand, so that resources can be supplied at reasonable cost without causing further environmental degradation.

Technological change – from incremental improvements in performance to systemic shifts – is driven in the short term by diffusion rates and enhancements of existing technology. New discoveries and the commercialization of early-stage technologies will also affect both demand and supply in resources markets. Yet barriers to a systemic transformation abound: technological lock-ins (such as a slow timeframe in retiring ageing infrastructure); high upfront capital investment costs (as in renewables); split incentives to improve energy efficiency in buildings (such as in rental properties, where tenants pay the energy bills and the landlord has no financial incentive to invest in insulation); consumer preferences (for example, resistance to genetically modified crops in Europe); and vested interests stemming from sunk investments and the long-term revenues generated by resource extraction.

Under business-as-usual practices, inventions in the energy sector have generally taken two to three decades to reach the mass market

Technology aficionados point to the 'valley of death' – where good inventions languish with insufficient investment, because costs are too high at early stages of product development, there is an absence of suitable financing options, or knowledge exchange between research institutions and the private sector is weak.[166] Under business-as-usual practices, inventions in the energy sector have generally taken two to three decades to reach the mass market.[167] This time lag is mirrored by the time it takes for any patent to be used in a subsequent invention. In a detailed study of 57,000 patents of six energy technologies, Chatham House found a significant mismatch between the urgency of climate challenges as set out by the Intergovernmental Panel on Climate Change (IPCC) and the time taken historically for technology systems to evolve and provide a return on investment.[168] Patents analysed in the six sectors take between 19 and 30 years to be used in subsequent inventions, with an average of around 24 years.[169] In a report produced for the US National Intelligence Council, Strategic Business Insights (SBI) identified 'no near-term breakthrough technologies that would facilitate large potential new supplies of clean water'.[170]

Yet rapid systemic changes in resource markets and technologies can and do occur. The rapid growth in shale gas production in the US has shown how quickly assessments can be revised when innovation changes the cost profile of extraction. Mainstream energy-sector projections suggest that wind and solar energy will meet around 5% of global energy demand in 2050,[171] but this could be stepped up dramatically if there are unexpected breakthroughs in cost reductions or – in the case of solar photovoltaic (PV) – better integration with consumer products and construction materials.

In addition to fossil fuel prices, some of the greatest uncertainties for future oil consumption also lie on the demand side – for example, whether a breakthrough in energy storage technology could transform the prospects for electric vehicles and/or fuel cell vehicles.[172] On the supply side, the scaling up of sustainable, next-generation biofuels and the potential for a large-scale switch to natural gas in transport are further uncertainties. Dramatic changes outside the energy and resources sectors have often been pointed to as potential models – personal computing, the internet and mobile communications being the most potent examples in recent decades. There has also been a radical shift in materials and manufacturing methods used in some sectors, not least plastics and other high-performance materials.

The diffusion of technology is typically dependent on a blend of policy drivers and private-sector leadership. Government incentives for deployment such as feed-in tariffs, tax incentives, procurement policies and advance market commitments can accelerate technological learning, demonstrating the potential of new approaches and bringing down the cost of technologies so that they become commercially viable. Yet while consumers at home may benefit from cheaper goods in the long run, such mechanisms can be hard for governments to justify where manufacturing primarily takes place overseas. Germany's feed-in tariff for solar PV, for example, helped to underpin the development of China's solar industry, which now accounts for about half of global production.[173] At the same time, the scale of China's domestic market and its position as a supplier of consumer and industrial goods to international markets put it in a unique position to bring new, clean energy technologies to maturity.

For countries as much as for companies, competition for technology may become as important as the contest for raw materials. Much has been made of the fast growth in innovation capacities in emerging economies such as Brazil, China and India. They are already significant technology providers in many sectors and this trend is likely to continue in the near future. Across many sectors, however, the US, Japan and Germany have been clear leaders in technological innovation. Manufacturing in emerging economies often continues to depend on links with companies based in developed countries, for example via joint ventures, patent licences or sourcing high-tech components from abroad. In the solar PV sector, one study found that Chinese firms are emerging in subsectors of the solar industry, but few are able to offer turnkey solutions at present,[174] while another found that 'the US and Japan continue to act as the most important international knowledge sources in both the first- and new-generation solar PV industries of Taiwan, Korea, and China'.[175]

Competition for technology may become as important as the contest for raw materials

With increasingly complex technology systems and diffuse patterns of knowledge generation, cooperation between countries and countries will be crucial to the pace of technology development. Yet at present innovation cooperation is primarily a national, not an international, activity. Across six energy sectors, Chatham House research found that 1.5% of total patents are co-assigned (i.e. list more than one company or institution as co-owners);[176] and 87% of co-assigned patents result from collaboration between companies and/or institutions from the same country.[177] While there is some collaboration among OECD countries, only 2% of joint patents are shared between developed- and developing-economy companies and institutions.[178] Lack of data means it is impossible to analyse intra-company cooperation across borders.

Box 4.2: GM – magic bullet or poison pill?

The need for technologies to boost agricultural productivity, raise returns to land and water, boost resilience and reduce agriculture's environmental footprint is widely accepted. But there is less agreement on the right technologies for achieving this, and nowhere is agreement more divided than on the issue of genetic modification (GM) – the process by which a gene of potential utility is incorporated into the DNA of a plant in the hope that the resultant genetically modified crop will express the useful trait. Essentially, GM represents an advance on conventional plant breeding, by both speeding up the process and potentially allowing for traits that might otherwise be unattainable.

In this sense, the possibilities for GM are huge, and it is often presented by its proponents as something of a magic bullet, with the potential to raise yields, reduce input use and increase tolerance to drought. On the other hand, opponents of GM argue that the technology may present serious risks to human and animal health, that there could be huge environmental consequences if modified genetic material flows from GM crops into other varieties, and that ultimately GM provides little more than a means for large corporations to control technology and exploit farmers. In some countries, the opponents of GM have been remarkably successful. Major restrictions on the use of GM crops exist within Europe in particular, and consumer distrust of the technology means retailers are reluctant to sell products containing GM ingredients.

The reality almost certainly lies somewhere between these two opposing views. While there are without doubt risks associated with GM, these have been successfully managed. People have been eating GM foods for 15 years with no apparent consequences. A recent academic review of the evidence concluded that commercial GM crops 'are at least as safe in terms of food safety as those produced by conventional methods'.[179] The risks posed by modified genetic material leaking into other varieties are more troubling – if, say, the result is a pest-resistant weed. In developed countries strict regulatory processes demand exhaustive trials to assess any risks before GM crops are commercialized. In poor countries, where the capacity, resources and institutions may be lacking, risk management is likely to be more difficult, and many have simply resorted to stringent liability laws, the impact of which is to make the production of GM crops almost impossible. Nevertheless, global use of GM crops continues to grow. In 2011 it was estimated that 16.7 million farmers were growing GM crops across 160 million hectares in 29 countries, largely outside Europe and sub-Saharan Africa.[180]

While GM has the potential, alongside other technologies, to make a significant contribution to the sustainable intensification of agriculture, much of its promise remains unfulfilled. The focus has been on technologies to reduce production costs for large farms in advanced agricultural sectors, because this is where companies have seen the biggest commercial opportunities. Associated yield increases have been due to better control of pest and weeds and from the incorporation of high-yielding traits through conventional breeding techniques, not the insertion of high-productivity genes.[181]

For GM to fulfil its potential, efforts need to be focused more sharply on the global challenges that agriculture faces: the need to increase productivity, strengthen resilience to climate change and reduce the environmental footprint. A greater emphasis on developing-country agriculture is also needed; this is where the biggest opportunities and greatest needs exist. All this implies a larger role for governments: to fund the creation of public goods and ensure that appropriate technologies – not limited to GM – are developed for, and made available to, farmers in developing countries. Support to establish appropriate regulatory regimes in poor countries will also be necessary, if environmental risks are to be appropriately managed and excessive liability terms reduced.

In addition to hardware, it is critical not to overlook the gains to be achieved through 'soft' practices and knowledge, such as natural resource accounting, monitoring, tracking and mapping systems and optimization of manufacturing processes. Compared with the deployment of capital-intensive technologies, these soft practices and systems have different barriers to implementation and pose different questions regarding intellectual property rights. Yet they are also closely connected with the use of hardware – for example, managing grid connections for renewable energy and identifying fossil fuel reserves in complex geology. Information technologies have also enabled new types of innovation, from crowdsourced data collection to open platforms and collaborative design.

New technologies can raise new material, environmental and security risks related to their use and manufacture. Public perceptions of the risk often focus on health and safety – for example the risks related to genetically modified food or the impact of fracking on water quality. Of particular concern are the knock-on consequences for water, land and greenhouse gas emissions. In terms of resilience, the risks are also shaped by the availability and cost of practical alternatives (both materials and technologies) and by the degree of confidence over long-term access. A switch to electric vehicles, for example, would reduce oil consumption but increase demand for electricity as well as lithium for batteries – at least until a preferred material is found. Concern over rare earth metals arises from their importance for a range of high-tech applications as well as the concentration of extraction in a single country – China. In some cases equipment, materials or fuels raise security concerns because of their dual-use capabilities. Smarter systems for resource management and tracking also generate new risks, not least including those posed by cyber security and the cascade effects of interconnected systems.

New technologies can raise new material, environmental and security risks related to their use and manufacture

4.3 Water scarcity

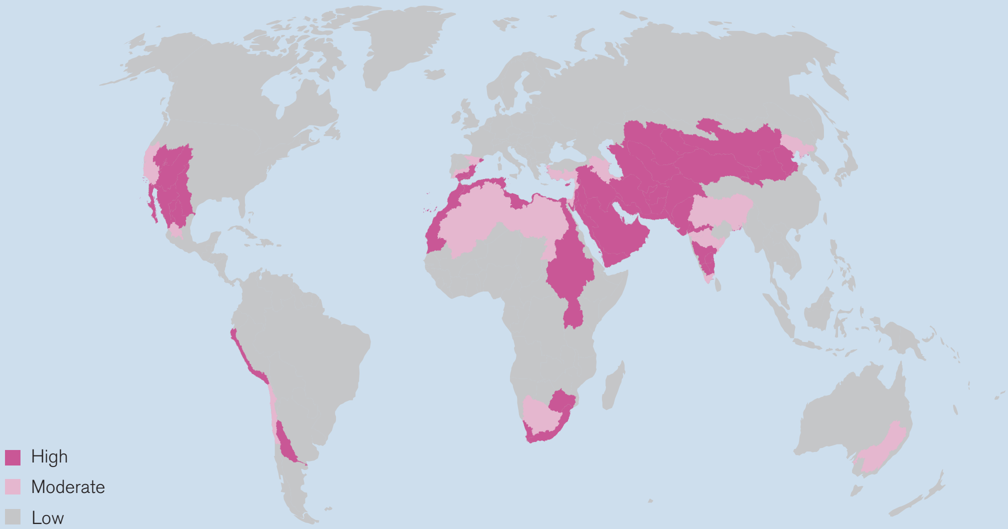
Freshwater scarcity presents one of the most pressing cross-cutting challenges for our resources futures. While global water withdrawals have tripled in the last 50 years, the reliable supply of water has stayed relatively constant during the same period.[182] According to the Water Resources Group's 2030 scenarios, global demand for water already exceeds sustainable supply, and unsustainable water withdrawals from non-renewable aquifers are coupled with unreliable availability in many places. Water demand could be as much as 40% higher than supply by 2030.[183]

There is, however, great geographical variation, with sufficiency depending on local conditions, quality and delivery mechanisms. Future ability to meet the demands of growing societies and competing extractives and industrial sectors depends on whether countries can put in place effective systems to capture, produce, treat and distribute water, as well as demand management strategies and/or cross-boundary water-sharing agreements. The supply gap is already severe in many developing countries and countries in transition, some of which have the least capacity to put in place the necessary governance and infrastructure.[184]

Box 4.3: The most water-scarce regions

The Middle East and North Africa, Central Asia, western India and northern China are particularly affected by water stress, as are the western Great Plains and parts of the west coast of the US, parts of the Andes in South America, South Africa and Southeast Australia.[185] Many of these areas are densely populated: an estimated 80% of the world's population currently live in areas with high levels of threat to water security (Figure 4.6).[186]

Figure 4.6: Global distribution of physical water scarcity



Source: FAO (2011).

If efficiency improvements and the expansion of water supply continue at historical rates, this would fill less than half of the projected gap, leaving huge numbers of people dangerously exposed to water scarcity. By 2050, three-quarters of the world's population could face acute freshwater scarcity. The situation is particularly challenging in the Middle East where 5% of the world's population are sharing less than 1% of the world's renewable freshwater resources. Water availability in the region is projected to be halved by 2050, with the potential for acute shortages as early as 2025.[187]

While there are some grounds for optimism in terms of the ability of existing water management arrangements (including treaties) in the region to prevent major conflicts over water,[188] the extreme nature of the projected shortages towards the middle of the century will increase the pressures on institutions and conflict resolution mechanisms. It is not only the likelihood of increasing water scarcity creating new tensions between riparian states over shared rivers in the region[189] – Turkey, Syria and Iraq all depend on the Tigris-Euphrates basin, for example – that gives cause for concern, but also the impact which increasing scarcity will have on existing conflicts such as in Israel and the occupied Palestinian territories.[190]

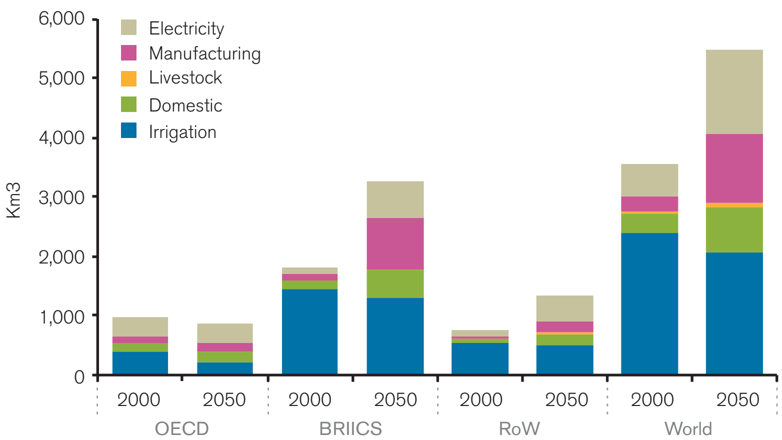
Water demand for global resource production is growing rapidly, as a result of both the overall increase in the volume of resources required to meet global needs, and the mounting water intensity of resource production systems themselves. This is due in part to changing consumption profiles. In particular, water-intense dairy produce and meat are increasingly replacing relatively water-efficient cereals in the diets of more urbanized and affluent consumers in emerging economies. There are large differences in water requirements for growing various types of crops and farming meat, as there are for producing different types of energy or metals.[191]

These differences are further amplified through differences in the water footprint of different types of production technologies – for agriculture, mineral extraction and energy production. Aquastat suggest that 723 km^3 of water currently used in industrial processes (representing 35% of water use globally in the industrial sector) is used in the mining, transport, processing or transforming of energy,[192] and this figure is set to increase steadily. Many resource production methods are becoming increasingly water-intensive as resources diversify, from non-conventional fossil fuels (shale gas and tar sands) to biofuels. A growing share of energy and mineral demand is also met by lower-quality mineral resources, such as heavy oils and low-grade metal ores, which tend to require much larger quantities of water in the extraction and processing stages.

Looking forward, competition for water between different types of resource sectors (e.g. agriculture versus extractive industries) is likely to escalate, as will competition between resource production and other societal uses. Agriculture may increasingly compete with cities for land and water use. Similarly, mining and refining operations may compete with other types of industries and urban centres for limited availability of electricity. Cities and industries in developing countries in the process of urbanization and industrialization are experiencing growth in water consumption; this trend is expected to continue until at least 2030, whereas water demand for these uses is relatively flat in developed countries (Figure 4.7).

Competition for water resources is likely to escalate, as will competition between resource production and other societal uses

Figure 4.7: Global water demand projections – OECD, BRIICS and developing countries



Source: OECD (2012).[193]

Municipal and industrial thirst for water, and the use of land for urbanization pose a threat to future food production and to rural communities.[194] Some of those regions most at risk of water shortages are also globally important agricultural centres, as discussed in Section 3.3.2.[195] Apart from countries with strong food self-sufficiency policies, developing-country governments often prioritize higher-value-added industries and urban regions over agriculture when it comes to land and water allocation and planning decisions.

Localized environmental degradation interacts with climate change to present a major challenge to food production

Similarly, in countries with weak environmental regulations there is a risk of over-extraction of water, damaging river ecosystems. The volume of water required to maintain environmental quality can be half of the total annual run-off in a river basin.[196] Localized environmental degradation (aquifer depletion, declines in soil quality, reductions in biodiversity) interacts with climate change to present a major challenge to food production and to other competing uses of water. For example, the water use and pollution of the largely unregulated Mongolian gold rush of the last two decades have exacerbated severe droughts in the country, with a devastating impact on herds and traditional livelihoods.

With intensifying local competition, the availability of and access to water have become critical determinants for investment and production decisions in extractive industries. In water-scarce regions, the large local water footprint of projects such as coal mining will lead to tensions with local communities, necessitate the transport of additional water resources over long distances or demand extensive treatment of water resources at the project site.

Water and power service provision will be increasingly interdependent. By 2050, water consumption to generate electricity is forecast to more than double.[197] The effects of water stress will be felt most directly in the hydropower sector – making the power supply in some hydro-dependent regions in Latin America, South Asia and sub-Saharan Africa especially vulnerable.[198] Nuclear and thermal power stations are indirectly reliant on water – for coolant systems – as is a wide range of manufacturing industries. Power is also an increasing factor in water security as several water-constrained regions will rely increasingly on pumps to extract groundwater and for desalination.

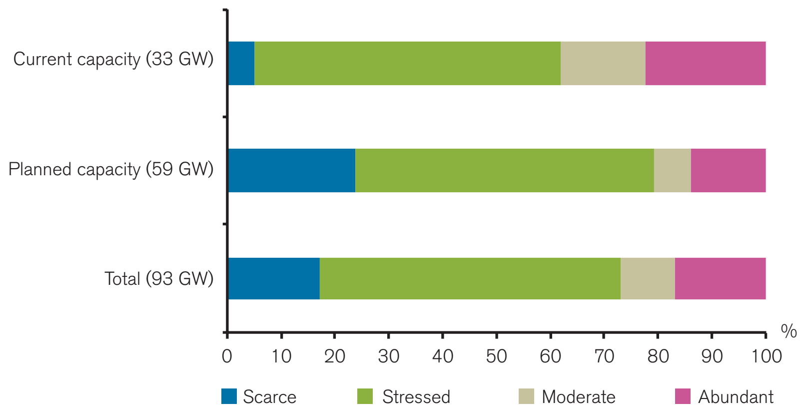
Major heat waves and droughts can also significantly affect water and energy security. They reduce the energy supply from hydropower and can force shutdowns of water-cooled thermal power stations and nuclear plants. A major drought in 2001 in Brazil – where 80% of electricity is derived from hydropower – reduced power supplies in the country by 20% and forced the government to introduce rationing. Nuclear plants have been shut in the US and Europe in the last few years when environmental regulations forbade the return of heated water to local rivers during unusually high summer temperatures. The Ethiopian economy is also particularly vulnerable to droughts, given its high dependence on agriculture as well as hydropower for its electricity.[199]

Water availability and price will be a critical determinant for decisions on where to invest and where to produce. For example, analysis by the World

Resources Institute found that 80% of existing and planned power plants in India are located in water-stressed areas (see Figure 4.8). For China, Bloomberg New Energy Finance estimated that 83.9 billion cubic metres of water were used in coal mining and washing, coal power production and coal-to-liquids in 2010 – about 60% of China's industrial water demand. Between 2010 and 2020, coal-related water withdrawals will account for 45% of industrial water demand growth.[200]

Water availability and price will be a critical determinant for decisions on where to invest and where to produce

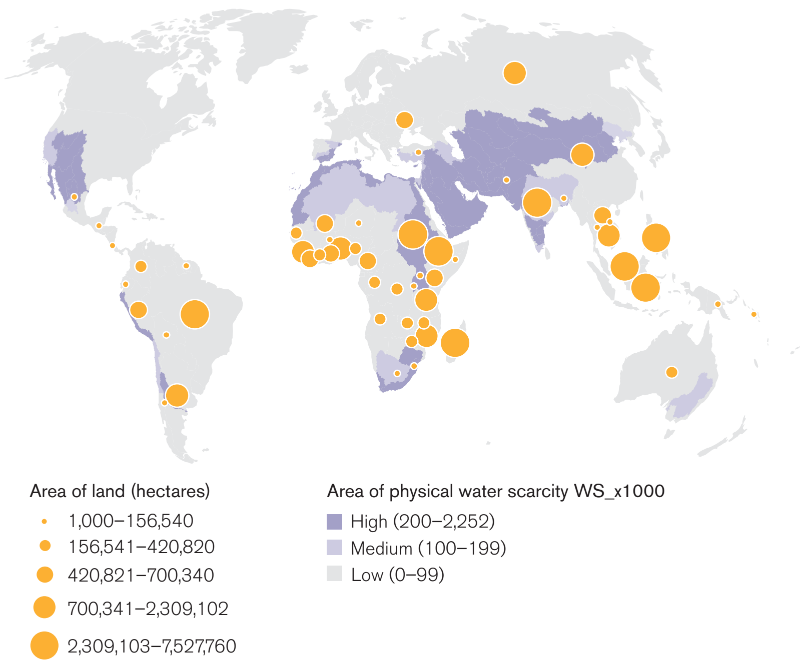
Figure 4.8: Power plants in India in water-stressed areas



Source: Sauer (2010).[201]

Investments in agriculture are focused on areas with less pressure from water scarcity. Figure 4.9 shows the total area of land acquisitions in each country – largest in South America, sub-Saharan Africa and Southeast Asia.

Figure 4.9: Agricultural land deals by area, 2003–11, and water scarcity, 2011



Source: Land Matrix Database (accessed 2012), FAO (2011).

Box 4.4: Copper production in Chile – water, ore grade and energy

A significant share of copper production in Chile – the world's largest producer – takes place in arid regions such as the Atacama Desert. Its copper industry consumes around a million tonnes of water a day. Even with significant water efficiency improvements, the government estimates a 45% increase in water demand by 2020 to sustain planned capacity expansions.[202] Mining companies are switching to desalinated seawater to meet likely shortages. But with several large operations in the Andean mountains, the seawater needs to be pumped inland and to a height of 4,000 metres above sea level to desalination plants at the mine sites. This presents a significant technological, environmental and financial challenge, and companies are investing more than $7.5 billion to improve water supply to the industry.

The desalination and transport of water over long distances and to high altitudes require large amounts of energy. Meanwhile, ore grades in key Chilean copper operations have been declining rapidly after decades of intensive large-scale mining. This means more water and energy are needed in mining operations, as larger amounts of host rock need to be processed to access the red metal. These factors – local water scarcity and ore grade declines – are rapidly increasing the energy intensity of Chile's copper industry, adding substantially both to production costs and to greenhouse gas emissions, which are projected to increase fourfold by 2030 owing to the use of coal. The sector is also extremely vulnerable to rising energy prices.

On the other side of the coin, agricultural and extractive activities are aggravating the situation as major contributors to freshwater pollution – a key threat to water supply security in many developing countries. Currently, 95% of wastewater worldwide is not treated. Agriculture and extractive industries contaminate large quantities of valuable freshwater resources either as a result of accidents or through normal operations such as pesticide use or disposal of waste products including 'produced water' from oil rigs or tailings from mining activities that often contain acids and heavy metals. The case of China – where all major river basins suffer from excessive pollution and over 300 million people lack access to safe drinking water as a consequence – demonstrates the urgency of this issue, particularly in rapidly industrializing countries.[203] Measures to treat wastewater for multiple reuse, to reduce water and food waste, and to improve irrigation technologies, are essential. According to McKinsey, drip irrigation and sprinkler systems could save 250–300 billion tonnes of water in 2030 compared with a business-as-usual scenario.[204]

Water rights, prices and pollution are becoming highly contentious issues. The extractive industries are particularly vulnerable to these dynamics

Against this backdrop of tight supplies and competition, issues related to water rights, prices and pollution are becoming contentious. Recent tensions in Peru and India illustrate the challenge of local conflicts over water rights.[205] In Peru, concerns over the water impact of large-scale mining projects triggered violent protests, a major government crisis and the delay and cancellations of billions of dollars' worth of investments. In India, the long-running dispute over the allocation of waters from the Cauvery River has become increasingly tense, with frequent protests and protracted legal battles between the states of Karnataka and Tamil Nadu.[206]

Box 4.5: Building resilient transboundary water arrangements

In many parts of the world, increased demand for water – the result of industrialization, population growth and urbanization – is threatening to destabilize the already sensitive politics of transboundary water management. Climate change is adding another set of uncertainties over the nature and extent of rainfall and evaporation. These evolving background risks and pressures mean that the terms of a water management treaty must be able to cope with stress conditions, or they are likely to break down. Facing a severe drought in 1998–99, for example, Israel threatened to renege on its agreed delivery schedule[207] under the 1994 Israel–Jordan peace treaty. Unfortunately the majority of water agreements propose fixed water allocations for each participating country, ignoring these complex dynamics.

Adaptation strategies can be integrated into agreements to facilitate the development of mechanisms for managing variability or extreme fluctuations. The 1996 Ganges River Agreement, for instance, incorporated an early-warning system to deal with drought, including immediate consultations between affected states. Similarly, the Mekong River Commission has developed programmes addressing variation: the Climate Change and Adaptation Initiative, the Flood Management and Mitigation Programme, and the Initiative on Sustainable Hydropower. These are innovative and progressive in comparison with efforts by most other transboundary basin authorities to address change within the hydrological system, although there are still challenges to implementation.

Binding agreements over transboundary water sources have to date only been achieved at a regional level. International provisions such as the 1997 UN Watercourses Convention aim to develop common international approaches and collaboration. However, in the absence of ratification the terms of the convention merely act as a series of guidelines that are referenced in transboundary negotiations.

The presence or absence of institutional provisions is also an indicator of a treaty's resilience. River basin organizations provide a more dynamic platform for negotiations between riparian states. They can promote collective action, facilitate negotiations and promote transparency. Challenges tend to arise where hegemonic actors are present. China, for example, declined to join the Mekong River Commission and has pursued unilateral development of hydropower with the construction of four dams and plans for eight more. Mechanisms for conflict resolution, variability management and allocation are also key.

Data-sharing can build confidence and trust among member states. The 2007 Okavango River Basin agreement explicitly refers to the collection and dissemination of information of common interest on the use and development of the basin.[208] In 2010 member states expanded upon this by agreeing on a Protocol on Hydrological Data Sharing to set up provisions for an early-warning information system.[209] Increased transparency is also a focus of the OECD Water Governance Programme, which has set a target of 30 countries to achieve implementation of transparent water budget processes.[210]

Conflict-resolution structures also show their worth during periods of stress. These processes can be undertaken by an independent third party, through arbitration, at basin level or on a bilateral basis. The conflict-resolution mechanism of the Okavango River Basin Organization (OKACOM) – which comprises Angola, Botswana and Namibia – is specified in the 1994 agreement. Article 7 stipulates that 'any dispute as to the interpretation or implementation of any Article of this Agreement shall be settled by the Contracting Parties'. This ambiguity may mean that it would not hold during instances of increased tension.

The high political visibility and large local water footprint of extractive industries will make them particularly vulnerable to these dynamics. In areas with limited capacity to govern shared resources, balance competing demands and mobilize new investments, tensions over water use may erupt into more open confrontations. New mining in Afghanistan and large hydropower projects planned in the DRC would threaten local agricultural resources, potentially exacerbating existing conflicts.

While there is significant consensus in the academic literature that little empirical evidence exists to support the notion of impending 'water wars',[211] these studies are weakened by the fact that they rely heavily on historical data alone to discuss future conflict and therefore take less account of the combination of a growing global population, increasing water and energy consumption and pressures created by climate change.[212]

A second problem with the vast majority of this literature is that it generally equates warfare with traditional inter-state war.[213] Such conflict has continually declined since the second half of the twentieth century, however; defence policy-makers and strategic analysts are now much more attuned to the changing nature of warfare and in particular to the increasing importance of insurgency, civil conflict, terrorism, pervasive criminality and widespread civil disorder. This has lowered the threshold for concern about the role of conflict over water in questions of strategy and defence.[214]

Not only is unequal access to clean water a potential trigger of conflict and instability; *perceptions* of unequal access are sometimes just as important, or even more so. This is particularly the case in regions where populations are experiencing, or have recently experienced, conflicts pre-dating the increased attention to issues of water security, or where levels of socio-economic, political or ethnic marginalization are high. Water shortages in Pakistan, for example, are also often blamed on India's actions in upstream Kashmir, triggering protests. Prior to the outbreak of civil war in Syria in 2011, there had been four years of consecutive drought. As many as 1.3 million people were affected, with a disproportionate impact on the vulnerable. Migration into urban areas accelerated and many were pushed into extreme poverty – factors which may have played an important role in the uprising.[215]

4.4 Emerging climate threats

Climate change is expected not only to change the seasonality but also the amount of precipitation, while extreme events such as heat waves and heavy rainfall are set to be increasingly common as the century progresses, according to the IPCC.[216] In its Global Environment Outlook 5, the United Nations Environment Programme (UNEP) concludes that these complex, non-linear changes in global environmental systems are already having serious impacts on human wellbeing.[217] Rockström et al. (2009) argue that three of nine critical and interlinked thresholds of global environmental stability have already been passed.[218]

Over the past few years the security implications of climate change have been explored more fully. These include reports and analysis by research institutions and non-governmental, governmental and intergovernmental organizations.[219] Even though no major actors see environmental change as the sole trigger for future conflicts, all now regard 'climate change as a threat multiplier' as a key factor exacerbating existing resource vulnerability in weak states.[220] Indeed, climate change has come to be viewed by many analysts as a security challenge that threatens both human security and traditional national security.[221] While the empirical research on, for example, the correlation between climate change and civil war has yielded mixed results (and faces similar challenges to the research on water scarcity and conflict discussed above), recent work on changing weather patterns and social conflict generally has demonstrated clear links between environmental shocks and unrest.[222]

One of the most difficult aspects of factoring climate change into scenarios and plans related to resource security and the potential for conflict is the high level of uncertainty about the exact location, timing and effect of the physical impacts of a changed global climate. Yet uncertainty is not a new variable in national threat assessments, and the limitations of climate modelling do not, in principle, pose a greater problem than information gaps in other areas of conflict analysis.[223]

The potential impacts of climate change on resource production systems are manifold. Many of these impacts – temperature change, changing rainfall, higher weather variability and increased incidence of extreme weather events – are likely to be felt most strongly in agriculture. Temperature increases and reduced precipitation are likely to result in increasing water scarcity in many parts of the world.[224] Climate change is also expected to accelerate desertification in many arid regions, which is already claiming agricultural land at an estimated 12 million hectares a year, enough land to grow 20 million tonnes of grain.[225] By 2050, up to 50% of agricultural land in Latin America – one of the world's two key production and export centres – may be subject to desertification.[226]

The potential impacts of climate change on resource production systems are manifold, and are likely to be felt most strongly in agriculture

Global temperature rises are also exerting a significant drag on cereal yields. A recent study has estimated that temperature rise between 1980 and 2008 has already reduced global production of maize and wheat by 3.8% and 5.5% respectively.[227] But these effects are still relatively small, with the most serious impacts of climate change on food security not expected to be apparent until the middle of the century. Box 4.6 shows that these impacts will be felt most keenly in developing countries, especially in sub-Saharan Africa, which is simultaneously likely to play an increasingly important role in global food production as it contains much of the remaining uncultivated arable land. In contrast to this, climate change is expected to have a benign impact on yields in the more temperate regions of Canada and central and northern Eurasia over the medium term.

Box 4.6: Projected climate impacts on different regions

The impacts of climate change and the resulting consequences vary across regions and latitudes, increasing the complexity of both the practical and the political problems involved in preparing for them. For example, an increase of 2°C could make parts of the northern hemisphere more agriculturally viable, while in South Asia and Latin America this increase would mean a significant deterioration in food production.[228] On the basis of the findings of the IPCC's 4th Assessment Report (2007), and as described in a recent report,[229] the likely impacts of climate change in different regions can be summarized as follows.

Africa: By 2020, between 75 million and 250 million people are projected to be exposed to increased water stress due to climate change. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020, and agricultural production in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. Towards the end of the 21st century, projected sea-level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5–10% of GDP. An increase of 5–8% of arid and semi-arid land in Africa is projected by 2020 under a range of climate scenarios.

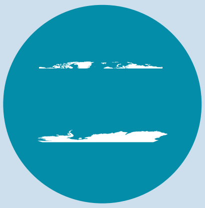
Asia: Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development. By the 2050s, freshwater availability in Central, South, East and Southeast Asia, particularly in large river basins, is projected to decrease. Coastal areas, especially heavily populated mega-delta regions in South, East and Southeast Asia, will be at greatest risk owing to increased flooding from the sea and, in some mega-deltas, from rivers. Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in these regions as a result of projected changes in the hydrological cycle.

Australia and New Zealand: By 2020, significant loss of biodiversity is projected to occur in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics. Water security problems and a decline in agriculture and forestry are projected for southern and eastern Australia, as well as eastern New Zealand, by 2030. However, initial benefits are projected in some regions of New Zealand. By 2050, ongoing coastal development and population growth in some areas of Australia and New Zealand are projected to exacerbate risks from sea-level rise and the severity and frequency of storms and coastal flooding.

Europe: Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods, more frequent coastal flooding and increased erosion (caused by amplified storm intensity/frequency and sea-level rise). Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% by 2080 under high-emissions scenarios). In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and crop productivity. Climate change is also projected to increase health risks from heat waves and the frequency of wildfires.

Latin America: By mid-century, higher temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia, and semi-arid vegetation will tend to be replaced by arid-land vegetation. There is also a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America; productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones, soybean yields are projected to grow. Overall, the number of people at risk of hunger is projected to increase. Changes in precipitation patterns and the disappearance of glaciers are projected to have a significant impact on water availability for human consumption, agriculture and energy generation.

North America: Warming in western mountains is projected to cause decreased snow pack (important when melting as a source of water), more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources. In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5–20%, but with important variations across regions. Major challenges are projected for crops that are near the warm end of their suitable range or that depend on highly utilized water resources. Cities currently experiencing heat waves are expected to face further challenges from an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts. Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.



Polar regions: The main projected biophysical effects are reductions in the thickness and extent of glaciers, ice sheets and sea ice, as well as changes in natural ecosystems, with detrimental effects on many organisms including migratory birds, mammals and higher predators. For human communities the impacts, particularly those resulting from changing snow and ice conditions, are projected to be mixed. Detrimental impacts would include those on infrastructure and traditional indigenous ways of life. In both polar regions, specific ecosystems and habitats are projected to be vulnerable, as climatic barriers to species invasions are lowered.

Small islands: Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. Deterioration in coastal conditions, through erosion of beaches and coral bleaching, for example, is expected to affect local resources. By mid-century, climate change is expected to reduce water resources in many small islands, for example in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods. With higher temperatures, increased invasion by non-native species is expected to occur, particularly in mid- and high-latitude islands.

Source: E3G (2011) based on IPCC report.[230]

Droughts, heat waves and floods will result in larger and more frequent local harvest shocks around the world

Increased frequency and severity of extreme weather events, such as droughts, heat waves and floods, will also result in more larger and frequent local harvest shocks around the world, further increasing the vulnerability of those parts of the developing world where a large share of the population consists of subsistence farmers. These shocks will affect global food prices whenever key centres of agricultural production are hit – further amplifying global food price volatility, as discussed in Section 4.1. Recent examples include the impact of the major heat wave hitting Russia in 2010, which led to a sharp spike in global wheat prices in late 2010, or the 2012 drought in the US that has driven global soybean and maize prices to levels not seen since the 2008 crisis.

Rain-fed agriculture is particularly susceptible to the negative impacts of increased climate variability. By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%. Sub-Saharan Africa, with its almost complete reliance on rainfed farming (currently over 95%), is again particularly vulnerable in this respect. This makes investment in irrigation alongside other adaptive measures critical to ensure the region's food security.

A significant share of global production occurs in water-stressed or drought-prone regions such as the Black Sea, Australia, China, India or Pakistan, where extreme weather events and harvest shocks mean supply is even more variable. Similarly, the role of countries that have demonstrated a readiness to impose export controls, such as Russia or Argentina, is likely to grow in global food markets, creating additional potential for disruptions.

Forests have climbed up the climate change agenda in recent years, and attempts are being made to develop a system for paying developing countries for the value of standing forests in absorbing carbon, thereby reducing the incentives to harvest timber unsustainably. The REDD+ (Reduced Emissions from Forest Degradation and Deforestation) framework is part of the UN climate change apparatus. It seems unlikely, however, that this framework can have a major impact in the absence of a global market for forest carbon. That in turn seems unlikely to expand until developing countries adopt emissions targets under a new global climate treaty and until concerns about illegality and unsustainability can be met. For the next decade, therefore, the international focus is likely to remain on encouraging sustainable forest management, promoting 'deforestation-free' products in consumer markets, and improving standards of governance and tackling the major problems of corruption and illegality which characterize the forest sector in many forest-rich developing countries.

The potential impacts of climate change on the fisheries sector have so far received relatively little attention in international climate debates. Both capture fisheries and aquaculture are likely to be significantly affected.[231] Changing sea temperatures could affect migration and reproductive patterns, destroy reef habitats through coral bleaching and change ocean currents. While high-latitude regions may in fact benefit from these changes through increases of 30–70% in catch potential, the latter is predicted to fall by up to 40% in the tropics.[232] In addition, changes in precipitation and evapotranspiration rates will affect inland fisheries by changing river flows and flood timings. An increase in severe weather events, such as storms or heavy rains, can prevent fishing vessels from putting to sea and damage aquaculture farms.

Climate change also poses a strategic challenge to the extractives sector – whether energy, mining or metals. To date, most attention has been focused on the impacts of carbon-related regulation and pricing,[233] rather than the geo-physical implications – from accelerated degradation of extraction, transport and energy infrastructure, and disruptions of operations to intensified conflicts with local communities over water resources in arid regions, to name a few (see Table 4.1). Apart from carbon pricing,[234] there has been little attempt to quantify in a comprehensive manner other commercial, operational and reputational costs and risks associated with climate change.

Table 4.1: Climate change impacts on the mining industry

Climate impacts	Implications for mining industry
Average temperature increases	Permafrost thaw will affect Arctic and sub-Arctic mining, creating engineering challenges for construction and maintenance of mines and related transportation infrastructure. Higher capital expenditures and operating costs are likely. There will also be positive impacts, such as increased shipping access to the Arctic region.
Increasing incidence of water stress	To ensure adequate water supply at mine sites, desalination and long-distance water transport will often be required. Higher incidence of dust and increasing need for dust suppression. Potential for intensified conflict with local communities.
Extreme weather events	Increased incidence of floods, heat waves and extended droughts and higher variability in weather patterns will bring operational and technical challenges (such as a more variable hydrogeology) and require higher capital expenditures. Increased incidence of production disruptions and the risk of catastrophic failures – including for tailings dams – will result in higher insurance costs. Transport links for mine supply and product delivery may also be more frequently disrupted. In some regions, more frequent forest fires will also lead to mining disruptions.
Sea level rise	Mining in coastal areas may be exposed to a higher incidence of floods.
Regulatory changes	Stricter norms and rising costs for carbon emissions and higher energy costs, aggravated by the extensive use of carbon-intensive coal energy in mining and metal processing. • Mandates to develop and implement carbon capture and storage technologies in mining and metal processing. • Higher costs for water use, tighter norms on water efficiency and stricter rules on the quality of water discharge from mine sites, especially in regions with intensifying water stress. • More restrictions on and increased costs of land-use change, including increasing stricter regulations on mine site rehabilitation. • Stricter engineering norms for mining operations to increase resilience against extreme weather events, including, for example, tailings ponds and open pit design.

Sources: Chatham House based on Nelson and Schuchard (2011); Loechel et al. (2010); Hodgkinson et al. (2010); Eskeland and Flottorp, (2010); Pearce et al. (2011); Broderick and Hendel-Blackford (2007).

The impacts of climate change are likely to result in more frequent interruptions in mining operations, unless upfront mitigation and adaptation measures (which are often costly) are incorporated. Investments are needed to strengthen the resilience of extraction, refining and transport infrastructure; to reduce energy and water intensity; and to build effective regulatory frameworks.

Extreme weather events have been the leading cause of tailings dam failures over the last decade

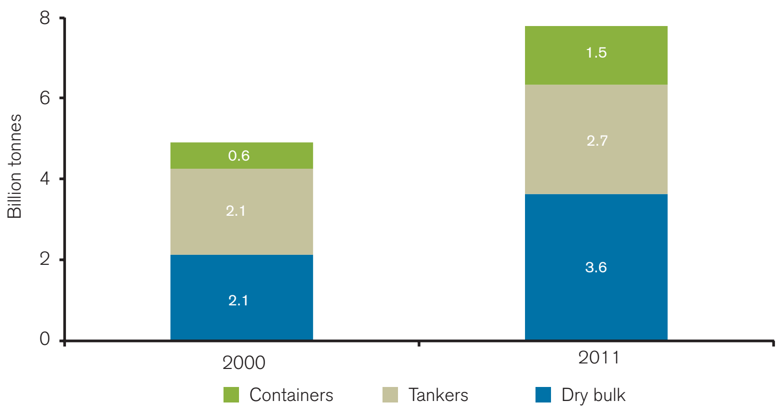
Many climate-related impacts affect mines after they have closed.[235] Mine site infrastructure such as tailings dams that have been constructed on the assumption of broadly stable climatic conditions may prove inadequate in the future. An increased incidence of extreme weather events may also create significant environmental hazards and financial liabilities for companies, either during the lifetime of a mining operation or after mine closure. Extreme weather events have been the leading cause of tailings dam failures over the past decade.[236]

Although a small number of mining companies are starting to address some of these issues, overall awareness about the real and multidimensional challenges remains limited in the mining community, and climate risk management strategies are lacking.[237] A recent survey of the principal risks facing the mining industry put climate change at number 13, dropping three places from the year before when it was ranked as one of top ten key threats to business.[238]

4.5 Transport risks in the age of interdependence

Global shipping capacity has doubled since 1980, in large part to facilitate trade in natural resources.[239] A few heavy and relatively abundant resources, such as those used to make cement, are typically produced locally and traded only with near neighbours. For most natural resources, however, trade is increasingly global. The US, for example, exported 845 different types of resources to South Korea in 2010; India 583 types to the UAE.

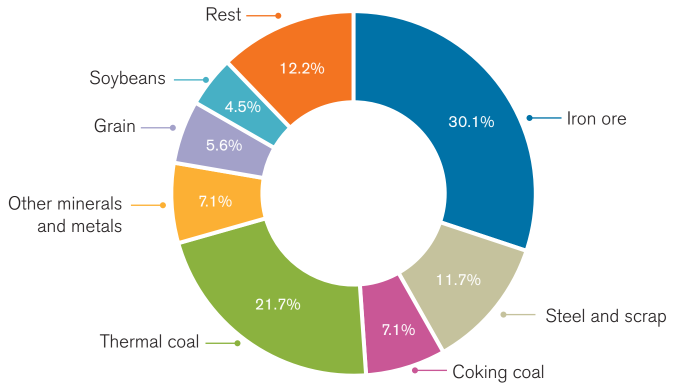
Figure 4.10: Natural resources account for over 80% of global sea-borne trade



Source: Chatham House based on data by the FT/DVB Research, reported in Nomikos (2012).

Natural resources account for as much as 80% of global trade, by weight (Figure 4.10). Iron, steel and coal dominate dry bulk cargo (Figure 4.11), while oil and LNG are the major traded liquids. A third of the total *value* of international trade, however, is carried by air; most of this comprises manufactured goods.[240] A few resources, including high-value agricultural and horticultural products and fine chemicals, tend to be air-freighted. Over land, railways and barges are often the cheapest way to shift bulky resources from production sites to end use or for shipping. Road transport plays a crucial end-point distribution role for petroleum and food.

Figure 4.11: Iron, steel and coal make up over 70% of dry bulk cargo



Source: Chatham House based on data by the FT/DVB Research, reported in Nomikos (2012).

In terms of resource security, three critical issues arise from growing trade and the expanding transport networks. First, with increasing flows between production and consumption centres, a large share of global resource trade now passes through a limited number of ports and shipping channels (see Box 4.7 on energy choke points). A disruption to these critical routes by, for example, extreme weather events or conflict would affect the price and potentially physical access to resources.

Second, the global transport system has evolved to support the just-in-time nature of today's economy.[241] Companies often hold limited resource inventories, instead relying on the delivery of materials as and when needed. While this has increased the economic efficiency of the global economy, it has increased vulnerability to a transport-sector disruption.

Third, the quality of infrastructure for resource transport is key to the competitiveness of countries – on both the supply and demand side – but many face challenges in attracting the needed investment in rail, road, river and marine (containerized ports) infrastructure. Key resource producers have seen rapid growth in resource transport in recent years, not least Brazil, Australia and China. Resource investments in Africa have also been closely linked with the development of new rail capacity.[242] A 1,344-km railway linking cobalt reserves in the DRC and copper mines in Zambia to a port in Angola is, for example, being restored by Sinohydro Corporation, the Chinese state-owned hydropower engineering and construction company.[243]

> The quality of infrastructure or resource transport is key to the competitiveness of countries, but attracting investment is a challenge

On the demand side, infrastructure is crucial to maintain access to global resource markets at competitive prices and to transport resources from where they are produced or imported to the point of demand. Prolonged fuel shortages and price spikes occurred in landlocked Uganda in 2008 and 2009, even after world oil prices had fallen sharply. This was due to disruptions in the supply chain from Kenya.[244]An analysis by IFPRI shows that in Africa, food price spikes are also more severe in landlocked countries.[245] Large volumes of coal are transported to power stations within the US and China, for example. The share of coal produced in China that is transported by rail fell from 65% in 1978 to 44% in 2009, owing to a lack of available rail capacity which meant a growing share had to be carried by road.[246]

Box 4.7: Choke points for global energy trade

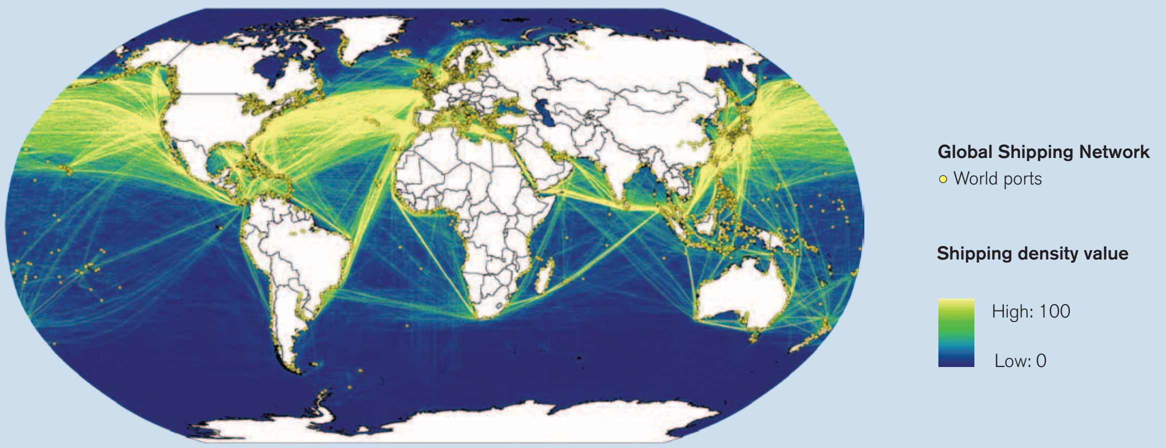
Geo-strategic ‘choke points’ have long been part of military strategy in terms of the importance of maintaining open supply lines. Numerous examples throughout history, including the battle of Thermopylae in 480 BC, the battle of Tsushima in 1905 during the Russo-Japanese war, the 1956 Suez crisis, and the ‘tanker war’ from 1984 onwards during the Iran–Iraq war, have demonstrated the extent to which adversaries will use ‘choke points’ of various kinds for military advantage. In recent times, the activity of Somali pirates over a very wide area of ocean also presents a threat to oil supplies.[247] Importantly, both the actual closure and even only the threat of closure[248] can have significant impacts on prices as well as long-term stability.

Energy supplies can also be affected by non-military political interventions. The Russia–Ukraine gas crisis, which came to a head in January 2009, resulted in 18 European countries reporting major falls or cut-offs in their gas supply. Sanctions affecting the oil market are by definition intended to create local restrictions on supply.

Other disruptions may result from low water-storage capacity, insufficient cooling water and adverse weather conditions, as occurred in the winter of 2010 in the UK where over 100 businesses had their gas supply cut off. In the Gulf, gas shortages in recent years have been compounded by under-pricing and heavy demand from the petrochemicals industry. Without change in the tariff system, this is likely to continue.

Extreme weather events, water shortages, changing sea levels or melting glaciers will pose growing threats to global energy production and delivery systems.[249] Mapping undertaken by the UK Meteorological Office in 2009 illustrates the density of a handful of shipping lanes upon which global energy trade depends (see Figure 4.12). On the basis of density, regions with the most vulnerable energy infrastructure include the east coast of North America, Europe, northern Asia (mostly the former Soviet Union), Southeast Asia, Japan and the Middle East, many of which are key producers of fossil fuel for the global market. These vulnerabilities highlight the imperative of climate- and energy-resilient investments.

Figure 4.12: Global shipping routes, pipelines and world ports



Sources: Hadley Centre (2010), NCEAS (shipping routes), FAO (ports), GIS-Lab (pipelines).

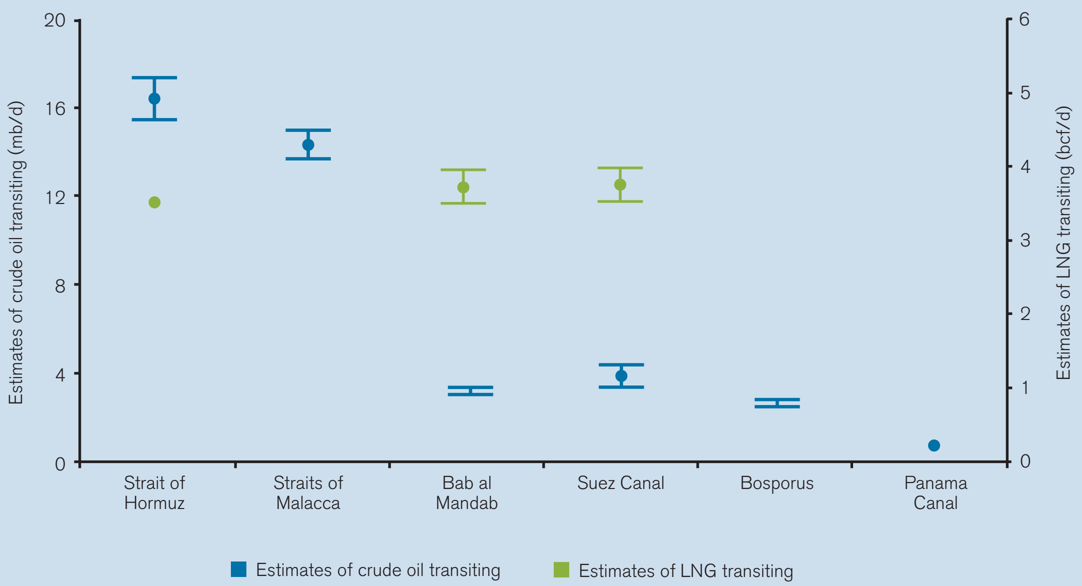
There are obvious choke points for oil, the most important being the Strait of Hormuz, which gives access to oil markets in Asia and the Atlantic Basin for Gulf crude oil exports. Iran could theoretically close the Strait as a political gesture. Because of their physical inflexibility, pipelines represent serious potential choke points, though the impact tends to be regional rather than global.[250]

For the most part, refineries are configured to take a particular quality of crude oil, but consumers want oil products rather than crude oil, which means this must often be processed and refined prior to export. The infrastructure associated with this process can therefore also be regarded as a choke point. The distribution of refinery capacity around the world reduces the risk.[251]

The Abqaiq oil-processing facility in Saudi Arabia plays a critical role in global oil supply infrastructure. It removes impurities from 5–7 million barrels per day (mb/d) of sour crude. It was the target of an attempted terrorist attack in 2006, although there was no impact on exports.[252] Other examples are the huge loading terminals at Ras Tanura in Saudi Arabia through which the bulk of Saudi exports normally pass, or those at Kharg Island in Iran.

Gas can be transported either by pipeline or as LNG. LNG seaborne trade is subject to the same sort of potential routeing problems associated with crude oil. The recent political upheaval in Egypt posed a greater potential threat to European gas supplies than to oil supplies, since closure of the Suez Canal would have prevented access to LNG tankers. The Strait of Hormuz sees the passage of some 28% of LNG exports. Figure 4.13 provides estimates of some of the key choke points and the volumes of oil and gas involved in 2010.

Figure 4.13: Estimated volumes of oil and gas through key choke points, 2010



Source: Stevens and Emmerson (2011).

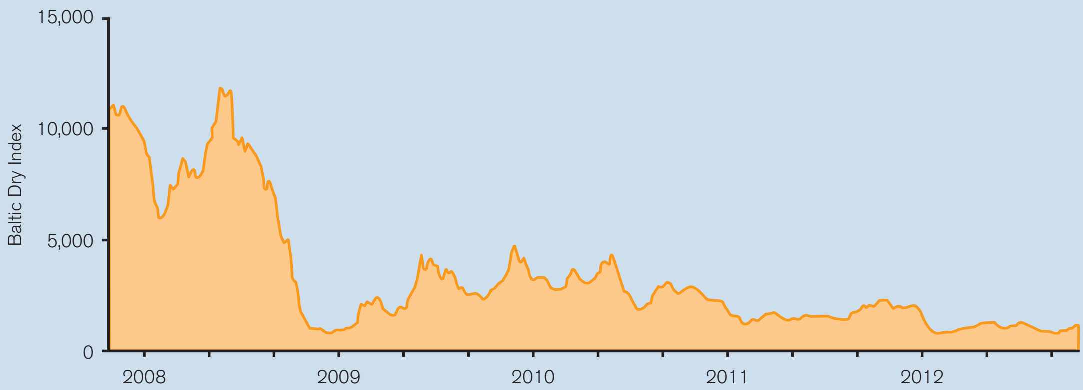
Decisions over transport infrastructure can be political; these in turn affect the availability and price of traded resources to some consumers. Brazil, for example, has developed a new class of dry-bulk carriers to cut transport costs to key Chinese markets (see also Section 2.3.2). The size of these Valemax ships means they can dock only in a handful of ports, making it necessary to develop dedicated infrastructure in China and elsewhere to accommodate them. Under pressure from the domestic shipping industry, the Chinese authorities have so far refused to allow the new ships to unload in Chinese ports. For some markets, such as LNG and radioactive materials, specialized transport infrastructure has a direct impact on the availability of products. As the size of shipping vessels grows, the market for shipping has become ever more concentrated.

While Maersk (Denmark) and MSC (Switzerland) are the largest shipping companies, Chinese firms now provide about 14% of global capacity – the largest share for any single country (Figure 4.15).

Box 4.8: Transport costs

When economic conditions change the outlook for global trade, it takes time for the shipping sector to adjust – by either reducing the capacity of ships in service or producing new ones. As a result, shipping costs are volatile. There were large price increases in the last decade in the run-up to the economic crisis of 2008. But as trade volumes by sea temporarily fell sharply in 2009 in the wake of the crisis, shipping prices fell by 95% within three months. While freight volumes recovered to pre-crisis levels in 2010, overcapacity has largely prevented shipping prices from recovering (Figure 4.14).

Figure 4.14: Shipping prices (Baltic Dry Index)

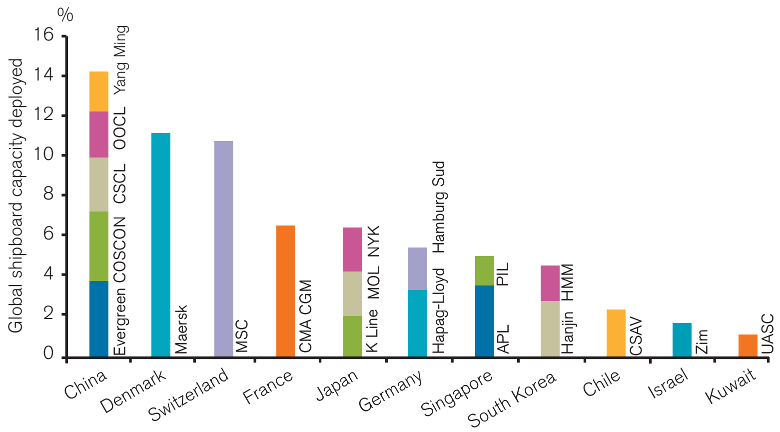


Source: Bloomberg (2012).

Over a longer time horizon, the cost of transporting natural resources fell by over 90% between 1870 and 2000, according to the WTO.[253] Ever larger tankers and dry-bulk carriers as well as information systems including automated tracking enabled significant efficiency improvements in logistics and reduced shipping costs. The increasing use of ports of convenience (which now account for over half of the global merchant fleet) also contributed to lowered fixed costs for shipping – though these ports have often been criticized for having weaker labour standards and environmental protection.

Chapter 4

Figure 4.15: The 20 leading operators of container ships, by capacity and country, 2011



Source: Based on UNCTAD (2011).[254]

4.6 Outlook on resource scarcities

Despite the uncertainties and interactions between resources presented in this report, at the aggregate level key trends for individual resources can be identified.[255] The outlook is for continued price volatility and potential scarcities for some resources.

Agriculture

Markets for agricultural goods are expected to remain tight through to 2020 and probably to 2030. Consumption and production substitutability of crops means that prices of these goods will generally rise together. However, among cereals, maize will probably demonstrate the strongest international price rises, of the likely order of 20% by 2020 and 80% by 2030 (against recent long-run prices). Rising demand for biofuels and animal feed puts particular pressures on maize prices, with climate change also expected to exert a significant drag on yields from 2030. Similar drivers will underpin oilseed growth, but more available cropland for expansion in South America will help restrain prices.

Markets for agricultural goods are expected to remain tight through to 2020 and probably to 2030

Market tightness and the reliance on maize as a biofuel feedstock mean that prices will continue to be volatile. This will affect feed prices, and hence meat prices. It will also transmit volatility to other cereals through substitution effects. There is also the risk of transmitting price volatility to white maize – the staple food of Mexico – via the intermediating effect of feed markets. Livestock producers switch to yellow maize when prices for white maize are relatively high.

High price volatility in wheat markets is likely to persist into the 2020s. Growing demand, as developing country consumers switch from rice, will strain productivity growth, which has been slowing rapidly and where technology has so far delivered relatively little. Significant production occurs in water-stressed and climate vulnerable regions in Asia (China, India, Pakistan) and Australia – indicating that markets will remain tight, and vulnerable to harvest shocks. A further potential supply disruption could result when Ug99 – stem rust – arrives in South Asia, something that is quite likely to happen within the next few years. Production is growing in Eastern Europe, but output is variable and governments have already demonstrated a readiness to impose export controls.

Fisheries

Aquaculture is expected to be responsible for the bulk of production increases in the coming years, although it is growing at a slower rate than in the last decade. Fisheries products will continue to be extensively traded. Developing countries are projected to remain high net importers of low-value food fish and net exporters of high-value finfish and crustaceans. Trade flows to and from developed countries will continue to follow the opposite trend.[256] By 2020, just over half of fish exports for human consumption will come from Asia.[257]

After a drop in 2009, fish prices have again been on the rise since 2010, a trend that is expected to continue in the light of growing demand, rising costs of inputs and limited growth in capture fisheries.[258] The price of farmed fish in particular is projected to increase by 50% in 2020 compared with average prices in 2008–10, while prices of wild caught fish are expected to rise by 23%. Prices of fish meal and oil are also likely to rise (by 43% and 19% respectively), which will have implications not only for fish farming (feed) but also for other sectors such as livestock (feed) or agriculture (fertilizer).

Energy

Oil markets are likely to remain tight overall to 2020, but with increased volatility

Markets for oil are likely to remain tight overall to 2020, but with increased volatility. Some loosening of the market may take place should certain trends and factors combine on supply and demand sides; for example, the scaling-up of North American unconventional oil combined with a slowdown in Asian economies. By 2030, more permanent easing would be achieved should ambitious policies on carbon pricing, efficiency and deployment of new technology take effect. In the absence of these, severe shortages of oil between 2025 and 2030 could prompt emergency measures to reduce demand in importing economies including the US, China and India. In some markets and given the necessary infrastructure and finance, electric vehicles may be cost-competitive with the internal combustion engine shortly after 2020, but they are unlikely to have a major impact on global fuel demand before 2030.

In gas markets, a confluence of factors could constrain supplies to certain regions by 2020, including lack of investment in LNG due to shale development expectation; failure of Russian Arctic gas projects and pipelines to materialize; rising domestic demand in the Middle East and failure of unconventional gas to compensate for the above given depletion, investment and regulatory obstacles. While there are abundant coal resources, a combination of massive demand from planned Asian power plants, mine closures as well as increased dependence on imports could cause intermittent scarcities through shipping and transportation bottlenecks. This is likely to worsen as the effects of coal mining and cleaning compete with water resources by 2030. By 2020, the prospect of cost-competitive renewable energy could become a destabilizing factor for fossil fuel-based investments in countries with sufficient renewable resources.

On current trends, prices for oil are likely to remain in the $80–120 per barrel range to 2020, with the potential to go much higher as a result of a crisis or supply crunch. Prolonged higher prices are expected to take effect by 2030, as government policies and consumer responses lead to fuel-switching and behaviour change. They could start to fall in the 2030s as substitute technologies displace oil demand.

Minerals

Depending on how rapidly China's metal demand growth slows over the next ten years, metals markets may experience less tight market conditions than in the past decade. But while prices may ease from their record levels, they are likely to remain high, owing to upward shifts in producer cost curves. A number of large greenfield projects coming into production over the next decade face significant technical, economic and political challenges (see Section 3.3.3). Especially for copper, the combination of continued ore grade declines and reliance on greenfield projects in countries such as Mongolia, the DRC and Afghanistan could keep markets under pressure. Continued high prices may also encourage lasting substitution, especially between copper and cheaper aluminium. While light rare earths are likely to continue to be in surplus over most of the next decade, heavy rare earth supplies are expected to remain tight until at least the middle of the current decade, relaxing only after a second generation of non-Chinese rare earth producers emerges.

Beyond 2020, tightness in metals markets will be determined by the growth of other emerging economies and the ability of industry to replace depleting mines and respond to growing demand. This may be through technological breakthroughs that allow for the processing of lower-quality resources at acceptable cost; by building large-scale mining industries in countries that currently still lack finance, expertise, infrastructure and political stability; or by developing recycling and remanufacturing industries much more extensively. Given the large investments needed for all of these, high prices are likely to persist for a considerable time to come.

Beyond 2020, tightness in metals markets will be determined by the growth of other emerging economies and the ability of the industry to meet demand

Against this background of potential supply crunches and resource scarcities concerns, the world is already witnessing a range of offensive and defensive moves by governments and businesses alike to ensure control over or access to affordable natural resources, or to reduce dependence on specific resources. The political nature of the resources markets is compounding the challenge, as is the grim outlook on global cooperation. Chapter 5 outlines the range of responses which are adding another layer of complexity and challenge.

5 Responses to Resource Threats: Adding Fuel to the Fire

- Moves by governments and companies to ensure access to affordable resources, or to reduce dependencies on specific resources, are reshaping the landscape of international politics.

- Governments are under pressure to shield domestic industries from high resource prices and to provide incentives for new production. Overseas, there are attempts to shore up long-term trade relations with resource producers. State-owned enterprises and export credit banks from emerging economies are scaling up their foreign investments. There is also the spectre of market manipulation. With production often concentrated among a few major exporters, OPEC could be joined by new international cartels in other resource markets if high prices persist.

- Ambitious resource efficiency measures are made more complicated by economic uncertainties and austerity measures in developed countries, but reducing resource intensity is key to building resilience to high prices in the medium term. Boosting investments in efficiency depends in part on tackling pricing: reducing subsidies harmful to both the economy and the environment and factoring in externalities.

- Trade has become a natural resource battleground. A number of key raw materials suppliers (especially manufacturers) have resorted to export controls as part of a broader move towards more explicit and interventionist industrial policy. Compulsory nationalization or the assumption of a controlling interest, the confiscation of foreign-owned assets, windfall profit taxes and similar measures are likely to become more common in an era of high resource prices.

5. Responses to Resource Threats: Adding Fuel to the Fire

The markets for critical resources have always been political. States have often taken action to preserve access to resources for their own economies – whether through diplomacy and direct interventions or via proxies such as state-owned enterprises or sovereign wealth funds (SWF). And many of these tools have also been used in the past. Unilateralism, however, is not always the norm. Security of supply fears have also driven many major diplomatic and cooperative initiatives. Water scarcity fears, for example, have often been cited as a driver of regional cooperation rather than conflict.

The rise of emerging economies has significantly altered the global balance of power in key resources markets

As outlined in Chapter 2, a number of new factors are driving the current phase of competition for key resources. First, the rise of emerging economies has significantly altered the global balance of power in key resources markets. On one level, this is a numbers game – with a larger number of actors competing for the same resources. Second, having an enlarged pool of competitors from outside the OECD club is casting further doubts on the ability of many of the world's governments to adhere to the rules of the game, or to find new ways to share critical resources.

More fundamentally, after a decade of resources boom, the looming investment and supply gap in the future production of resources – highlighted in Section 3.4 – has called into question the long-held assumptions on both the prospect of smooth, linear change, with the emergence of technological solutions, and the world's ability to seek technological solutions to meet resource needs. High and volatile prices have become the new normal.

Against this background of resource scarcities concerns, governments and other actors have adopted explicit action to ensure access to affordable supplies or to reduce demand at home. Table 5.1 describes some of the tools.

This chapter highlights the range of recent responses by governments to address resource security concerns. Policies and strategies are often shaped by an array of conflicting factors. Alongside unilateral measures to secure access to resources, there are also multilateral initiatives to sustain their availability through open markets and fair market access, including the negotiations for new regional and bilateral trade agreements. International resource management regimes – such as the UN Convention on the Law of the Sea or the array of regional fisheries management organizations – also continue to develop, often with some degree of success.

Table 5.1: Example of government responses

Broad goals	Specific policy objectives	Examples of tools
1. Ensuring access to affordable supplies	Protect domestic supply	Nationalization; export restrictions – quotas or removing export credit; investment restrictions; import tariffs; expropriating foreign-owned assets.
	Increase domestic production	Industrial policy: subsidies/tax incentives, technological support; concessionary loans; import restrictions; industrial policy; cheap money.
	Ensure access to foreign resources	Diplomacy; foreign direct investment by sovereign wealth funds; incentives to encourage 'go-out' strategies by state-owned enterprises and private companies; export credit; long-term contracts; assertive territorial claims over territories with resource wealth; tied aid.
2. Reducing demand	Resource efficiency	Recycling; waste management; reusability and recovery of products; public procurement; labelling and certification; standards and regulations; fiscal instruments – tax.
	Promote substitution for scarce resources	Renewable energy; new product designs; industrial policy; public procurement; labelling and certification.

Similarly, many of the policy instruments in Table 5.1 have been, and continue to be, deployed for objectives not explicitly connected to resource access. Renewable electricity and transport projects, for example, benefit from subsidies in many countries as a result of concern over greenhouse gas emissions and local air pollution, as well as a desire to reduce fossil fuel dependence. Industrial policy and connected instruments, such as technology support, may be used to support regional growth in areas of deprivation, or to support emerging export industries, as well as to secure access to resources. This chapter focuses on primarily unilateral policy instruments used explicitly to secure access or to reduce dependence on resources where shortages are anticipated or experienced.

5.1 Securing supplies: the new scramble?

In addition to efforts to reduce demand at home, governments and other actors have moved to ensure access to affordable resources, reshaping the landscape of international politics. The return to largely protectionist and beggar-thy-neighbour manoeuvres – often in reaction to short-term supply bottlenecks or perceptions of scarcities rather than actual ones – can act as fuel to the fire.

Control over resources has, among other factors, motivated colonial adventures and wars of territorial expansion. Civil wars and secessionist movements, too, have often been triggered and fuelled by natural resource wealth. More peacefully, governments have frequently interfered in the market to attempt to ensure adequate supplies of resources: subsidies, taxes, import barriers and export restrictions have all been used to this end.

The economic collapse of the Soviet bloc in the 1990s led to a collapse in prices in most natural resources, resulting in a period of relative calm in resource geopolitics. The price trend has been reversed over the past decade, bringing resource-based politics to the fore once again. In any case, strategic resources such as oil, or key sectors such as agriculture, were often treated differently by national governments because of their importance to national security.

5.1.1 Protecting domestic resources and industries

Subsidies are used in resources sectors to promote domestic production, shield producers from competition, or protect consumers from world prices

5.1.1.1 Battling over subsidies

Government subsidies are used extensively in the natural resource sectors – to promote domestic production, shield producers from competition or protect consumers from world market prices. The total value of fossil fuel subsidies worldwide was estimated at over $400 billion for 2010,[259] about twelve times as much as the value of renewable energy subsidies. As in other areas, there are World Trade Organization (WTO) disciplines attempting to limit their use for purely protectionist purposes – in this case the Agreement on Subsidies and Countervailing Measures. Nevertheless, subsidies remain pervasive.

The key challenge remains for the international community to distinguish between those subsidies or policy support mechanisms that spawn positive public goods outcomes and those that incur incentives leading to further environmental degradation and resource depletion.

Agriculture

Even though production subsidies for agriculture remain widespread, they have been steadily falling within the OECD. In 2010 their value amounted to 18% of total farm receipts, the lowest since the OECD started collecting these data in 1986.[260] In addition to the overall trend towards declining support, high resource prices reduce the need for subsidies. In some emerging markets, however, their use has gone up. As a share of total farm receipts, subsidies in China have risen from 6% in 1995 to 17% in 2010.[261]

Concerns over the impacts of high food prices in many developing countries remain a key motivation to continue or even increase consumption subsidies. Governments remain wary of abrupt food price changes, fearing that they will trigger further unrest following the Arab uprisings. Rising global prices will render consumption subsidies steadily less affordable, which will have knock-on effects.

Box 5.1: WTO and subsidies

The Subsidies and Countervailing Measures (SCM) Agreement of the WTO addresses the use of subsidies as well as countervailing measures introduced to counterbalance injury caused by subsidized imports. The definition of 'subsidy' in the SCM has three elements, all of which must be satisfied: (i) a financial contribution (ii) by a government or any public body within the territory of a WTO member (iii) which confers a benefit.[262]

The SCM Agreement categorizes specific subsidies into those that are prohibited and those that are actionable. Export subsidies designed to promote the use of domestic over imported goods are prohibited, including local content requirements and subsidies based on export performance. 'Actionable' subsidies are not prohibited, but can be challenged in the WTO and/or countervailing measures may be applied, in the event that they cause adverse effects to another WTO member. No action – neither a challenge in the WTO nor countervailing measures – can be taken against subsidies that are non-specific i.e. not targeted to a particular region or industry.

The SCM Agreement provides three definitions of an adverse effect: where harm is incurred to a domestic industry as the result of a subsidized import; where exports from rival members are injured in the market of the subsidizing country or a third market; and where benefits accruing under the General Agreement on Tariffs and Trade are impaired.[263]

Given the interconnected nature of the resource production system, subsidies for production in one sector often put pressure on others. Agricultural subsidies, for example, put pressure on other natural resources such as land, water and energy. The case of biofuels also amply illustrates the challenge of dealing with unintended consequences emanating from the interconnectedness of resource production systems.[264] First, it is now commonly accepted that support measures in the US and EU to encourage the expansion of biofuel production contributed to higher and more volatile food prices, among other factors.[265] These subsidies also distorted incentives for domestic production of other resources. For example, generous subsidies for maize and maize-based ethanol reduced the appetite for scaling up soybean production in the US.[266] This meant that farmers in South America could take advantage of growing markets for soybean in China without competition from US farmers. Expanding soybean production in Argentina and Brazil has in turn been blamed for encouraging unsustainable land-use change in the Amazon.[267]

Agricultural subsidies put pressure on other natural resources such as land, water and energy

Fisheries

The issue of subsidies in the fishing sector remains hotly debated in international trade negotiations at the WTO. Globally, fisheries subsidies have been estimated at around $25–29 billion, with the largest share being provided to EU, Japanese and Chinese fleets.[268] By now, it is generally agreed that certain subsidies – in particular those that increase the capacity of fishing fleets – are contributing to the decline of global fish stocks. Such capacity-enhancing subsidies are thought to account for 60% of fisheries subsidies, while 15–30% support fuel purchases.[269] Although effective fisheries management schemes that limit fishing effort overall could help to address these negative effects, most fishing still takes place under open access or in ineffectively regulated fisheries.

Energy

Incentives and stimuli for energy production are common in resource-rich developed countries. The OECD estimated an aggregate value in the order of $45–75 billion per year between 2005 and 2010 for fossil fuels in 24 OECD countries.[270] The Global Subsidies Initiative estimated global fossil fuel production subsidies at around $100 billion per year (2010/11).[271] These values are difficult to estimate accurately, however, given the variety and complexity of support mechanisms – with 250 types identified for OECD countries alone.[272]

Extractives companies are often given tax breaks as well as reduced royalties on land concessions, technology grants and loans, research and development funds or other favourable treatment. Shale gas became competitive in the US in recent years partly through R&D support for low-permeability hydrocarbon operations and the Alternative Fuel Production Tax Credit (see Section 3.3.1 and Box 3.2).

The oil price shock of 2008 has activated renewed interest in eliminating fossil fuel subsidies on multiple grounds: that they dampen the global demand response by insulating consumers from price movements, prolonging each period of high prices; encourage excessive consumption and the associated carbon emissions; and inhibit sustainable and green growth. In 2009 the G20 leaders, for example, committed to 'rationalize and phase out over the medium term inefficient fossil fuel subsidies that encourage wasteful consumption.'[273] Despite these high-level declarations of intent, the debate over how to tackle the problem is still fraught with sensitivities about equity and political anxieties over the impact of subsidy removal on inflation and competitiveness, and over the backlash from those whose incomes would be affected. In 2010 the EU, for example, introduced a requirement for subsidies to the coal-mining industry (€3 billion per year in Germany and Spain alone) to be phased out by 2018, but this legislation came at the end of a lengthy battle with labour unions, coal-producing regions and industrial lobbies which succeeded in extending the proposed subsidy period by four years. This is likely to lead to more mine closures as production becomes uncompetitive.

In developing countries energy consumption is usually subsidized to protect infant industry, stimulate the economy and meet basic needs. As with food, rising world energy prices increase budgetary pressures and encourage reforms to decrease subsidies. The cases of Iran and Nigeria demonstrate that even large exporting countries with significant windfalls from high prices can be motivated to remove subsidies. In both countries, reforms have been aimed at cutting escalating import bills, exacerbated by inadequate downstream (refining and power) infrastructure. For more self-sufficient energy producers such as the UAE and Saudi Arabia, domestic energy price reform is entering into policy debates given its role in limiting national export potential and the rising costs of producing new resources to meet domestic power demand (tight or sour gas, for example), or having to import them at international prices (in the case of Dubai, for example).

Sudden removal of subsidies often ends in political disasters – a violent backlash followed by a policy climb-down

Sudden removal of subsidies often ends in political disasters – a violent backlash followed by a policy climb-down. Nigeria, for instance, announced on New Year's Day in 2012 that domestic fuel subsidies would end. This led to an overnight doubling of prices and national strikes – which evolved into further protests against endemic corruption. In response, the government reduced rather than removed these subsidies, in part over fears that the protests would overwhelm police and armed forces already facing the Boko Haram insurgency in the north and the ongoing oil-related violence in the south of the country.[274] High fuel prices also raise the price of other resources – for instance, through higher transport costs.[275]

Although most subsidy reforms are likely to follow a halting process, necessity and a growing convergence of interests towards removing fossil fuel subsidies among producer and consumer governments are producing context-specific solutions to subsidy reform. Several countries are managing gradual fuel price rises (China, Malaysia, Jordan) and a learning curve is emerging in mechanisms to allow lifeline rates/quotas or to offset subsidy removal with welfare transfers (Iran, Indonesia, Chile). One salient component of 'lessons learned', for example, is clear articulation and public communication of the objectives of price reform. Another is building in robust monitoring, evaluation and feedback mechanisms and some flexibility so that schemes can be adjusted in response to unforeseen consequences and the process does not end up undermining those objectives.[276]

5.1.1.2 The return of strategic reserves

Stockpiles of natural resources held or supervised by governments are among the oldest resource policy instruments guarding against disruptions of supply and sudden price spikes, especially those arising from natural disasters or wars. The high costs of building and maintaining stockpiles mean that governments and market participants are very selective about which to keep as well as their size. Keeping perishable agricultural goods is particularly difficult and costly, as it is for some metals that oxidize over time. But stockpiles will need to be sufficiently large to have meaningful impacts on short-term prices if they are intended to bridge extended supply disruptions. This is no mean task given the large size of resource markets today, especially for fossil fuels, cereals and oilseeds.

With governments playing mostly minor roles in production processes in advanced economies, it is mainly private companies, with the exception of the military, that hold the largest shares of oil stocks. Governments in some countries, such as Japan and Germany, may require commercial actors to keep a minimum stock level of critical resources through a legal mandate or compensation, and this is normally part of the IEA's Emergency Sharing Mechanism.

Even though companies may hold stocks for supply management or business continuity, advances in logistics and communication technologies have led increasingly to the adoption of just-in-time production models with extremely low stockholdings to reduce operating costs. These in turn exacerbate vulnerability to supply disruptions.

Crude oil and petroleum stocks are among the most important strategic stockpiles, given the damaging consequences of even short-term supply disruptions in liquid fuels. The 28 IEA member countries hold most of the world's strategic oil stocks – as the organization requires its members to hold reserves that could replace net imports for 90 days, a requirement introduced in 1974 in response to the Arab oil embargo.[277] The US Strategic Petroleum Reserve is the largest resource stockpile in the world, currently containing nearly 700 million barrels of crude oil, acquired at an average cost of nearly $30 per barrel.[278] India and China have also begun to develop significant stockpiles, with China planning to expand its current stock of 170 million barrels to 90 days' worth of supply by 2020. Other fossil fuels (gas and coal) are not stockpiled to the same level. China, the largest coal consumer, holds less than a month's stock of thermal coal.[279]

China has begun to develop a significant oil stockpile, planning to have 90 days' worth of supply in storage by 2020

Stockpiles of agricultural goods have been substantially reduced since the 1970s when cereal prices were high. Oversupply and falling prices ever since have motivated many to dismantle them to reduce costs. As a result, global cereal stocks outside China dropped to less than three months' worth of annual supply in the 1990s (and have remained at low levels).[280] China was a major exception to this trend, holding around one year's worth of consumption for major cereals until the early 2000s when its cereals production fell (in response to agricultural market reform and environmental pressures). By 2006, stocks had been reduced to four months' worth. They have since been rebuilt but to a lower level than in the 1990s.

Box 5.2: China – stockholder of last resort?

As one of the world's largest holders of reserves, changes in China's stockholding policies have important implications for global commodity markets. In the case of cereals such as rice, wheat and maize, China has a long-standing policy of self-sufficiency – keeping imports and exports roughly balanced. It also maintains large strategic stocks, which during the 1990s accounted for roughly half of global cereal stocks.

Policy shifts began around 2000, when cereal cultivation mandates were relaxed as part of farm-sector liberalization and a 'Grain to Green' reforestation programme was introduced to combat soil erosion and desertification.[281] As a result, Chinese grain production declined by 17% between 2000 and 2004. Stocks fell by two-thirds between 2000 and 2006, with stocks-to-use ratios declining from 87% to 29% – still high by international standards, but lower than they had been in China since the Cultural Revolution.[282]

Large quantities of grain stocks were released to meet rising domestic demand while production declined. These also helped meet growing demand elsewhere through exports. It has been argued that China's stock release onto international markets helped to prevent what would have been the twenty-first century's first global price spike in 2003/04.[283] In 2005, grain exports were placed on hold and production was ramped up quickly. Growing output and imports were used mainly to replenish stocks, slightly raising China's stocks-to-use ratio again to 36% in 2012.

China's restocking and the related increase in imports from 2005 onwards contributed to increasing tightness in global agricultural markets and helped to set the scene for the food price spikes of 2008 and 2011. The question is whether other countries should carry on treating China as the stockholder of last resort. While they have benefited from China's willingness to maintain large stocks at significant cost, helping to keep food price spikes at bay, recent experience shows the concentration of global reserves in one country makes international markets highly vulnerable to the production, policies and politics of that country. If China catches a cold, the world sneezes.

China has been amassing a soybean reserve since 2008, along with a stockpile of rare earths and nine other critical metals

In recent years, strategic food reserves have been on the rise again. As well as rebuilding its cereal stocks, China has also been amassing a soybean reserve since the 2008 food price spike. Saudi Arabia and other countries have also begun to stockpile cereals to ensure national food security.

Governments in advanced economies also maintain extensive stockpiles of metals considered strategically critical for military and industrial applications. As part of the National Defense Stockpile, the US has maintained emergency stocks of strategic metals since the Second World War. The US government chose to dismantle part of this system in the 1990s and US stockholdings were significantly reduced. In 2010, it took the decision to rebuild the stockpiles.[284] Japan maintains stockpiles of seven different metals (via its companies) and monitors the supply of another seven metals closely.[285] The rationale for these stockpiles is supply security for Japan's high-tech industries, not military applications.[286]

China is also developing a stockpile of rare earths and nine other critical metals. As a key producer, it uses this strategy not only to ensure supply security but also to manage the prices of valuable and exhaustible resources.[287] In its Raw Materials Initiative, the EU and several member states have considered establishing metals stockpiles, especially for rare earths. But the fact that no decision has been taken to date reflects the difficulties involved in selecting and paying for stockpiles.

Box 5.3: Which metals are 'strategic'?

Which metals are considered strategically important changes over time. In the past, governments focused on the materials needed to make military equipment. Ferro-alloys such as tungsten were, for example, considered to be of key importance during the Second World War because of their use in armour and armour-piercing projectiles, as well as in high-speed cutting tools that allowed for faster manufacture of military hardware.[288]

The importance of metals supplies for economic growth and competitiveness has received increasing attention by governments. In the 1980s, for example, the US and other Western countries became concerned about access to platinum, a key material for electronic devices and car catalysts. Platinum reserves are mainly located in Russia and South Africa. The increasing destabilization of the apartheid regime was raising concerns about the possibility that an overthrow might lead South Africa to join the communist bloc, cutting off Western countries from platinum supply.

Recent concerns over China's monopoly and restrictions of rare earth supplies have had a military dimension, particularly in the US. But fears over affordability and access are primarily focused on the indispensable role of rare earths as raw materials for advanced magnets, which are widely used in green technologies such as electric vehicles and wind turbines, as well as many consumer products.

The US, for example, currently defines metals as strategic if they are 'materials for which the US is largely import dependent, for which no viable economic substitute exists, or for which there is concern over the source (for geopolitical reasons) or the supply (for market reasons)'. The EU designates 14 metals and minerals as 'critical', mainly on the basis of economic criteria.[289]

5.1.1.3 Expropriation and the return of 'resource nationalism'

In recent years, resource-rich countries have been pushing aggressively for more control and a higher share of profits from their natural resources – especially projects in the extractive industries. In marked contrast to the wave of privatizations in the 1990s, governments have not shied away from seizing assets or declaring contracts void. Argentina, for example, announced in April 2012 that it would take a controlling stake in the country's main oil company, YPF, from its Spanish owner Repsol, in the latest in a series of resource-sector expropriations over the past decade (see Table 5.2). The expropriation of foreign-owned companies or assets has a long history, including Mexico in 1938 (nationalization of US and Anglo-Dutch oil companies), Argentina in the 1940s (French and British railways, among others) and Iran in 1951 (Anglo-Iranian Oil Company). Some observers have characterized the recent wave as a rise or a revival of resource nationalism.[290]

The perception that foreign multinationals have not adequately invested in the long-term development of natural resource industries in host countries has been a key factor fuelling the latest wave of interventions. The trigger for Argentina's nationalization of Repsol's controlling stake in YPF was the country's escalating oil import costs. Argentina started to import oil only in 2010, as a result – the government claimed – of the Spanish-owned company's failure to invest enough in the development of energy sources to cope with growing internal demand, and its decision instead to repatriate 90% of its profits.[291] This 'use-it-or-lose-it' argument has also been used in other cases. For instance, in 2008 the government of Guinea awarded half of Rio Tinto's

The perception that foreign companies have not adequately invested in host countries' resources industrieshasfuelled expropriations and other interventions

Chapter 5

concession in the Simandou iron ore deposit to a rival investor, arguing that Rio Tinto had delayed the development of the valuable resource. In South Africa, a bitter debate has been raging over a potential nationalization of the mining industry, which critics have accused of failing to contribute effectively to employment and poverty alleviation.[292] This criticism has also been a factor in tense industrial relations in the South African mining sector where, after a series of violent clashes, police opened fire on striking miners at a platinum mine owned by London-listed Lonmin on 16 August 2012, killing 34 people.[293]

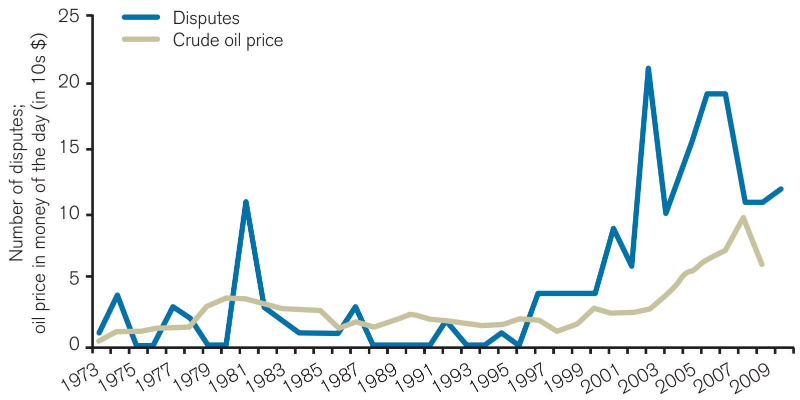
Table 5.2: Disputes and expropriations in the extractive sector – recent examples

Year	Government	Companies	Resources
2012	Argentina	Repsol	Oil, gas
	Bolivia	Glencore	Tin, zinc
	Bolivia	South American Silver	Silver
2011	Madagascar	Madagascar Oil	Oil, gas
	Mongolia	SouthGobi Sands	Coal
	Venezuela	Rusoro	Gold
2010	Bolivia	Pan American Energy	Gas
	Ecuador	Petrobras	Oil
	Kazakhstan	Ascom	Oil, gas
2009	DRC	First Quantum Minerals	Copper, cobalt
	Venezuela	Gold Reserve	Gold, copper
2008	Kazakhstan	Caratube International	Oil, gas
	Venezuela	Crystallex	Gold
	Guinea	Rio Tinto	Iron ore
2007	Jordan	Trans-Global Petroleum	Oil
	Kazakhstan	Liman Caspain Oil, NCL	Oil, gas
	Venezuela	ConocoPhillips	Oil
2006	Bolivia	Petrobras, Repsol, BP, Total	Gas
	Ecuador	Occidental	Oil, gas
	Russia	Shell	Gas
	Uzbekistan	Newmont	Gold
	Venezuela	Eni, ExxonMobil	Oil
2005	Grenada	RSM Production	Oil
2004	Russia	Yukos	Oil, gas
2002	Venezuela	Vannessa Ventures	Gold, copper

Source: Chatham House Arbitration Database (2012).

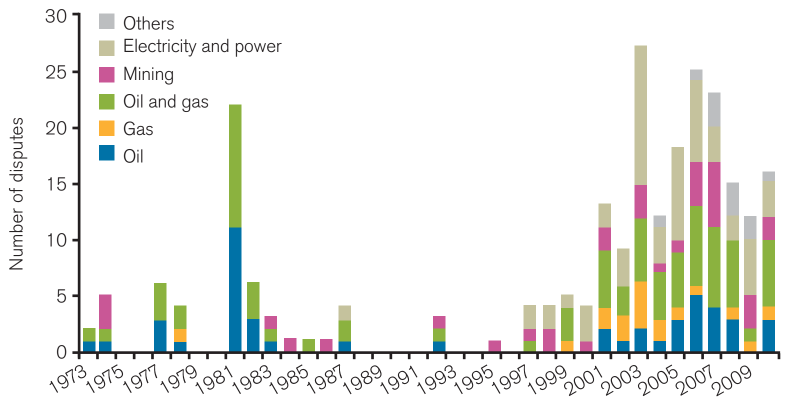
Record-high resource prices have also been a key driver, with foreign multinationals frequently accused of pocketing excessive windfalls from the price boom. The propensity of a government to expropriate or intervene is often closely linked to resource prices (see Figure 5.1). The recent upsurge in disputes and expropriations is reminiscent of earlier waves that also corresponded with periods of high resource prices (see Figure 5.2).

Figure 5.1: Correlation between resource dispute arbitration and crude oil prices



Source: Chatham House Arbitration Database (2012).

Figure 5.2: Frequency of dispute arbitration in extractive industries, by year



Source: Chatham House Arbitration Database (2012).

Compulsory nationalization, or the assumption of a controlling interest, the confiscation of foreign-owned assets, windfall profit taxes and similar measures can therefore be expected to become more common in an era of high resource prices. The aim in each case is to increase national access to resources and/or to the revenues that flow from them; motivations can also be ideological, political or practical.[294] Russia effectively nationalized the oil company Yukos, for example, by 'reassessing' its tax liabilities in 2003. Such expropriations have, however, been the most extreme form of governments seeking to increase their fiscal take. Brazil is currently pressing Vale, its mining champion, for back-taxes worth over $12 billion[295] that Vale claims it does not owe. This phenomenon is not limited to developing countries. The Australian government decided to impose additional taxes to capture a larger share of the windfall profits in extractive industries, with significant domestic political implications.

While it is unlikely that resource nationalization will lead to direct inter-state confrontation (of the kind seen in the 1956 Suez crisis), it can engender a spiral of mistrust and reprisals. Nationalism of any kind, including resource nationalism, requires the identification of external threats to justify extraordinary measures, a process that erodes trust and reinforces ideas about the importance of self-interest. As one analyst tracking the increasing trend towards resource nationalization has put it, 'even in the age of globalization, nationalistic mercantilism still lurks deep in the shadows of geopolitics'.[296]

Foreign investments by state-owned enterprises could lead to new types of political tension between developing countries

With continued global demand pressure (see Chapter 2) and the centrality of the sector for resource-rich countries, an imminent return to a more laissez-faire attitude towards resource industries seems unlikely. Anticipation of tight markets and price volatility (and the way these fluctuations in turn affect company profits and tax revenues) may instead trigger further disputes between host governments and foreign companies. If left unchecked, these disputes can spill over into diplomatic tensions. This issue is particularly pertinent with the growth of investments by state-owned enterprises (SOEs) and sovereign wealth funds in resource projects abroad (see Section 3.1.3.1). New types of South–South conflicts between state-backed investors from resource-hungry emerging economies and host countries may emerge as these projects mature, making renegotiations or expropriations more attractive.

Higher political risks associated with conflicts of this sort will also compound uncertainty in global resource markets. Should fear of expropriation or resource nationalism keep investors away from attractive deposits and deter future investments, it could result in global supply constraints and market volatility. While expropriations can provide short-term gains, in the long term they carry significant risks. Countries such as Bolivia, where there have been regular nationalizations under the Morales government, may effectively become no-go zones for international investors. The risks are also exemplified in the South African case, where the mere talk of potential nationalizations has deterred foreign investments and held back the ability of industry to capitalize on the global resource boom in recent years.

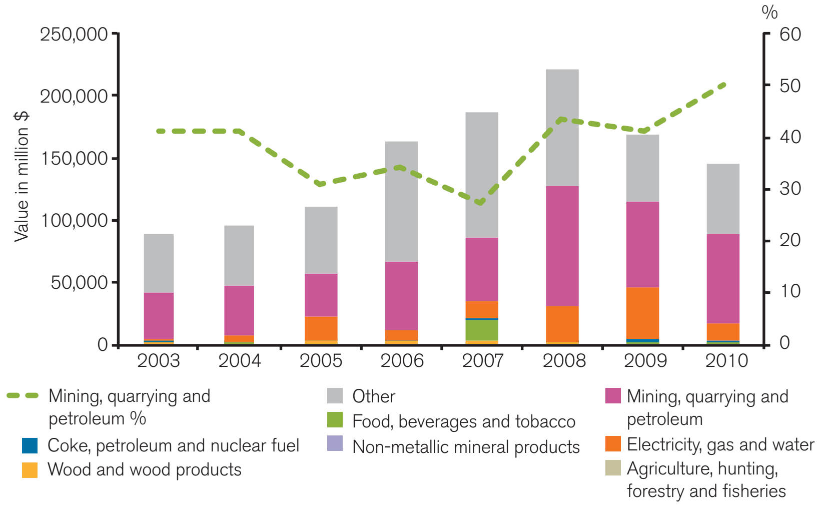
Looking to the future, resource-rich states, foreign investors (whether multinationals or SWFs and SOEs from emerging economies) and import-dependent consuming countries all have a joint interest in creating transparent and legitimate contractual arrangements resilient to changing market conditions (through mechanisms such as sliding-scale royalties). Also critical will be further investment into capacity-building in resource-rich countries with weak governance of extractive industries, from Mongolia to Peru and the DRC.

5.1.2 Securing access to foreign resources

5.1.2.1 The rise of foreign direct investment from state-owned enterprises in resources sectors

Today, the role of SOEs as active international investors in the global economy is also in the spotlight, even though cross-border mergers and acquisitions (M&A) purchases and greenfield investments by SOEs amounted to only around 11% of global outward foreign direct investment (FDI) flows in 2010.[297] Receiving most global attention are overseas investments by SOEs in strategic resource sectors such as energy, minerals, agriculture and forestry, although they also operate in many manufacturing or service sectors. This is in part because the bulk of FDI by SOEs has gone to the mining, quarrying and petroleum sectors (see Figure 5.3), which accounted for 50% of the total outward FDI from SOEs in 2010, up from 27% in 2007 (see Figure 5.4). The value of investments in these sectors reached a peak of $96 billion in 2008, but even the 2010 level of $73 billion remained significantly larger than in 2007 ($51 billion). Overall, resource sectors now account for nearly two-thirds of FDI from SOEs.

Figure 5.3: State-owned enterprises – outward FDI by sector, 2003–10

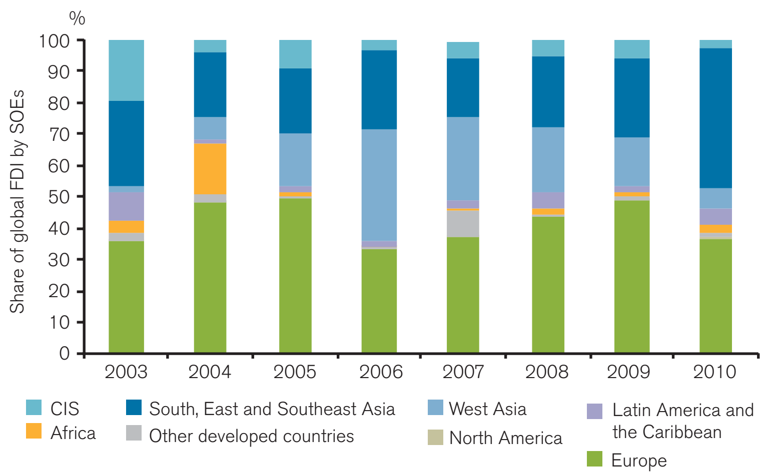


Source: UNCTAD (2011), *World Investment Report 2011: Non-equity Modes of International Production and Development*. Data compiled by Chatham House (2012).

By definition, the overseas activities of SOEs are often entwined with the strategic goals of their home governments. This has contributed to mounting distrust in host economies, even though the level of direct state intervention varies. China's 'going out' strategy, for example, has encouraged domestic firms to invest overseas (in Africa, Latin America and Australia in particular) in resource sectors, to ensure long-term access to affordable supplies.[298] In 2009, Chinese national oil companies were involved in 10 overseas acquisitions with a value of $18 billon.[299]

China's 'going out' strategy has encouraged domestic firms to invest overseas in resource sectors to ensure long-term access to affordable supplies

Figure 5.4: State-owned enterprises – outward FDI by source region, 2003–10



Source: UNCTAD (2011), *World Investment Report 2011: Non-equity Modes of International Production and Development*. Data compiled by Chatham House (2012).

The level of government ownership also varies across SOEs. In most cases the state has a controlling share: 10% of SOEs have less than 10% government ownership, 32% have 10–50%, 44% have 51–99%, and 14% are fully government-owned.[300] Taking the mid-point of each range produces a rough estimate of 50% for the average government stake in an SOE.

The quest for reliable and affordable supplies of critical resources has led to a rapid increase of FDI by SOEs from emerging economies, from 42% of total SOE outflows in 2003 to 59% in 2010. SOEs from China accounted for 27% of total outflows in 2010, up from just 13% in 2003, predominantly in oil, iron ore, aluminium and uranium. European SOEs accounted for a larger share than China (36% of total outflows – see Figure 5.4), although less than the Asian total. The scale of investments by SOEs in developing countries has increased too; these accounted for four of the six investments valued at over $10 billion in 2005–10.[301]

State-owned banks in the emerging economies also provide credit lines to other developing-country governments and companies. In addition to strengthening long-term ties with these countries, such loans are sometimes directed towards infrastructure development so that SOEs' FDI projects can follow. Other loans are made in return for purchases of goods and services from the debtor country. According to the *Financial Times,* the state-owned China Export Import Bank and China Development Bank lent a total of $110 billion to other developing countries and companies in 2009–10.[302] These Chinese loans are often backed by future resource revenues at below-market rates and over long periods (examples include oil from Angola, Russia, Venezuela and Brazil, and copper from Congo).[303] Box 5.4 describes China's foreign investments in mining. As of 2011, India's Exim Bank had extended 126 credit lines to 55 countries with a total value of $7 billion.[304] More than half of the 30 largest non-financial SOEs operate in the resource sectors (see Table 5.3).

Box 5.4: China's foreign mining investments

China's growing import dependence has led to increasing investment in mining abroad to secure supplies and capture a larger share of the profits from meeting its burgeoning import demand.[305] In Zambia and a number of other African countries Chinese mining companies have sometimes encountered stiff opposition over their business practices.[306] China has also at times been accused of neo-colonialism as it seeks to gain control over mineral riches, especially in African countries.[307] These tensions have not been limited to developing countries. For example, attempts by China to acquire Rio Tinto in 2007 failed owing to opposition among UK shareholders,[308] and Chinese bids for strategic rare earth mining assets in Australia have been blocked by Australian regulators on national security grounds.[309]

As a report by PriceWaterhouseCoopers pointed out, the ability of Chinese companies to control the global mining industry is often exaggerated. They are estimated to have a controlling stake in less than 1% of the global mining industry outside their own country.[310] Although Chinese investment has increased dramatically over the past decade as part of the 'going out' strategy, Western multinationals still account for the lion's share of global mining and acquisitions.

Table 5.3: Top 30 non-financial SOEs, ranked by value of foreign assets in 2009

Corporation	Home country	Government stake (%)	Sector	Foreign assets ($ bn)	Government stake of foreign assets ($ bn)
Enel	Italy	34.7	Electricity, gas and water	157	54
Volkswagen	Germany	20.0	Motor vehicles	156	31
GDF Suez	France	36.4	Electricity, gas and water	146	53
EDF	France	84.7	Electricity, gas and water	134	113
Deutsche Telekom	Germany	31.7	Telecommunications	113	36
ENI	Italy	30.3	Petroleum	1,002	304
General Motors	US	32.0	Motor vehicles	76	24
France Telecom	France	26.7	Telecommunications	73	19
EADS	France	22.4	Aircraft	72	16
Vattenfall	Sweden	100.0	Electricity, gas and water	72	72
Veolia Environment	France	10.7	Electricity, gas and water	52	6
CITIC Group	China	100.0	Diversified	44	44
Statoil	Norway	67.0	Petroleum	43	29
Deutsche Post	Germany	30.5	Transport and storage	39	12
Vale	Brazil	5.5	Mining and quarrying	39	2
Petronas	Malaysia	100.0	Petroleum	34	34
TeliaSonera	Sweden	37.3	Telecommunications	32	12
Renault	France	18.3	Motor vehicles	30	5
Japan Tobacco	Japan	50.0	Food, beverages and tobacco	30	15
Finmeccanica	Italy	30.2	Machinery and equipment	29	9
China Ocean Shipping Group	China	100.0	Transport and storage	28	28
Lukoil	Russian Federation	13.4	Petroleum	24	3
Singapore Telecom	Singapore	54.4	Telecommunications	23	13
Zain	Kuwait	49.2	Telecommunications	19	9
Qatar Telecom	Qatar	55.0	Telecommunications	18	10
Tata Steel	India	12.9	Metals and metal products	16	2
Petrobras	Brazil	39.8	Petroleum	15	6
Abu Dhabi National Energy	UAE	100.0	Electricity, gas and water	14	14
Petroleos de Venezuela	Venezuela	100.0	Petroleum	12	12
CNPC	China	100.0	Petroleum	12	12
Total					**1,000**

Source: UNCTAD (2011), *World Investment Report 2011: Non-equity Modes of International Production and Development*. Data compiled by Chatham House (2012).

The return to prominence of SOEs or SWFs has generated fears that they are blunt instruments of foreign governments

The return to prominence of state actors such as SOEs or SWFs (see Box 5.5) has generated fears that they are blunt instruments of foreign governments, not least China. SOEs are criticized for having non-commercial objectives, such as securing resources, opening new markets and forging new alliances. However, the extent to which they are or can be directed by governments on a day-to-day basis varies considerably from country to country.

Attempts by developing-country SOEs to purchase assets in developed countries have often been derailed. Most famously, China's national oil company CNOOC was forced to withdraw its bid for UNOCAL in 2005 after moves by the US Congress. The chair of Australia's Foreign Investment Review Board recently warned Chinese state-owned investors 'not to invest here for political purposes'.[311] Elsewhere, Chinese, Korean and Japanese SOEs have taken stakes in the world largest niobium mine at Araxá, owned by Brasilian Companhia Brasileira de Metalurgia e Mineração (CBMM).[312] BHP Billiton's attempt at a hostile take-over of the Canadian Potash Corporation was torpedoed by the Canadian government under the Investment Canada Act, which allows regulators to block foreign direct investments exceeding 330 million Canadian dollars if they are deemed to counter national interests.

If access to resources is key to future competitiveness, could SOEs help to ensure that domestic industries are fed cheap resources such as energy and steel by tying up resource deals overseas? So far the evidence is mixed – for example, much of the oil produced by Chinese state companies is sold directly onto the international markets. It is possible that physical ownership of assets and supply chains could be an advantage in times of major crisis – that is, in the last resort, SOEs would help secure supplies from a dependent group of exporters – but access to functioning global markets remains the best source of resource security for most countries.[313]

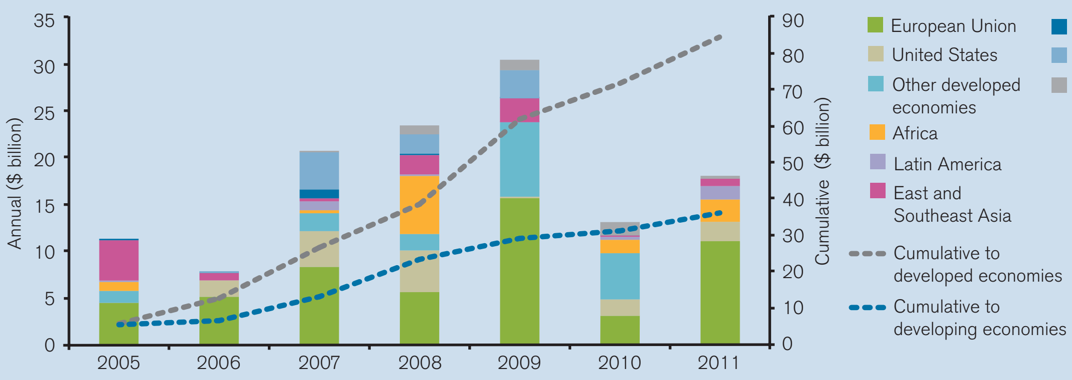
Private-sector companies complain that SOEs are operating with unfair advantages. Because of their higher risk appetite, concessional finance or political connections, SOEs seem able to access investment opportunities that are effectively off-limits to international corporations. The principle of non-intervention in domestic political issues followed by some of the owner-shareholder governments of these companies undoubtedly also facilitates their entry. SOE investments in these challenging investment environments could be seen as a boost to resource security at global level, but the fear is that SOEs are carving out large chunks of international resources markets. This potentially undermines the role of a diverse and flexible trading system in underpinning resource security.[314]

Box 5.5: Foreign direct investment by sovereign wealth funds

The primary objective of sovereign wealth funds is to contribute to their home economies' macroeconomic development. Commonly, SWFs place their funds in relatively liquid financial assets, putting only a small portion of their value (approximately $109 billion) into direct investments in productive assets. FDI by SWFs accounted for less than 5% of their assets under management, and less than 1% of global FDI stock, in 2011.[315]

The share of developing-country SWFs in global FDI has been falling since 2005 – from a third in 2005 to a quarter in 2011.[316] Owing to a surge in the availability of acquisition opportunities in North America and Europe during the global financial crisis, there has been a redirection of funds to developed economies, which accounted for an average of 74% of FDI by SWFs in 2008–11 (Figure 5.5). This is likely to be a temporary phase; in future SWFs are expected to invest a growing share directly in emerging economies.[317]

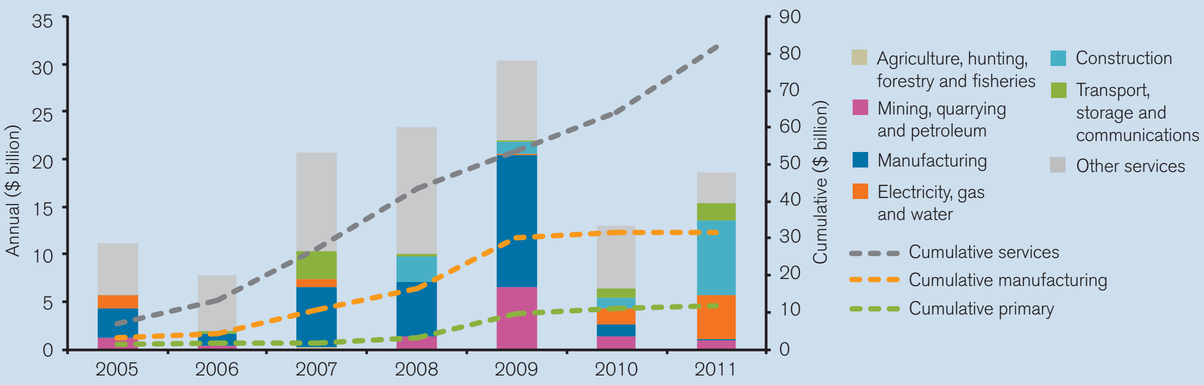
Figure 5.5: FDI by SWFs according to host region, 2006–11



Source: UNCTAD (2012).

Such investments centre around natural resources, real estate and banking (see Figure 5.6), directly reflecting the strategic aims of the few SWFs active in FDI, such as Temasek, China Investment Corporation, the Qatar Investment Authority and Mubudala.[318]

Figure 5.6: FDI by SWFs by sector, 2006–11



Source: UNCTAD (2012).

5.1.2.2 Long-term contracts and land acquisitions

Keen to secure access in an era of potential resource scarcity, importer states including Middle Eastern countries (for food) and China (for most raw materials) are intensifying economic, trade and political links with major producing regions. Examples of these initiatives abound, including investments by Gulf states in large-scale land deals in Africa and Southeast Asia – mainly food-producing regions. Preliminary research indicates that Middle Eastern countries account for over a fifth of reported investments in sub-Saharan Africa.[319] Similar examples include Chinese engagement in extractive industries in Africa and Australia.

Land acquisitions and similar investments are targeting countries with the weakest institutions and governance

These investments have been referred to pejoratively as 'land grabs' (or 'water grabs'). A World Bank study in September 2010 found that over 46 million hectares in large-scale farmland acquisitions or negotiations (probably an underestimate) were announced between October 2008 and August 2009 alone, with two-thirds of the land in sub-Saharan Africa.[320] Of these projects, 37% related to food crops, 21% to cash crops and 21% to biofuels; in only 21% of cases, however, had farming actually started, with the rest in various stages of discussion and development. These investments often took the form of long-term (25–99-year) leases, rather than purchases, often because of constitutional prohibitions on land sales to foreigners. More recent research from the International Land Coalition has identified 203 million hectares of land deals under consideration or negotiation between 2000 and 2010 – an area over eight times the size of the United Kingdom – of which 134 million hectares were in sub-Saharan Africa, with biofuel production being the principal driver.[321]

Clearly, these investments could bring benefits to the host country, not only by injecting investment capital but also through accompanying investments in infrastructure, new sources of employment, the transfer of skills and increases in agricultural productivity. Equally clearly, however, there can be negative impacts, particularly if the host country has poor levels of governance and a high degree of corruption. Worryingly, the World Bank's research found that investments were targeting precisely those countries with the weakest institutions and governance. The transfer of wealth and skills may be lower than expected, particularly if the investing country brings in its own workforce; local producers may be displaced and local techniques of production replaced by (possibly less environmentally sensitive) high-intensity methods; and land may be locked up for speculative purposes. Even if the local impact is positive, growing volumes of production are effectively taken outside world markets and insulated from normal patterns of supply and demand.

Such land acquisitions may also arouse national political opposition. Brazil and Argentina, among others, are legislating to limit the size of agricultural properties that can be purchased by foreign entities. The previous government of Madagascar fell amid national outrage at a huge land concession granted to the South Korean investor Daewoo. At the local level, communities and civil society organizations have mobilized against investments in countries across Africa, with conflict and violence ensuing in some cases.

Asian investment in extractives projects and oil and gas transportation infrastructure has rocketed over the last fifteen years in response to growing import dependence and efforts to diversify supplies. In several cases, there has been a return to investments tied to long-term oil and gas supply contracts. These are unlikely to specify set prices over time but rather involve lines of credit, investment packages for the host country and diplomacy to secure government supply agreements and/or pipeline transit.[322] For example, in 2009 the China Development Bank (CDB) lent Russian company Rosneft $15 billion over 20 years (at an average rate of 5.69%) to help develop its Far East oil fields as part of an agreement to receive 300,000 barrels of Russian crude oil per day at market prices between 2011 and 2030. At the same time, CDB lent Transneft $10 billion for construction of a pipeline link to transport the contracted volumes of oil to China.[323]

Asian foreign resource investment has also evolved from stakes in high-risk conventional oil and gas exploration acreage to purchasing shares in producing projects and companies in new strategic areas such as Brazilian deepwater, Canadian oil sands and US shale gas. For example, CNOOC spent $2.1 billion in 2010 to acquire a 33.3% interest in Chesapeake's 600,000 net acres in Eagle Ford Shale, in the US.

Box 5.6: Power plays in Afghanistan's mining sector

As a result of its complex geological history, Afghanistan contains rich mineral resources: gemstones, metals such as copper, gold and iron and valuable reserves of gas, oil and coal.[324] Developing the country's mining sector is a strategic priority for the Afghan government. Several large new concessions have been tendered, and oil and gas installations are being developed. At least 108 contracts have been signed already, leading to concerns among local and international NGOs of an ill-prepared rush to develop the sector that puts Afghanistan in a poor negotiating position, with the risk of exacerbating corruption and causing serious environmental and social impacts.[325]

Two major contracts, signed with state-backed Chinese and Indian firms, have attracted particular attention as they may reveal larger strategic interests at work. The 2007 agreement with the Metallurgical Corporation of China (MCC) aims to develop the country's largest copper deposit at the Aynak mine, 30 km to the south of Kabul. Containing an estimated 11 million tonnes of copper valued at $88 billion, the Aynak deposit is one of the biggest in the world. Development has been slowed by the discovery of an ancient archaeological site, by difficulties in developing infrastructure and by concerns over security, but officials say that they 'hope' production will begin by 2016.[326] Some analysts have expressed scepticism that the Chinese government is fully committed to developing the mine, suggesting that the contract might be part of a larger 'play' to manage prices on the global copper market.[327]

A 2011 agreement to develop a world-class deposit of 1.8 billion tonnes of iron ore at the Hajigak mine in Bamiyan province, 100 km west of Kabul,[328] was signed by a consortium of seven Indian companies led by the Steel Authority of India Limited (SAIL). The consortium promised to invest $11 billion in Afghanistan to develop the mine, construct a power plant and railway and build a plant capable of processing 6 million tonnes of steel per year.[329] This contract comes hard on the heels of a 'strategic partnership' on security, trade and cultural issues signed between India and Afghanistan the same year. The investment has rung alarm bells in Pakistan, which fears that it is part of a wider move by its old rival India to reduce Pakistan's influence in Afghanistan.[330]

5.1.2.3 New sources and new supply routes

Expanding the supply of many resources will mean a shift in production to ever more challenging technical environments: poorer-quality soils, deeper wells and lower ore grades. Although the specific consequences of this shift vary according to the sector and with consideration of local conditions, this overall shift to more marginal and unconventional production is likely to bring common challenges:

Expanding the supply of resources will mean a shift in production to ever more challenging technical environments

- ***Ecological impacts associated with land-use change***, including in pristine environments – such as energy and minerals production in the Arctic and the conversion of rainforests into agricultural areas.
- ***Increasing production in climate-sensitive areas*** – for example, where future water availability is uncertain or infrastructure is exposed to rising sea levels and melting permafrost.
- ***Risks of technological failure*** – especially where production takes place in extreme environments, such as deep-sea oil and mineral extraction. The expected rise in extreme weather events due to climate change will exacerbate these risks.
- ***More resource-intensive production*** – extraction of unconventional energy sources such as shale gas and tar sands uses far more water and affects more land than extraction of conventional fuels. Agricultural production in areas of poor soil quality also requires additional land and water for the same output. (See Section 4.3 for discussion on competition for water between sectors.)
- ***Urgency of accelerating innovation*** – prices will climb to unaffordable levels unless innovation can keep pace with rising production costs. This includes production of lower-quality ores; substitution for alternative resources; efficient extraction of materials from waste; and drought-tolerant seeds suitable for developing countries.

Today, fear of future resource scarcity and the associated high commodity prices are driving resource exploration and development in more challenging terrains. For example, the Arctic regions have been known to contain oil and gas for over two centuries, yet the high risks associated with a remote, ice-bound or ice-infested and unpredictable environment mean that commercial development has only been undertaken in response to scarcity concerns and high international prices. Government support for domestic production prompted by the first oil shock of 1973 and the wave of oil industry nationalizations led to a decade-long boom in the US and Canadian parts of the Arctic in the 1970s.[331]

While interest waned during the late 1980s and 1990s as oil prices collapsed, high prices and perceived future scarcity – along with technology evolution and temperature increases – have brought the Arctic back into strategic calculations of exporter and importer governments. The desire of producing-country governments to maintain and increase their resource rents in the long term is another key factor. The Russian government, for example, is counting on Arctic gas from the Yamal peninsula to compensate for declining gas production elsewhere in the country. It intends to use Arctic production to allow it to keep to its European commitments while attempting to capture a part of the growing Asian gas market. For this, it needs foreign investment and while Russian tax and investment terms are considered unattractive in other areas, the terms for Yamal's LNG development are described as being 'among the lowest in the world'.[332]

As described in Sections 3.3.2 and 4.3, land for food production is coming under increasing pressure from competing uses, with good cropland being lost to urbanization and industrial development, or being put to alternative uses such as biofuel production and reforestation. Losses of high-quality cropland are expected to continue owing to the higher returns available from non-agricultural uses.[333] In response, agriculture is gradually shifting onto more marginal lands, with poorer soils and less developed infrastructure, and a particular focus on sub-Saharan Africa where the largest reserves of arable land remain.

The displacement of agriculture to more marginal and climate-vulnerable regions presents obvious challenges. As well as having lower productive potentials, these areas have weak infrastructure and are generally more susceptible to production shortfalls, particularly as climate change gathers pace and more extreme climatic events become more common.

The case of fisheries highlights how, increasingly, scarcity of resources can lead to growing competition and potential conflict. Competition over stocks and the potential for accessing new stocks is, for example, raising tensions between states in the East and South China Seas and the South Atlantic. Conflicts have arisen between local fishing communities and outside fishers (particularly large-scale commercial operations) as well as within local fishing communities. Competition over fishing grounds has also helped to fuel existing social and ethnic tensions in some regions, such as the communities around Lake Chad[334] and coastal populations in Southeast Asia.[335]

Given the importance of fishing to livelihoods in many poor and rural areas, over-fishing can have other effects on security. Analysts have linked the rise of piracy off the Horn of Africa in recent years, for example, with the inability of the Somali state to prevent the overfishing of Somali waters by European, Asian and African ships.[336] The reduction in fish stocks essentially raises the cost of legitimate livelihood. As one account puts it, 'in a region where legitimate business is difficult, where drought means agriculture is nothing more than subsistence farming, and instability and violence make death a very real prospect, the dangers of piracy must be weighed against the potentially massive returns.'[337] Some pirates have even used this as a justification for their actions, arguing that they are protecting their resources and that ransom payments should be seen as a form of legitimate taxation.[338] Overfishing also played an important role in the development of piracy in Southeast Asia.[339]

The rise of piracy off the Horn of Africa has been linked with the inability of the Somali state to prevent overfishing by European, Asian and African ships

Box 5.7: Resource conflict flashpoints

While the existence of competing sovereignty claims or the reliance by multiple states on a transboundary resource[340] does not necessarily mean that conflict is inevitable, a number of areas can be thought of as potential flashpoints in the coming decades. Such flashpoints can both spark new disputes and be used for political advantage in existing conflicts.

Territorial/economic zone disputes in resource-rich areas[341]

- The East China Sea, where China and Japan, and to a lesser extent Taiwan and Korea, continue to dispute maritime borders. The discovery of hydrocarbon deposits has exacerbated existing tensions over fisheries, and led to several violent and non-violent confrontations.
- The South China Sea, where China's claim to historical sovereignty is not accepted by several countries, including Vietnam, the Philippines, Malaysia, Taiwan and Brunei. Hydrocarbon deposits and fishing rights are again the main sources of tension.
- The Eastern Mediterranean, where Israel, Lebanon, Cyprus and Turkey disagree over the ownership of recently discovered offshore gas resources; the issue is complicated by the historical tensions generated by the creation of the state of Israel in 1948 and by the division of Cyprus.
- The South Atlantic, where Argentina continues to dispute the UK's right to hydrocarbons and fisheries exploitation round the Falkland Islands.
- The Arctic Ocean, where the gradual break-up of the ice cap under the impact of climate change is opening up the possibility of the exploitation of mineral and hydrocarbon deposits.[342]
- Sudan and the newly established state of South Sudan, where a dispute over the ownership of oilfields (heightened by the fact that South Sudan is entirely landlocked and therefore unable to transport its oil independently) led some commentators to discuss the potential for war over oil profits in early 2012[343] following ongoing violence in and around the Heglig oilfields.[344] Despite progress on a negotiated solution, both countries still have unresolved border disputes.
- Between China and OECD countries and other emerging economies, where competition is likely over access to resource bases in Africa, Asia and Latin America.

Shared water resources and transboundary river systems

- The Nile basin, where Ethiopia and Sudan have both expressed an interest in constructing dams on the Nile to generate electricity. On several occasions Egypt has stated its view that any upstream interference with the Nile waters would be regarded as an act of aggression; in 2010, Egypt and Sudan both declined to sign the Cooperative Framework Agreement seeking to develop access to the Nile's resources.
- Lake Chad, where the rapid drying of the lake is forcing herders to seek new pastures and exacerbating existing tensions between Nigeria, Cameroon and Chad over access to increasingly scarce water in this area, even after the International Court of Justice settled a border dispute between Nigeria and Cameroon involving more than 30 Lake Chad villages in 2002.
- The Indus basin, which provides water for over 80% of Pakistan's irrigation needs. Despite the robust nature[345] of the Indus Waters Treaty,[346] increasing tensions between India and Pakistan (in part due to Indian dam projects upstream of the disputed territories of Jammu and Kashmir) have fed the hostile narratives of extremist groups such as Lashkar-e-Taiba[347] and of prominent nationalists on both sides.[348]

Resource-related rebellion and insurgency

- In the Congo basin, various rebel groups, Rwandan, Ugandan and Zimbabwean troops fought each other for control of diamonds, gold, coltan and other minerals, and timber, from the late 1990s in a conflict that has yet to be resolved.

- The Niger Delta region of southern Nigeria has been plagued by a rebellion, mainly (but not exclusively) driven by the unequal distribution of oil and gas revenues and the continued underdevelopment of the region despite the success of foreign companies, particularly in exploiting oil reserves. The Movement for the Emancipation of the Niger Delta (MEND), a conglomerate of rebel and paramilitary groups, has become notorious for high-profile attacks and kidnappings of foreign oil workers. Despite a reduction in militant activity following government negotiations and an amnesty in 2009, renewed attacks in 2012 (including on police checkpoints and pipelines) have been linked to continued perceptions of marginalization and inequality.[349]
- Oil exploration in the Somali region of Ethiopia (in an area that also includes the Calub and Hilala natural gas fields) has provoked a violent response from the separatist Ogaden National Liberation Front. An attack by the group on a Chinese oil rig in 2007 resulted in 74 deaths, and it has claimed responsibility for attacks in the last three years including one that killed a British geologist working for Petronas.[350]
- In Russia, high revenues from oil and gas are likely to strengthen elites and stall the reform agenda, leading to domestic discontent.
- In India, higher food prices may lead to discontent and riots, especially in the poorer north and east. Depleting groundwater reserves are likely to reduce agricultural production and trigger internal unrest and tensions with neighbours. Pressures to increase mining (e.g. of iron ore), resulting in further forced internal migration such as evicting peasants from their land and power outages, could affect business, industrial productivity and social cohesion.

5.1.3 Market manipulation and cartels

Domestic politics in oil-producing states suggest that OPEC will work to support a rising international oil price. High population growth and generous social spending increases in the wake of the Arab uprisings are squeezing budgets in key oil exporters: since 2007, government spending in several OPEC countries has risen in the region of 50–60%. Budget cuts are likely to be politically damaging, so instead, governments will continue to work together through OPEC to target a sufficiently high 'fair' or 'preferred' oil price. For example, the Saudi minister of petroleum stated that $35 per barrel was a fair price for oil in 2004–05; by 2010, this had risen to $70–80 per barrel and in early 2012 it was around $100 per barrel.[351] In the longer term, however, as Saudi Arabia is acutely aware, the targeting of higher price levels is likely to undermine rather than strengthen OPEC (see also Box 5.5).

More generally, with resource scarcity expected to persist, and production often concentrated among a few major exporters, the question is not whether OPEC will continue to exist, but whether it will be joined by new international cartels in other resource markets.

Where countries share political, cultural or economic ties collusion may be more easily initiated and sustained. In food markets, the risks of cartel formation are probably most pronounced at the regional level. For example, in wheat the potential for a Black Sea cartel was mooted at the 2009 World Grain Forum in St Petersburg,[352] but the OECD membership of other major exporters (such as Australia, the US, Canada and France) makes a global cartel unlikely. Similarly, for soybeans a regional cartel in South America including Brazil, Argentina, Paraguay and Uruguay is more plausible than a global one that also includes the US. In Asia, fears of a rice cartel surface regularly, particularly surrounding the long-term intentions of the ominously named Organization of Rice Exporting Countries consisting of Cambodia, Laos, Burma, Thailand

and Vietnam. These fears may be well founded: at a recent ASEAN summit, the Cambodian prime minister campaigned for the five countries to form an export cartel.[353] The almost exclusive concentration of palm oil production within neighbouring Indonesia and Malaysia and the close commercial ties between the two production centres would make the establishment of a palm oil cartel relatively straightforward.

There are few indications of cartel formation among producers of metals, but risks of market manipulation emerge on two fronts. First, many countries are dominant producers in individual speciality metals; these include China for rare earths, Brazil for niobium (mainly used in the manufacture of extremely high-strength steel) or the US in the case of beryllium (used in military and aerospace equipment because it increases hardness and reduces corrosion when alloyed with other metals). The rare earths case clearly demonstrates that monopolistic production structures for individual metals can result in attempts at price manipulation and trade restrictions aimed at subsidizing valuable downstream industries. These practices are also driving attempts to bring supplies online elsewhere.

A more serious threat to the functioning of international metals markets is the growing concentration at company level. Large economies of scale and consecutive rounds of mergers and acquisitions over the past decade have resulted in oligopolistic market structures. Three companies – Vale, BHP Billiton and Rio Tinto – now control over 70% of the lucrative sea-borne iron ore trade and an even larger share of the vital transport infrastructure in the mining industry. Similarly, just three companies control over 60% of platinum production.[354] Another series of large-scale mergers in the global mining industry could lead to further growth in producer concentration and significantly increase the risk of market manipulation by industry players.

Box 5.8: OPEC's future role

OPEC is likely to retain and increase its significance to the world oil market – particularly with the potential re-inclusion of Iraq in the quota system. OPEC's share of oil production (around 40% today) is likely to increase as many major fields in other areas face decline and incremental additions are unlikely to fill the gap. However, its ability to act cohesively to regulate price through either the release of spare capacity or the reduction of export volumes may be weakened by a combination of diverging member-country interests over price and rising domestic and industrial consumption. Rising domestic fuel demand and lack of infrastructure to import gas in Saudi Arabia, for example, could jeopardize that country's ability to increase volumes to the global market at short notice in the event of a crisis as its spare capacity declines.

Paradoxically, the increasing oil prices needed to sustain growing OPEC economies mean that the significance of the oil market itself will wane over time as responsive policies and investment make substitute fuels and technologies competitive. This has been a long-term fear of OPEC leaders – particularly Saudi Arabia – manifest in the fairly recent drive to accrue knowledge and build capacity in areas of new energy technology and 'green' oil fuels. OPEC members are banking on continually rising demand in transportation in Asia – particularly China and India – to offset declines in the OECD. If the Asian transport demand trajectory looks in danger of being disrupted by (potentially a combination of) new technology, subsidy reform policies and lower growth, OPEC may scramble to produce more in the short term in order to maintain oil's competitiveness.

5.2 Efforts to reduce demand

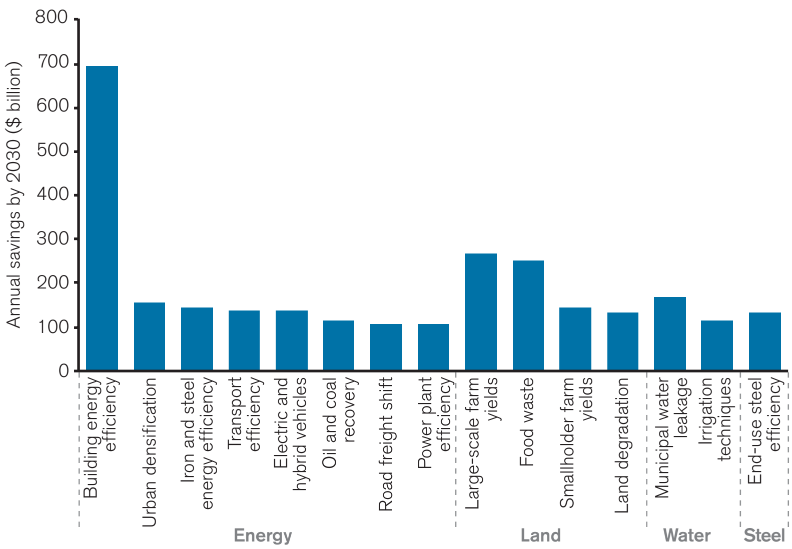
On the positive side, there are now serious attempts to reduce demand, either through improving the efficiency with which resources are used, or through seeking alternatives to scarce resources. There is a defensive aspect to these moves: ensuring that industries will remain competitive in the event of a supply disruption and avoiding macro-economic exposure to a price spike. But increasingly, companies are recognizing that new business models can give them a competitive advantage in a world of high and volatile resource prices.

Companies are recognizing that new business models can give them a competitive advantage in a world of high and volatile resource prices

5.2.1 Resource efficiency

A more efficient economy is more competitive and less exposed to price fluctuations on global markets. Consumers would benefit from lower and more predictable bills. Efficiency savings offer enormous economic potential. McKinsey identified 130 opportunities to increase resource productivity, which together could reduce demand for different types of resources in 2030 by 13–29% – offering at that point $2.9 trillion in global savings per year.[355] Three-quarters of these savings could be realized by implementing 15 priority measures (Figure 5.7), with energy-efficient buildings topping the list.

Figure 5.7: Estimated annual savings by 2030 from potential resource efficiency measures



Calculations assume a 4% discount rate, an oil price of $105 per barrel, a steel price of $716 per tonne, a carbon price of $30 per tonne, and water prices of $0.10, $0.90, and $1.50 per cubic metre for agricultural, industrial and municipal water use respectively.
Source: McKinsey (2011).

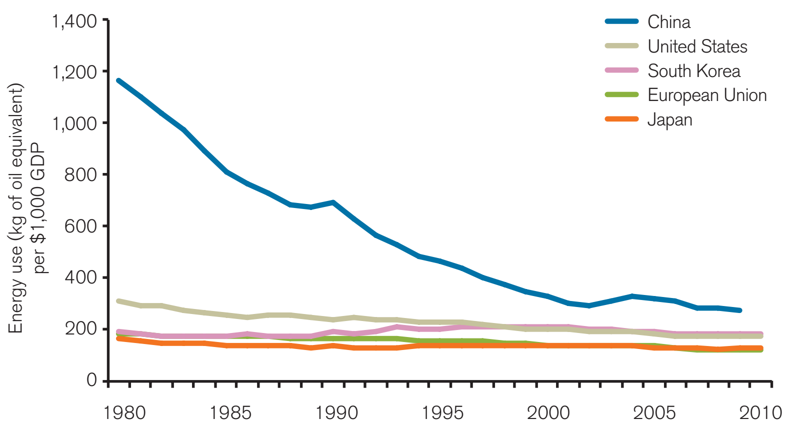
Building energy efficiency, in particular, offers a huge commercial opportunity. According to the World Business Council for Sustainable Development (WBCSD), investments of $150 billion annually out to 2050 could reduce energy use in buildings by 40% with an average discounted payback of five years or less.[356] The World Economic Forum (WEF) suggest that $2 trillion (1.7% of GDP) of economic output would be put at risk by 2030 if the major global economies fail to address the potential supply gap in steel and iron.[357]

The WEF also suggests that applying resource-efficient approaches and increasing recycling rates could avoid costs of $47 billion in 2030, equivalent to cutting steel costs by half.[358]

Improving resource efficiency faces significant barriers such as inappropriate pricing, and lack of technology, human capacity and finance

Although improving resource efficiency is often seen as a 'quick and cheap win' among the array of policy instruments, in practice significant barriers exist, including inappropriate pricing (see the discussion on subsidies in Section 3.1), lack of awareness, lack of data on which to base measures and lack of technology, human capacity and finance. Further concerns have been raised about the extent of the rebound effect, whereby reductions resulting from improved efficiency are reduced if any savings lead to greater activities in other resource-using areas.[359] Economic uncertainty during an era of austerity has, for many, introduced further complexity to the introduction of ambitious resource efficiency measures and the overhaul of energy systems.

Figure 5.8: Energy intensity in selected countries, 1980–2010



Source: World Bank WDI (2012).

At the national level, however, many countries have been encouraging greater energy efficiency for several decades, and governments are increasingly introducing policies on water efficiency as well as sustainable production and consumption. The experience of Japan in the 1970s – where the government's introduction of a set of radical policies following the oil shocks meant the Japanese economy quickly became the most resource-efficient in the world – powerfully demonstrated the impact of efficiency policies. Japan's relative advantage over other countries diminished after 1990 as ambition dipped in the face of the increasing costs linked to scaling up energy efficiency and growing domestic demand and consumption. Despite this, in 2009 Japan was still, by a factor of almost 20, more resource-efficient than the country with the lowest resource efficiency among its Asian neighbours, Indonesia.[360] There are also large differences in resource productivity among advanced economies, with the energy intensity of countries such as Japan and Germany, for example, approximately 30% below that of the US (see Figure 5.8).

In the wake of the Fukushima disaster, Japan has stepped up efficiency-related policies once again. Concerns over energy shortages triggered a government-led push to increase energy efficiency in the power sector. Utilities were directed to introduce energy efficiency measures to curb peak electricity consumption by 15%. In the area serviced by the Tokyo Electric Power Company (TEPCO), for example, energy consumption in the aftermath of the disaster fell by 18% for small businesses, 17% for households, and 15% for heavy industries. While 40% of this reduction was due to the direct effects of the tsunami and earthquake, a further 35% was achieved through the introduction of new energy efficiency measures.

In China, efficiency measures have focused on industry and the power sector.[361] The country has developed a broad range of policies to tackle resource efficiency for energy, underpinned by national carbon intensity targets. Key programmes include a 'top-1000 industries' scheme to upgrade the energy efficiency of major industrial companies, a 'circular economy' programme to increase recycling rates and industrial ecology practices, and resource taxes to encourage efficiency. By 2020, industrial energy consumption per unit of added value is scheduled to drop by 40% compared with 2005, avoiding around 1.5 billion tonnes of coal equivalent.[362] These efficiency policies are intimately linked to China's wider development strategy and the upgrading and reorganization of its industries with the aim of boosting its international competitiveness.[363]

Transport and electrical appliances are two other crucial areas of efficiency policy. The average fuel consumption of new passenger vehicles in the EU, for example, fell by more than a third from 1975 to 2003, and is continuing to decline as EU-wide standards are enforced. Over 50 countries have standards and/or labelling programmes for appliances, and these have already resulted in substantial energy savings. The EU labelling scheme helped increase refrigeration efficiency by 25% between 1992 and 1999. Many countries, including China, are considering introducing a scheme similar to Japan's Top Runner Standard, which was launched in 1998. This requires products to catch up with the performance of the best available technologies on the market within a certain period, with periodic reviews, ensuring continuous improvement in efficiency levels across a wide range of demand-side products. Top Runner uses a corporate average approach that allows businesses more flexibility in meeting the target than a fixed 'minimum performance standard'.

Efficiency largely remains a national (or corporate) policy exercise – there has been slow progress on international target-setting. At the clean energy ministerial in 2012, governments committed to double the rate of global energy efficiency improvements by 2030, but with insufficient detail to make this a practical goal as yet. Even within the EU, the 2020 energy efficiency target was not adopted as mandatory, weakening its potency relative to the target for renewable energy. For other resources very little has been agreed internationally – after ten years of negotiations, a framework for an action plan on sustainable production and consumption was adopted at Rio+20, but actions by individual countries are voluntary. Sustainable production and consumption will be central to negotiations around the Sustainable Development Goals, which governments have agreed to set by 2015.

Efficiency largely remains a national policy exercise. There has been slow progress on international target-setting

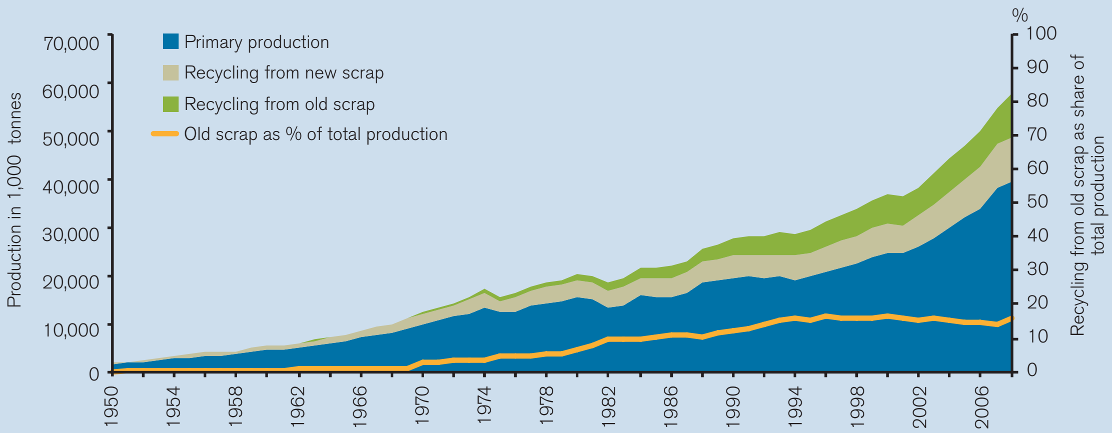
Box 5.9: Metals recycling

Using metal scrap instead of ores for metals production offers large resource efficiency gains – carbon emissions and energy and water use from mining are saved, while most of the resource-intense processing and refining steps can be avoided. Producing aluminium, nickel, lead and tin from scrap rather than through mining and refining reduces energy consumption by over 90%. For copper, the savings are still over 60%.[364] Carbon reductions are also large, with steel recycling, for example, avoiding over half the carbon emissions of production from iron ore.

The metals recycling industry has grown rapidly over the past decade, but the mining sector has grown even faster.[365] Even for aluminium, one of the most intensely recycled metals, end-of-life ('old scrap') recycling accounts for less than a fifth of total supply – and this share has not increased since the early 1990s (Figure 5.9).[366] For most other metals, the recycling shares are considerably lower. Stepping up recycling rates will require improvements in product design, collection infrastructures and separation technologies as well as stronger incentives.

The large stocks of metals in landfills have largely been ignored as a source of valuable scrap.[367] Looking forward to 2030 and 2040, recycling from such 'urban mines' may become an important source of supply for metals with rapidly declining ore grades such as copper.

Figure 5.9: Aluminium production and recycling



Source: Chatham House calculations based on IAI data.[368]

To improve resource efficiency and supply security, many countries are seeking to improve recycling efforts. The European Commission recently introduced a Raw Materials Initiative strategy document with a view to improving the functioning of recycling markets. Suggestions include developing best practices in collection and treatment of waste, improving the availability of certain statistics on waste and materials flows, and supporting research on economic incentives for recycling.[369]

Under its circular economy programme, China's production of secondary (i.e. recycled) non-ferrous metals production is expected to expand to 3.8 million tonnes (Mt) of copper, 5.8 Mt of aluminium and 1.5 Mt of lead by 2015, accounting respectively for 58%, 29% and 30% of total production of these metals. Secondary steel production will also grow rapidly – and because less energy is required than for primary production from iron ore, this will avoid 200 Mt of CO_2 emissions by 2020.[370]

Chapter 5

5.2.2 Substitution and advanced materials

Industrialized countries and companies are looking to increase the resilience and flexibility of manufacturing by using substitute resources or developing alternative approaches. Japan and the EU recently agreed to synchronize their research efforts to reduce their vulnerability to a supply disruption in critical resources.[371]

Japan and the EU recently agreed to synchronize their research efforts to reduce their vulnerability to a supply disruption in critical resources

The recent concern over access to rare earth elements highlighted the importance of perceived scarcity as a driver for such innovation. Rare earths are frequently used in many high-tech products, including the permanent motors of hybrid electric vehicles. The New Energy and Industrial Technology Development Organization in Japan is supporting efforts to substitute alternatives or reduce use in permanent motors. This has encouraged Hitachi, for example, to develop a motor that uses a new magnetic material based on ferrous metal instead of neodymium and dysprosium.[372] Magnets in large wind turbines could also be produced without rare earth elements, although they are currently still lagging in their performance relative to rare earth-based turbines. Innovators are also tackling alternatives to the rare earth content in phosphors used for light emitting diode (LED) and compact fluorescent (CFL) efficient lighting solutions.

Innovation is also focused on advanced materials that improve mechanical or electrical performance or require fewer resources. For example, the drive to improve fuel efficiency in key markets is accelerating the use of lightweight automotive composite components to replace metal parts.[373] Advanced steel materials can also reduce the need for the material in buildings and vehicles, but at the same time alternative metal alloys, composite materials and glass-reinforced and fibre-reinforced polymers are increasingly common in commercial construction – where they could displace concrete and steel.[374] Biofuels are another example of the substitution of resource inputs, although to date Brazil is the only major economy to have decisively reduced its dependence on fossil fuels in the transport sector. Another area of research relates to the use of biomass feedstock to make chemicals, avoiding the use of fossil fuels.

Nanotechnology has the potential to enhance the novel properties of certain critical minerals or even open up entirely new avenues for alternative product designs. For example, nano-sized rare earth compounds are being considered in magnets, batteries, fuel cells, hydrogen storage and catalysts.[375] Scientists at Japan's National Institute of Advanced Industrial Science and Technology (AIST) have developed an advanced composite material partly consisting of multi-walled carbon nanotubes which, when used in dye-sensitized solar cells, exhibits a photoelectric conversion efficiency as high as that of the conventionally used platinum.[376] The US Department of Energy's national laboratory sees nano-structured permanent magnets as a key strategy for lowering the rare earth content in permanent magnets.[377]

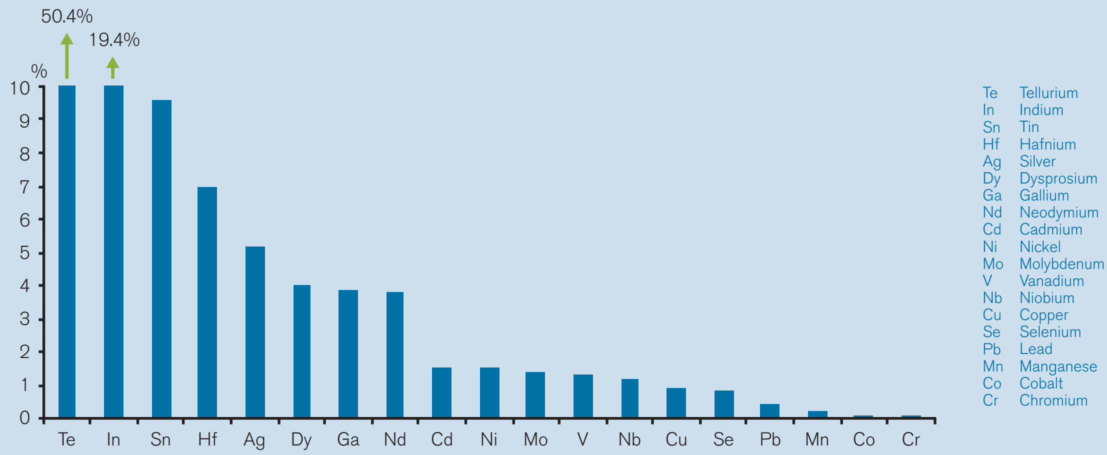
Box 5.10: Advanced materials for the low carbon energy transition

The transformation of the global energy system is bringing new pressures on the supply of metals and other raw materials. New technologies for energy generation (e.g. wind and solar), storage (e.g. novel types of batteries) and consumption (e.g. electric cars and energy-efficient lighting) often rely on innovative advanced materials for their performance. Many of these advanced materials are in turn based on the unique physical and chemical characteristics of speciality metals and minerals such as rare earths, indium, lithium or flake graphite.

Scaling up the use of these new energy technologies is creating new demand pressures in speciality metals markets. Between 2010 and 2015, the use of rare earths in permanent magnets (e.g. in wind turbines and electric cars) and phosphors (e.g. in energy-efficient lighting), for example, is projected to increase by half – even after taking into account significant demand destruction following high prices and concerns about supply security.[378] Rapid demand growth has also occurred for other speciality metals in recent years, but could accelerate further if technologies such as electric vehicles take a significant share of the market.[379] A recent study indicated that the implementation of the European Strategic Energy Technology (SET) Plan would create significant additional global demand for at least 14 different metals including the rare earths neodymium and dysprosium, as well as indium and gallium.[380]

Because the markets for most speciality metals are small and inefficient, they are typically unable to respond to such demand bursts. This results in price spikes and sometimes in temporary physical shortages. Such market disruptions could slow the deployment of green technologies and lead to diplomatic tensions where states try to intervene in such market dynamics, as has been recently demonstrated in the rare earths case.

Figure 5.10: Estimated additional annual demand between 2020 and 2030 for various metals due to the EU SET Plan (as % of 2010 world supply)



Source: Moss et al. (2011).

5.2.3 New business models moving towards a more 'circular economy'

For much of the last century, corporate strategies and business models were built on the assumption of cheap and stable resource prices.[381] The World Economic Forum has called for a paradigm shift in business models 'to enable growth through resource efficiency, closed loops and decoupling at a systems level'. It argues that this is a core strategic imperative for any company that intends to thrive and grow – avoiding costs, generating new revenue streams and preparing for a tougher regulatory environment and greater public scrutiny.[382]

The 'circular economy' offers a radical vision for reshaping resource use in the economy. Since the 1970s academics have been calling for a rewiring of industrial structures along ecological lines, to ensure that waste from one factory becomes a useful resource for another; that products are made from sustainable materials; and that consumer products can be repaired and 'remanufactured' or are designed to biodegrade safely. The OECD has also explored options for scaling up sustainable materials management, especially in waste reduction, and encouraging consideration of life-cycle issues.[383]

Several factors lie behind the resurgence of optimism around this vision. First, the circular economy could deliver business models fit for a resource-constrained world. Second, innovation in key areas such as information technology and advanced materials has opened up avenues that were previously unavailable, including the ability to track and optimize the use of resources along global supply chains. Third, many governments have become more active in their support for high-tech manufacturing industries and in policies related to resource efficiency. Finally, while few companies have fully made the transition to a circular business model, many have invested in innovation and introduced experimental product ranges in the last few years.

The 'circular economy' could deliver business models fit for a resource-constrained world

Both governments and business are waking up to the economic opportunities available if circular economy business models can be taken to scale. The Ellen MacArthur Foundation suggests that if even a subset of the EU manufacturing sector adopted circular-economy business models, it could realize net materials cost savings worth up to $630 billion per year by 2025.[384] Reusing and repairing equipment, rather than producing a new item from virgin material, can deliver dramatic energy, water and resource and cost savings, yet it is not always in the interests of manufacturers to encourage longer product life, and third-party providers can be frustrated in their attempts to supply these reuse markets. It is important to ensure that remanufactured products are brought up to the performance of best-in-class technologies, to take into account innovation over time.[385]

5.2.4 Sustainable consumption

It is widely acknowledged that consumption patterns may need to be adapted in the face of future resource constraints and the effects of climate change. However, there have been varied responses to regulating consumption to increase sustainability across sectors and from different actors (government, the private sector and civil society). Exploration of legislative interventions in the form of efficiency standards, certification and labelling and accounting and taxing systems has increased significantly in recent years, but such measures have experienced varying levels of take-up and success.

In addition to effective legislative options, behavioural change remains key to increasing sustainable consumer patterns in the long term, particularly during a period of rapid population growth. There have been many attempts to encourage more sustainable consumption through information campaigns, public education and labelling of products. Yet despite a proliferation of eco standards and labels over the last 60 years, non-aligned regional and international frameworks to support and enforce them remain stumbling blocks in some sectors and countries.

Box 5.11: Legality, certification and deforestation

Governments and other stakeholders have developed a range of policy and technical responses, including domestic legislation, non-binding international agreements to conserve forests, and financial mechanisms to support these agreements. Yet success to date has been patchy: the rate of global deforestation – mainly caused by the conversion of tropical forest to agricultural land – has slowed, though it continues at a high rate in some countries. Around 13m ha of forest were converted to other uses or lost from natural causes each year between 2000 and 2010, a fall from 16m ha per year in 1990–2000.[386] However, this was offset to a degree by large-scale planting of trees in some countries and some natural forest expansion; the net loss of forest area in 2000–10 is estimated at 5.2m ha (an area the size of Costa Rica) per year, down from 8.3m ha per year in 1990–2000.

At a regional level, South America suffered the largest net loss of forests between 2000 and 2010 – about 4m ha per year – followed by Africa, which lost about 3.4m ha per year. Extensive forest fires and drought in Australia were largely responsible for a net loss of about 0.7m ha per year in Oceania. Northern and Central American forest areas remained more or less stable, while European forests continued to expand, though at a slower rate than in the previous decade (0.7m ha per year compared with 0.9m ha per year). The most dramatic change was in Asia, which, overall, reversed a net forest loss of about 0.6m ha per year in 1990–2000 to see a net gain of more than 2.2m ha per year in the following decade. This was mainly due to large-scale afforestation in China; many South and Southeast Asian countries continued to experience high net rates of loss.[387]

Increasing concern over global levels of deforestation, particularly in the context of climate change, is likely to constrain timber production from natural forests; industrial roundwood will accordingly increasingly be derived from plantations which are already expanding, particularly in Asia and to a lesser extent in Europe. This will be reinforced by the current international focus on illegal logging, a major problem in many developing countries; both the US and EU, in particular, are now taking steps to exclude illegal timber from their markets, and several countries, mainly though not only in the EU, are using public procurement policy and building regulations to give preference to legal and sustainable timber.[388]

This, in turn, requires timber importers and users to be able to distinguish between legal and illegal products, and recent years have seen the rapid spread of certification, licensing and tracking systems, both governmental and private, designed to provide evidence of the legality (and often sustainability) of the product. By mid-2010 the global area of forest certified as sustainable amounted to 356m ha, accounting for around 26% of total industrial roundwood production.[389] During 2007, 25% of solid timber products imported into the EU was derived from independently certified or legally verified forests, the majority of it either from Russia or from other European countries. The UK and the Netherlands are the markets with the highest penetration of certified timber; in 2008, certified products accounted for over 80% of the UK market (both domestic production and imports), having grown from about 50% in 2005.[390] In the Netherlands, the share of certified products grew from 13% in 2005 to 34% in 2008.[391] Although in the early years these issues were mainly seen as a European concern, legality and sustainability schemes are now spreading more widely; the Chinese government is currently developing its own legality verification scheme for timber.

The last decade has also seen a sharp rise in protected forest areas, for which the protection of soil and water, cultural heritage or biodiversity are the primary functions, to reach an estimated 13% of the global total. Some 8% of forests are designated specifically for ecosystem services such as soil and water conservation, avalanche control, desertification control or coastal stabilization; this area increased by almost a fifth between 1990 and 2010, mostly because of large-scale planting in China.[392]

This growing focus on the legality and sustainability of timber marks it out from other resources with which it competes – for example, in plastics, metal or concrete used in construction. Indeed, some competitor companies have on occasion attempted to use concerns over deforestation to steer consumers away from wood products entirely – which, given the overall environmental impacts, and the environmental benefits from sustainable forestry, would be a highly perverse outcome.

Consumers may be more aware and more concerned about environmental factors, but their choices are still determined by socio-economic circumstances, cultural norms and infrastructure factors such as availability and access. There is thus a diverse and complex set of drivers on which to exert influence.

However, there have been major achievements in some areas. In terms of greenhouse gas emissions, the successful application of appliance standards and labelling worldwide is estimated to be producing a cumulative reduction from 2010 through to 2030 of 23 billion tonnes, or almost 90% of global emissions in 2005. In the residential building sector, potential energy savings and emissions reductions could level emissions by 2015, and reduce them after about 2020 – bringing global emissions in domestic housing almost back to 2005 levels by 2030.

Driven by mounting consumer pressure, a number of private and public initiatives are under way in the EU and the US to assess the embedded carbon content of specific products, with a view to developing carbon labelling schemes for consumers. Product standards and labels have been widely used to address market information failures and other barriers to disseminating high-efficiency products and services. (See Box 5.11 for the case of timber.)

5.3 Trade as a natural resource battleground

At a time when the global economy is more dependent than ever on trade in resources, with the looming supply gap and other critical uncertainties, trade is becoming a frontline for conflicts over potential resource scarcities. In addition to export restrictions, some instruments of industrial policy, e.g. subsidies (see Section 4.7.1.1), are also increasingly coming under the spotlight in the trade arena. The return of protectionism in the global public policy agenda means it is crucial to analyse trade-related resource dynamics and how these may play out in the age of scarcities.

Trade is becoming a frontline for conflicts over potential resource scarcities, just as the global economy is more dependent than ever on resources trade

Trade restrictions – in the form of taxes, quotas, licences or outright bans – are instruments used by governments to protect specific sectors from foreign competition. The international community has attempted, first through the General Agreement on Tariffs and Trade (GATT) and then through the World Trade Organization (WTO), to reduce this type of protectionism, making it less trade-distorting, though the rules are much tougher for import protection than for export restraints.

While countries can impose import tariffs (albeit within agreed parameters) under WTO rules, import bans are only justifiable in exceptional circumstances. The disciplines on export taxes, on the other hand, are much weaker – except for countries that acceded to the WTO after 1995. As the price of their accession, many (including China) had to accept constraints on their ability to levy export taxes on different products.

Since the inception of the GATT, governments have steadily removed many barriers to trade. But this trend has not been applied evenly. All sectors are subject to the general provisions of the GATT and General Agreement on Trade in Services (GATS), but – in contrast to agriculture – no specific rules have been agreed for the energy sector, so that competing forms of energy are subject to different international rules, depending on whether they qualify as a good or a service.[393] Important issues for oil and gas, such as investment protection, are also absent from the WTO.

There have been attempts to take these concerns forward in other arenas such as the Energy Charter Treaty (although, without Russian ratification, this treaty continues to lack efficacy).[394] Higher resource prices have diminished Russia's need for foreign capital, further reducing the incentive to play by the rules. In energy markets, for example, production (and export) restraints have been used by OPEC to control oil prices. Examples of the overt use of these restrictions for political purposes abound, including the oil embargo to Europe and US in response to their support for Israel in its 1973 war with Egypt.

5.3.1 The rise of export controls in crisis response

In recent years, many governments have resorted to export controls as part of their crisis response. In the face of the recent food price crises, for example, nearly 30 governments applied export restrictions on crops of importance to consumers, especially rice and wheat (see Table 5.4).

Table 5.4: Trade restrictions on food introduced since 2008 price crisis

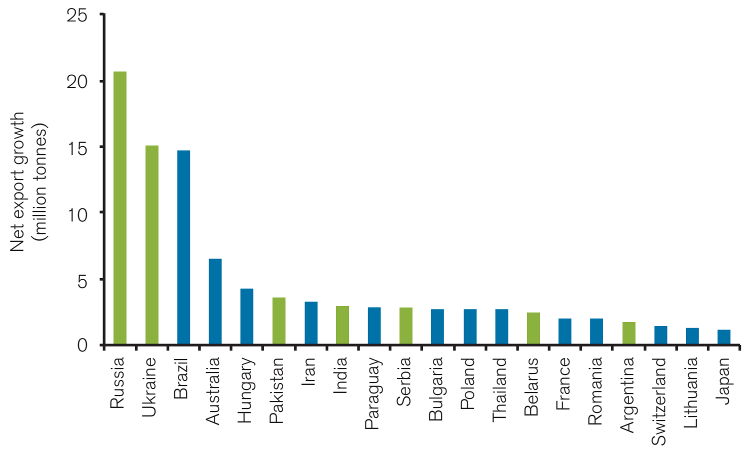
Country	Product	Restrictive policy instrument used
Argentina	Wheat, maize, soybean, sunflower seeds	Tax (ad valorem), tax (variable), quota, ban
China	Rice, wheat, maize, flour	Tax (ad valorem), quota/licence
India	Basmati rice	MEP, tax (specific), STE
	Ordinary rice	Ban, MEP, STE
	Wheat	Ban, quota, STE
Egypt	Rice	Tax (specific), quota, ban
Pakistan	Rice (ordinary and Basmati)	MEP
	Wheat	Tax (ad valorem), quota, ban
Russia	Wheat, maize, barley, flour	Tax (ad valorem), ban
	Rapeseed	Tax (ad valorem)
Ukraine	Wheat, maize, barley	Quota
Vietnam	Rice	MEP, quota, ban, tax (variable), STE
Other countries[395]	35 products affected, mostly cereals, but also sugar, beans, oils	A total of 32 bans, 1 MEP, 1 tax (ad valorem) and 1 STE

MEP: Minimum Export Price.
STE: Measures taken by or via State Trading Enterprise.
Source: Sharma (2011).

Export controls intended to prevent sharp domestic food price inflation in many producer countries ended up magnifying price spikes in 2008 and 2011.[396] While such measures cater to popular discontent, effective market interventions are extremely difficult to design and can backfire. For example, export controls suppress domestic agricultural investment, reduce output and have long-term consequences for food security. They also deprive exporters of market share, and risk forfeiting export markets altogether, as the United States found after its ban on soybean exports to Japan in 1973. Even in the short term, export controls may backfire if they precipitate similar actions among other producing countries, driving prices higher and higher and creating a collapse in confidence that spreads from one resource to the next, as happened in 2008. More worryingly, many of the countries that are emerging or large producers are also prone to using trade restrictions (see Figure 5.11).

While export controls aim to cater to popular discontent, effective market interventions are extremely difficult to design and can backfire

Figure 5.11: Countries with largest additions to global cereal exports (2010 versus 2000, by weight)



Countries that introduced trade restrictions during 2007–08 food crisis shown in green.
Sources: Chatham House database, Sharma (2010).

To date, there remains no global governance framework preventing or removing agricultural export restrictions. Attempts to address the issue at G20 gatherings have been unsuccessful, in part because negotiations became tied to the issue of developed-country farm subsidies. Wheat remains a more likely subject for future export controls given its volatile price outlook, susceptibility to regional harvest shocks and production in countries that readily resort to implementing export controls, such as Russia, India, Pakistan and Ukraine. Rice was also severely affected by export controls during the 2008 price crisis, but the likelihood of future restrictions has been reduced through regional-level discussions in Asia to improve transparency on stock levels and avoid further controls (see the discussion of the Organization of Rice Exporting Countries in Section 5.1.3).[397]

5.3.2 Export restrictions as part of industrial and other policy

In recent years, a number of key raw materials suppliers (especially manufacturers) have resorted to export controls as part of a broader move towards more explicit and interventionist industrial policy – for example, to support domestic processing of raw materials, subsidize inputs for domestic

Chapter 5

industries or enforce price discipline among mineral product exporters. Well into the 1990s, Australian coal exporters were required to submit the details of a proposed transaction when applying for an export permit, information the government could use to enforce price discipline.[398] Since 2004, China has applied tighter quotas and taxes on coking coal exports, for which it is the world's largest producer. According to the OECD, this provided Chinese steel producers in 2008 with 'a cost advantage equal to more than 20% of the world market price for carbon steel'.[399] More than 20 countries have also applied restrictions on the export of steel scrap that is easily recycled into new steel products.[400]

Polysilicon, a key material for solar panels, has recently become a focal point for renewable energy-related trade disputes. China imported $2.5bn of high-purity silicon for use in its solar and electronics manufacturing sectors in 2010, largely from the US ($1 bn), South Korea ($0.7 bn) and Germany ($0.5 bn). It has now launched probes into polysilicon imports from all three of these major supplier countries, in response to anti-dumping tariffs and countervailing measures introduced by the US on Chinese solar panels in 2012 and a related investigation launched by the EU.

Export restrictions on minerals have been used for national security purposes, to combat corruption and human rights violations, and to protect the environment

Beyond industrial policy, export restrictions on minerals have also been used for national security purposes (mainly in the case of uranium); to combat corruption and human rights violations (such as the extensive export controls for rough diamonds, and restrictions on the export of tin, tantalum and tungsten that have recently been introduced by countries in the Great Lakes region of Africa to rein in the trade of conflict minerals from the DRC);[401] and to protect the environment. Several states in India are considering banning exports of iron ore to combat illegal mining in these regions.[402] Beijing has used a similar argument to defend its controversial regime of export restrictions on rare earth elements.

A number of key emerging economies have either imposed or are considering new export restrictions on a variety of metals. Indonesia, a major exporter, has forced companies to submit plans to develop domestic processing capacities in order to obtain an export licence for nickel ore and other unprocessed metals, and plans to move to a full ban by 2014. Export taxes and domestic supply requirements are also being debated for coal producers.[403] Vietnam too has imposed restrictions on iron ore, copper and speciality metals.[404] In India, the world's third largest iron ore exporter, there has been a long-running debate about an export ban to support the domestic steel industry, and Brazil has also been recently debating the introduction of export taxes. Ironically, large emerging economies such as China and India would be among the hardest hit from such bans, because they are the main importers of metals from these countries.

In March 2012, the US, EU and Japan jointly filed a complaint at the WTO over Chinese quotas on exports of 17 rare earth minerals (the first time the three have acted together in a WTO dispute). China claimed in response that it had enforced the quotas to ensure there was no environmental damage from excessive mining.[405] It had used a similar claim in an earlier WTO dispute case over export quotas and duties on various raw materials, including bauxite, zinc and magnesium, but finally lost that case in January 2012.[406]

Against this background of potential supply crunches and concerns about resource scarcities, there is increasing evidence of these types of offensive and defensive moves by governments and businesses across the world to ensure control over or access to affordable natural resources, or to reduce dependence on specific resources. The political nature of the resources markets is compounding the challenge, as is the grim outlook on global cooperation.

6 Building a New Politics of Resources

- Volatility presents a major challenge for the international community. Past attempts to manage international resource price volatility have been costly and largely unsuccessful. Market interventions have often exacerbated the problem, as illustrated by the case of export controls. Smarter use of emergency stocks and more resilient production could be part of the solution, as well as effective early warning systems.

- With tighter markets and interdependent global supply chains, local risks in producer countries will become increasingly global in their consequences, while the production of food, metals and energy is likely to become more dependent on new resource frontiers. Efforts to build institutional capacity to manage these resource investments, operations and revenues effectively and sustainably are essential. Efforts are also needed to protect environmentally sensitive areas where resources are present.

- The urgent need for a new growth paradigm is rarely matched by commensurate government policies and action. This includes pricing of resources to reflect their true cost and value; getting serious about tackling inefficiency and waste in resource consumption and production; and new business models which harness information systems, dematerialization and ‘cradle to cradle’ strategies that offer radical departures from mainstream consumption growth projections.

- The challenge of establishing a rules-based system for the production, consumption and trade of resources is immense, not least because it amounts to a comprehensive rewiring of the global economy. Despite the potential obstacles, it remains critical to seek pathways that will steer countries towards mutually advantageous models of cooperation, even though the appetite for enhanced global governance remains low.

6. Building a New Politics of Resources

As Chapter 5 suggests, zero-sum competition and unilateralism seem to have formed the bulk of early responses to the new phase of perceived resource threats, alongside attempts to encourage collaborative initiatives. The multilateral trading system, among others, is set to become the proxy theatre of global resource war.

This chapter outlines a number of ideas and recommendations that could be components of a framework for achieving the transition to a world where global resource consumption is environmentally, economically and politically sustainable.

6.1 Managing volatility – smart interventions

Volatility in resource prices resulting from tight markets presents one of the major challenges for the international community. As discussed in Section 4.1, price fluctuations could trigger social unrest and political instability. The nature of production and extraction is in part responsible for persisting volatility, owing to the long lead times, as are the pace and scale of demand growth.

Additionally, in an interdependent global economy, any local disruptions – whether resulting from extreme weather or labour unrest – can rapidly translate into higher prices in international markets. These high prices in turn trigger macroeconomic pressures for producer or consumer countries. Political sensitivity to fluctuations could also trigger overreactions that compound the challenge. Militarized responses to the threats posed by volatility could heighten these tensions.

Seeking measures to defuse the threats posed by price volatility is tantamount to seeking an insurance policy for the global economy

In this context, seeking measures to defuse the threats posed by volatility is tantamount to seeking an insurance policy for the global economy. Past attempts to manage international resource price volatility by such bodies as OPEC or the International Tin Council have, however, been long, costly and largely unsuccessful.[407] Market interventions have often exacerbated the problem, as illustrated by the case of export controls (see Section 5.3.1). Despite these failures, tackling resource price volatility has been a key theme for the 2011 French G20 and G8 presidency and for the 2012 Mexican presidency. The IMF, World Bank and OECD have also devoted attention to the problem.

Today, there remains strong disagreement on whether tighter regulation of resource markets is needed in the first place, and tangible progress remains elusive. One key question is whether smarter use of emergency stocks and more resilient production can be part of the solution. The following ideas are offered as a starting point for renewed discussion on managing volatility.

6.1.1 Better responses to oil shocks

An effective mechanism to dampen the impact of oil price shocks could in principle benefit producers as well as consumers. Producers have an interest in price stability, while importing countries would benefit from avoiding an adverse shift in the terms of trade and therefore of national income. Such a scheme would require rapid releases of emergency stock, targeted at the source of the volatility. Ready access to these supplies would divert companies from bidding to replace their lost oil in the spot market, decreasing the likelihood of a spike in the spot price.

An effective mechanism to dampen the impact of oil price shocks could in principle benefit producers as well as consumers

In practice, the oil-consuming countries under the aegis of the IEA participate in an emergency response mechanism (ERM) which requires them to each maintain a stock equivalent to 90 days' worth of oil imports. Release is automatically permitted if there is a shortage totalling 7% or more of existing supply (see Section 5.1.1.2). However, the ERM is explicitly not for 'price management', given the potential to mask price signals and discourage investment in new supplies. The problem is that local shortages triggered by major events – whether a political crisis, war or natural disaster – may create price spikes that reverberate through international markets even though they do not cross the 7% threshold. During the oil shocks of the 1970s, the companies directly affected by supply disruptions (oil refiners and importers) suffered shortages of up to 40%. Their aggressive bidding in the spot market led to international price spikes.

Following the experience of the 1970s, the IEA developed a more flexible and discretionary framework, but decisions to release still require collective agreement by IEA member governments.[408] Over the four decades of the ERM, limited releases to stabilize oil supplies have taken place on a global scale on three occasions – in responses to the first Gulf war in 1991, Hurricane Katrina in 2005 and most recently the revolution in Libya in June 2011. Use of the mechanisms, and interpretation of the conditions required to trigger a release, remain controversial. As growing consumers in the emerging economies which are not part of the ERM – particularly China and India – establish their own oil stocks, there is more potential to effectively limit the impact of supply disruptions, as well as greater difficulty in coordinating responses. Dialogues should take place between IEA countries and emerging economies to gauge the latter's willingness to participate in a global 'emergency response mechanism' for oil, or to coordinate oil stockholdings, and to encourage greater transparency in reserve and resource accountability.

The challenge for the international community is to agree on a mechanism that could allow for a rapid and targeted response to an oil crisis that would not mask important market signals. One proposal would make companies involved in the oil trade responsible for managing part of the emergency

The international community's challenge is to agree on a mechanism for a rapid and targeted response to an oil crisis that would not mask important market signals

stocks. Some non-IEA countries – potentially major importers and exporters – would need to be involved. The proposal could therefore be discussed as part of negotiations over the future participation of major developing countries on the IEA governing board, as well as in other relevant international fora – not least the G20 and the 2008 Jeddah agenda for market stability.[409] Governments could work through existing fora (IEA, G20 and IEF) to discuss specific measures or mechanisms to respond to local shortages in a way that mitigates the price impact on global markets. This could include discussions on a potential ticketing scheme for the oil industry.

6.1.2 'Virtual reserves' for food

A ticketing scheme for food markets along the lines described in Box 6.1 for oil is not applicable owing to the structure of agricultural supply chains. Traders and speculators are, by and large, the same agribusiness companies that import, process and hold stocks. There is also no equivalent of the IEA, and therefore no system of jointly coordinated strategic reserves that could be used to underwrite the emergency market.

In theory, it might be possible to create an analogous club of reserve-holding countries, for example the G20, plus a number of remaining key grain producers such as Thailand and Vietnam, and agree a set of rules under which they would intervene in the *real* market in order to stabilize prices – for example by the setting of a floor price at which members would agree to build stocks, and a ceiling price at which they would agree to release stocks. Such an approach would be subject to speculative attacks, however, and history demonstrates that price band schemes inevitably fail, eventually running out of either stocks or money.[410]

A less interventionist approach could build on the G20's Agricultural Market Information System (AMIS). Housed at the FAO, it aims to anticipate periods of volatility in international food markets by monitoring production, demand and stock data (as price spikes are typically preceded by a run-down in stock-to-use ratios). Based on the information generated by AMIS, member countries could coordinate inventory holdings to help ensure global stock-to-use ratios remain above crisis thresholds. Importantly, however, the willingness of many of the key member countries to resort to unilateral export controls during periods of market volatility suggests that enforcement of the club's rules – whether for price targeting or stock targeting – would be seriously problematic. Governments should secure the wider participation of nation-states and large private-sector stock holders in AMIS and foster dialogues on measures to militate against global stock-to-use ratios breaching crisis thresholds.

Another proposal in the wake of the 2008 food price crisis was to establish a global virtual reserve in which a similar club would commit funding for a 'high-level technical commission' to intervene in futures markets in order to prevent price spikes.[411] A 'global intelligence unit' would detect price spikes unrelated to market fundamentals, allowing the high-level technical commission to execute a series of short sales in the futures market to encourage the release of stocks and reduce prices. This proposal, which called for an initial funding commitment of $12–20 billion, has been criticized for its reliance on a group of experts to out-forecast the market, and for its potential to accrue huge losses if others successfully judge the market a better indicator of true price, and bet against the global intelligence unit.[412]

A better way to establish a virtual reserve might be for governments to purchase call options from biofuel producers.[413] The contracts would specify a trigger which when activated would obligate the producer to release feedstock back into food chains. The trigger could be based upon a price index, for example, such that releases were made in response to price surges. Biofuel producers would enter into contracts freely and receive the option price in return. This approach should be more acceptable to biofuel producers than alternative proposals more threatening to their interests, such as the dismantling or flexing of mandates. Ultimately, the effectiveness of the approach would be constrained by the extent of biofuel producers' participation. By auctioning contracts, governments could in theory achieve satisfactory participation through an appropriate option price, though should the price be too high, taxpayers may baulk at having to buy expensive contracts from already heavily subsidized industries.

A slightly different approach could see donor governments buy contracts with delivery specifications that would see grain diverted to the World Food Programme (WFP), effectively hedging WFP's exposure to price spikes. (WFP was hamstrung by rising prices and a fixed budget during the 2008 price crisis, and was ultimately unable to secure the supplies it needed to respond.[414])

Reserves can be used to ensure critical supplies reach vulnerable populations during periods of high prices or constrained availability

In general, rather than as a means to control prices, reserves can be used more effectively to ensure critical supplies reach vulnerable populations during periods of high prices or constrained availability. National strategic reserves offer import-dependent countries a means to insure poor populations against future price spikes or supply disruptions by allowing governments to undertake targeted distributions during emergencies. The 'premium' paid by governments is the storage and capital costs of maintaining the reserve: greater food security means a larger reserve and greater costs. By releasing stocks only during emergencies, and targeting relief at the poorest consumers who are priced out of the market, disincentives to local farmers and traders are minimized. However, during crises domestic pressure for general releases to reduce prices may be considerable. Governments therefore need clear criteria to determine when distributions will occur, and which members of society will qualify.

6.1.3 Making speciality metal markets work

The rationale for strategic stockpiles for metals is weaker, as the impacts on society of metal price swings are often more indirect in consumer countries. Experiences of major metals stockpiles have been costly and relatively ineffective in terms of managing volatility and prices in international markets.

Since the rare earth débâcle, many governments have explored options including strategic stockpiles to safeguard the security of metal supplies. Many of them did not take off because of the challenge of selecting the right mix of metals for stockpiles. Despite the challenge, there remains a case for government support for more transparent and better-functioning metal markets. But achieving this would be no mean feat, involving collaboration among governments and companies to gather production data as well as pricing information and available stocks.

This is particularly important for, though not limited to, speciality metals such as rare earths, given their strategic importance for advanced technologies and many green-tech applications. Oligopolistic market structures and opaque trading channels also inhibit competitive price formation, especially for speciality metals, and add to uncertainty over future production levels for such metals, contributing to recurrent speculative bubbles and panic buying. These spikes and temporary shortages translate into cost increases and delays in downstream manufacturing, slowing the deployment of key technologies that depend on these metals.

Governments should implement stronger regulation of over-the-counter-trade in speciality metals and strengthen safeguards against anti-competitive practices. Government and companies should improve the data on metals production, trade and stockholdings. Licensed traders could be required to submit stock levels on a regular basis, which would be published in aggregated form. The work of the international commodity study groups for zinc, copper and other metals should be brought together in a single, publicly accessible data hub and expanded to include production data for all key metals, in virgin and secondary markets.

6.1.4 Link early-warning systems to triggers for early action

The increasing threats posed by natural disasters, conflict and market shocks highlight the need for effective early-warning systems (EWS). Should coordinated approaches be used to manage price volatility, for example through the release of reserves or the initiation of dialogues to limit panic buying or export controls, these are likely to be more effective when participants have advance warning of shocks and can begin planning in advance.

The potential returns from effective early-warning systems are huge. Following the set-up of EWS in Bangladesh, cyclones now incur a fraction of previous losses in human lives

At the local level, EWS that help governments and communities anticipate shocks offer an important means to build resilience and minimize avoidable disruption – whether for natural hazards such as droughts, floods and tsunamis or for socio-political hazards including conflict. The potential returns from effective early-warning systems are huge. Following the establishment of a national cyclone EWS in Bangladesh, cyclones incur a fraction of previous losses in human lives.[415] EWS for tornados in the United States and floods in Mozambique have achieved similar success.

These systems have not only worked, however, because they predict emergencies. They are, more importantly, linked to robust decision-making processes and located within enabling institutional and political contexts. Chatham House research on slow-onset food crises has demonstrated that where these conditions are not in place, EWS do not result in early action, irrespective of their reliability.[416] Early warnings eleven months in advance of the impending famine in Somalia during 2011 triggered negligible early action.

This was in part because there was no effective state in Somalia to respond. It was also because decision-makers within the humanitarian system were insufficiently incentivized to prevent famine, and because early action was inconsistent with the foreign policy agendas of some donor governments.[417]

The effectiveness of EWS therefore hinges upon the accountability of decision-makers for preventing crises and their insulation from competing political agendas. There should be clear decision-making and risk-management processes in international organizations and/or donor governments to respond to EWS, with accountability for action clearly assigned to specific institutions as well as personnel.

This poses particular challenges at the international level, where accountability tends to be low and political concerns dominate. In the case of food markets, AMIS should generate early warnings of future volatility, while responsibility for agreeing early action rests with the Rapid Response Forum (RRF), a body comprising officials from AMIS member countries. However, what would constitute early action remains unclear, as the purpose of the RRF is to 'promote early discussion' rather than agree collective early action.

The RRF got off to an uncertain start in its endeavour to promote early discussion in August 2012, when news of initial conversations to hold a meeting about market turmoil triggered by the US drought was leaked to the *Financial Times*, potentially increasing market jitters in the process. This was followed by a period of indecision about whether to hold a meeting of RRF members and public disagreements about what should be done in any case. AMIS member countries could agree robust institutions for collective decision-making, with accepted rules and frameworks for triggering decision-making processes, evaluating response options and agreeing actions.

6.2 Resilience, governance and new frontiers

With tighter markets and interdependent global supply chains, local risks in producer countries will become increasingly global in their consequences. The risks themselves may also change and multiply as the production of food, metals and energy is likely to become more dependent on new resource frontiers. Some of these will be in developing countries with weaker governance regimes, high rates of poverty and inequality, and greater risks of conflict and or natural disaster than existing exporters. Efforts to build institutional capacity to manage the new or increased resource investment, operations and revenues effectively and sustainably will be essential in this context. This will not only benefit local populations but also help insure against production disruptions and wider market and macroeconomic instability.

Tighter markets and interdependent global supply chains mean that local risks in producer countries will be global in their consequences

6.2.1 Safeguarding ecological frontiers

High prices and the potential future scarcity of natural resources pose a challenge to the safeguarding of ecological systems, biodiversity and natural habitats. The political and investor pressure for extraction or production will in many cases overwhelm the case for environmental protection, especially in countries where there is little political representation on behalf of local communities. There is also the thorny question of indirect impact of land-use changes, as well as the wider impact on species in terms of habitat and movement.

Resource exploration and production in ecologically sensitive areas should be preceded and accompanied by a rigorous and transparent impact assessment

Without a shift towards analysis and management of natural wealth and ecosystem services at the system level, and not only in a national but also in a global context, the argument for 'developing resources' will not be properly weighed against the losses involved. Resource exploration and production in ecologically sensitive areas should be preceded and accompanied by a rigorous and transparent environmental impact assessment process. Yet such assessments for resource projects are not always far-sighted enough or reflective of the wider impact of a project on other resources. These assessments must also consider the dynamic impacts of future changes in the climate, water scarcity and other factors in terms of production and the associated environmental risks.

With the dwindling of easily accessible, high-grade (EAHG) reserves, energy and metals production is heading into ever more extreme environments or remote areas. Infrastructure may be located in zones that are prone to earthquakes or extreme weather, in deep sea or deep underground, subject to extreme temperatures or pressures, or in complex and challenging geologies. This applies not only to project locations but also to transport links, inputs supply (not least water) and waste disposal. Poorer ore grades and extraction processes for heavy, tight or shale oil and some types of unconventional gas also require more inputs such as energy and water per unit of output compared with EAHG reserves. With much of the EAHG reserves of natural resources already depleted, marginal production opportunities are increasingly being sought in wilderness areas with high ecological importance.

The Macondo oil disaster in in the Gulf of Mexico in 2010 and the Kolskaya drilling rig disaster in the Russian Sea of Okhotsk in 2011 highlighted the challenge of operating in extreme environments. First, pushing the boundaries of engineering tolerance and operating experience incurs huge risks despite the potential rewards. Second, minor engineering failures can quickly escalate into catastrophes owing to the remoteness or inaccessibility of the locations and challenge of effective rescue and clean-up operations. Governments, businesses and industry associations should discuss and implement (national or local) governance mechanisms and best practice on extreme engineering options, from deep-sea operations to weather modification.

As water scarcity becomes a critical health and economic issue in many regions, governments are likely to turn to engineering solutions that have uncertain impacts and risks as well as transboundary implications. In addition to conventional dams and irrigation infrastructure, other countries may follow in China's footsteps on large-scale river redirection projects. These major projects tend to involve resettlement of local populations and can affect water availability for countries downstream. Other countries will pursue desalination, boosting fossil fuel demand and emissions – at least until solar desalination technology becomes affordable and environmentally sustainable at scale. In the near future, further experimentation with weather modification is another likely response, with uncertain environmental and political implications. Renewed dialogues are needed to explore best practice and collective agreements on the deployment of such approaches.

Governments and communities should impose moratoria or ban production or extraction in areas so biodiverse or sensitive that effective mitigation efforts or remedies are not available or affordable, or where future changes affecting projects would impose unacceptable levels of risk to either future taxpayers or the wider society. Such decisions are often politically challenging as they involve difficult trade-offs that are not easily captured by tools such as cost-benefit analysis.

6.2.2 Investing in social stability in producing regions

Developing countries able to protect the poorest and most vulnerable communities from the impacts of shocks and hazards will be less prone to societal unrest (see Section 4.1). They also tend to offer more stable and attractive investment environments. This underlines the importance of social protection and safety nets for vulnerable populations, which can help protect them from the impacts of resource constraints and price shocks. This will reduce the risks of political instability following from such events, and thus diminish the incentive for governments to pursue knee-jerk responses such as export controls.

> Developing countries able to protect the poorest and most vulnerable communities from the impacts of shocks and hazards will be less prone to societal unrest

Donor support will be needed in some countries to put social protection in place: Ethiopia's Productive Safety Net Programme, which extends cash and food transfers to an estimated 7.6 million people, is supported by a number of donor governments and the World Bank. It was identified in recent evaluations of the 2011 food crisis as 'decisive' in ensuring the survival of the most vulnerable.[418] Donor governments, recipient governments and international financial institutions could develop a new multilateral global reinsurance mechanism to underwrite safety net liabilities in poor countries to enable their governments to extend social protection.

Meanwhile, economic and human exposure to sudden hazards is also increasing. The numbers of reported disasters and people affected are both on an upward trajectory, driving increases in humanitarian needs and economic (and insured) losses.[419] Although detailed economic studies are scarce, the case for investing in disaster risk reduction (DRR) and resilience-building initiatives is compelling. While oft-quoted cost-benefit ratios of 1:4 and 1:7 are too simplistic given the highly context-specific nature of risks and DRR interventions, the literature indicates that in general such initiatives offer attractive rates of return.[420]

One recent study on drought-prone regions in the Horn of Africa found that interventions to strengthen resilience of vulnerable communities offered cost-benefit ratios of 1:6.5 in Kenya and 1:7.2 in Ethiopia when compared with emergency humanitarian responses.[421] Yet despite this advantage, donor investment in DRR remains low, with only about 1% of all ODA designated for DRR.[422] While many governments are making progress with national plans for DRR, implementation is fragmented and few have adopted legislation.[423] Coordination – across ministries or between national and local governments – is often poor, resulting in siloed approaches, a disconnect between the national policy and local practice, and a lack of resources at the community level.[424] There should be closer integration of humanitarian and development activities as well as innovative arrangements to increase the flexibility of donor funding lines.

Adaptation measures to climate-proof economies and infrastructure and build resilience among vulnerable communities also remain critical. Without these investments, climate change is likely to reduce growth potential, with significant socio-environmental consequences. The costs of adaptation in developing countries are estimated at around $100 billion a year in the 2°C warming scenario. These costs will soar rapidly should warming exceed this level – which appears increasingly likely on the basis of current mitigation commitments. Current support for adaptation remains a long way off: OECD donors provided $9.3 billion in adaptation-related aid in 2010, inclusive of spending on other priorities.[425]

Assisting developing-country governments to manage and respond to risks more effectively requires greater flexibility from donors and development agencies, as well as a willingness to explore new, innovative financing mechanisms. The post-2015 development framework that replaces the Millennium Development Goals should reflect the new global outlook of greater volatility and uncertainty. It should explicitly address risk, and include objectives to build resilience and reduce vulnerability among groups at risk.

6.2.3 Strengthening institutions and transparency

Natural resource endowments in poor countries have at times brought 'resource curses' of low growth and high unemployment, leading in turn to inequality and increased risks of conflict and instability. Policies, institutions and governance frameworks to ensure transparency, the equitable distribution of revenues and broader economic development are required to avoid these outcomes.

Only a few governments in poorer mineral-producer countries have been able to successfully implement revenue stabilization funds to cope with volatility

Volatility poses a major challenge for governments in poorer mineral producer countries, for example, and only a few have been able to successfully implement revenue stabilization funds. Ongoing efforts to strengthen capacity for effective revenue management in producer countries should be stepped up. International efforts to increase transparency in the extractives sector provide another starting point, from the Extractive Industries Transparency Initiative (EITI and EITI++) and the Kimberley Process on conflict diamonds to the US Dodd-Frank Act requiring US companies to disclose their payments publicly to foreign governments.

Broadening these measures and closing loopholes remain critical, as does the need to deepen engagement with emerging economies. It is particularly important to extend these initiatives across the entire project cycle (from exploration to project closure) and the full value chain (from extraction to end-use). However, the push for transparency should not overshadow efforts to improve legal frameworks for regulation and accountability. Scaling up capacity within civil society and among communities as well as local media is also critical to ensure proper scrutiny.

Competing claims from energy, industry, municipal uses and food production will place new pressures on existing national governance regimes responsible for resource allocation. Governance mechanisms for land or water, for example, will come under increasing scrutiny in many parts of the world. Building blocks to strengthen land management include legislation on tenure, land titling and property rights to ensure equitable and secure access to land. Also crucial are institutions to manage the allocation of common or government-owned land and deal with foreign and domestic investors in a manner that ensures transparency and mitigates corruption, alongside rules to ensure the consultation of affected communities and standards to minimize social or environmental costs.

Competing claims from energy, industry, municipal uses and food production will place new pressures on existing national governance regimes

As climate impacts escalate, water governance frameworks may not be resilient to changes in precipitation. The determination of future water usage rights will be challenging in terms of both administrative capacity and domestic political economy as different interest groups compete for access, as well as ensuring vulnerable communities do not lose out in such a process. Governments should examine governance and water-sharing agreements at catchment level to provide flexibility and adaptability against future environmental changes, together with international efforts to strengthen water data collection and monitoring.

6.2.4 Making data and information work

The use of data for resource governance depends on a clutch of technologies and systems. Information collection typically requires *in situ* or remote monitoring and tracking devices. Communications technologies play a crucial role ahead of and during crises, and are used to make everyday decisions – for example, giving farmers access to real-time market prices for different foodstuffs. From major social media platforms to bespoke tools, online platforms play a key role in sharing information, but also for crowdsourcing information. Analytical tools are required to find patterns in the ever-growing volume of resource and environmental data, and to identify and prioritize a range of appropriate responses. Financial tools are needed to integrate resource use and waste fully into company financial systems and profit and loss accounts. Supply chain management tools are another crucial area, though attempts at carbon and water footprinting have shown the difficulties in measuring the life-cycle footprints of complicated products. Governments and businesses should support global efforts to implement environmental accounting practices and tools to assess natural wealth and ecosystem services

In the more open information age, new mechanisms are available in addition to national monitoring and reporting. These could be explored and factored into policy processes. The private sector is taking a lead, for example, in some aspects of monitoring environmental change, and a mix of NGOs, private-sector companies and communities has shown that vital information can be quickly crowdsourced in crises. Combinations of new technologies and platforms (such as mobile phones, social media, digital photography, geotagging, mapping, remote sensing, 'the internet of things') have opened up new possibilities for data collection, collaboration and analysis. Yet using these tools to measure progress against policy goals is challenging, and public institutions have struggled to keep pace with their rapid evolution – data sources are often 'unofficial', trends are complex, accuracy is sometimes hard to verify and the process is potentially open to manipulation.

Such advances in data collection and analytical tools (and access to these) increasingly pose a challenge to the ability of states to retain control of the collection and release of information – in critical areas such as water and land availability, deforestation and desertification. Data collection by a range of state and non-state actors could affect the legitimacy of official resource-related information, although if managed properly it is just as likely to complement official efforts. Foreign governments – as well as civil society organizations – can also choose to make data public without the approval of another government.

An annual 'State of the World's Resources' report could improve the data and transparency for natural resources markets

Measures to promote access to information and transparency over methodologies and to ensure the legitimacy of the data provider are therefore just as important as the quality and quantity of data collection. 'The Future We Want' – the Rio+20 outcome document – mentions several areas where data transparency could boost evidence-based decision-making processes and improve resource governance: better food price information to help address volatility concerns; transparency over fisheries management; information on the life-cycle impacts of chemicals; transparency in the mining sector to prevent illicit financial flows; information on technology transfer and the pace of innovation; and transparency over trade-related measures, as envisaged by WTO rules.[426] Some stakeholders have proposed an annual 'State of the World's Resources' report to improve the data and transparency for natural resources markets.[427] This would demand standardization of the collection and sharing of data on resource endowments, stocks and trade figures. Support could be mobilized for the launch of an international resources data bank.

6.3 Sustainability, efficiency and pricing

For all the prospect of green growth, the urgent need for a new growth paradigm is rarely matched by commensurate government policies and action. These measures should include the following:

6.3.1 Get the prices right

The correct pricing of resources to reflect their true cost and value is integral to achieving sustainable production and consumption. There is some indication that developing-country governments often do not secure a fair return from investors for agricultural land transfers.[428] Pricing land fairly could also help limit unproductive speculation and land-banking, reduce rents and the scope for corruption, and ensure that local communities are properly compensated.

Resources are often overexploited, wasted and used inefficiently because they cost little or sometimes nothing. Regulation to impose standards for buildings and vehicles, for example, can be inhibited by concerns about choice and competitiveness. Efforts to enhance efficiency or reduce environmental impact could also be rendered uneconomic by low prices.[429]

Many resource-efficiency opportunities only make economic sense once externalities are priced in and subsidies removed. The elimination of perverse subsidies – estimated at over $1 trillion a year worldwide[430] – remains high on the global environmental agenda even though progress has been slow. For example, the G20 agreement for the elimination of inefficient fossil fuel subsidies provides a broad basis for further work on energy subsidies, but faltered in its implementation in part because of its vague, non-binding nature.[431] While most countries accept that reducing subsidies can be appropriate, elimination within a short timeframe risks causing severe economic and political crises.

Meanwhile, allegations of green protectionism still tarnish the fossil fuel subsidy elimination agenda in many developing countries, as does the fear of detrimental effects on export competitiveness and foreign investment. To address these concerns, at least equal attention should be devoted to production subsidies including tax breaks for the various resource production industries in developed countries. Predicting and mitigating the impacts of subsidy removal on inflation and the poor also remain challenging, and more effective channels and fora to share experience and technical expertise are needed. A group of like-minded governments could establish a concrete timeline for subsidy removal, while providing assistance on implementing nationally defined subsidy reform pathways through a range of measures – including technical capacity-building, public education assistance and specifically targeted finance, depending on a country's needs.

A group of like-minded governments could establish a concrete timeline for subsidy removal and provide assistance on implementing reforms

These challenges also apply to sectors beyond energy, especially water where many developing countries face particular problems. Having no price for water often results in waste and unsustainable abstraction. In India, for example, this is compounded by subsidies for water use and water-intensive energy generation.

Financial incentive policy mechanisms such as payments for ecosystem services (PES) – while controversial – could in principle provide mutually beneficial solutions to biodiversity loss, environmental degradation and the drivers of unsustainable livelihoods. PES schemes offer mainly financial incentives to ecosystem beneficiaries – individuals (e.g. farmers, fishers and small land-holders), businesses and organizations interacting with resources at the ground level – in order to protect natural habitats and promote ecosystem services over the longer term. Some stakeholders worry that PES departs too far from the 'polluter pays' principle.

Despite some successes, particularly in the Caribbean and Latin America, elements of PES and similar schemes require further clarification to secure effective and more widespread participation. It remains challenging to assess environmental and social preconditions, which in turn makes it difficult to determine payment values and fair distribution. Additionally, PES may struggle to deal with complex systems or with ecosystem services that are not 'owned'.

PES could be integrated by governments into existing frameworks – carbon markets, resource-related taxation, waste management and watershed management – to provide mutually beneficial solutions to biodiversity loss, environmental degradation and the drivers of unsustainable livelihoods.

6.3.1 Responding to the efficiency challenge

While governments and businesses are scaling up policies and action to improve efficiency, they are only scratching the surface. Although many of these investments can be cost-effective even over a short timeframe, the barriers to efficiency savings are well known. They include subsidized resource prices; high transaction costs; upfront capital costs; the principal-agent problem; information gaps and asymmetry; the rebound effect; lock-in to inefficient infrastructure; and cultural practices and consumer behaviour.

To respond to these challenges, McKinsey identified 15 critical areas for improvement in resource efficiency (see Chapter 5). Of these, energy savings in buildings, efficient use of water in agriculture and cities, and avoiding food waste are among the top priorities. Other key areas include industrial efficiency, end-use efficiency (for vehicles and consumer products), and boosting agricultural productivity (in terms of resource inputs and outputs). Capturing the economic benefits of these improvements is partly dependent on getting the prices right for resources (see above).

Yet behavioural change is driven by more than economic rationale. Large-scale capital spending or grand supply projects can be more attractive to governments than the incremental, technical nature of efficiency drives. In addition, the level of information, cross-sector coordination and localized participation to drive the implementation of nationwide efficiency policies are often wanting.

Clear and strong regulatory frameworks have shown their value in driving up efficiency in major consuming countries

Clear and strong regulatory frameworks have shown their value in driving up efficiency in major consuming countries. Key policy areas include minimum performance standards for buildings, vehicles, industry and products. Japan's Top Runner standards, which gradually improve the performance of products over time, are also an attractive approach. This scheme allows for greater flexibility in implementation because it applies to the average performance of goods produced by a company. China is considering introducing energy-intensity targets for key industrial products. Governments from the major economies should agree a clear pathway for incremental improvements in resource efficiency standards. This could be based on the Top Runner approach.

Market creation through public procurement for highly resource-efficient products can demonstrate the utility and affordability of efficient practices. The relatively large size of the public sector in many countries also means that procurement has the potential to affect energy and water use directly.[432] This applies in particular to government buildings and transportation requirements for public agencies, but also to the purchase of equipment. Public procurement also has a role to play in fostering markets for technologies that boost resource productivity. Governments should adopt clear policy incentives, government procurement rules and market creation schemes to incentivize higher resource productivity.

Reducing waste is a critical but often under-prioritized policy area, especially for food. Post-harvest losses and food waste account for up to a third of global food production.[433] Commonly used fishing methods where a large share of the (unwanted) catch is dumped back in the ocean are another example of wasteful practice. In developing countries interventions must focus on agricultural technology, storage and infrastructure to minimize these losses. In developed countries the focus must be on consumer awareness and better supply chain management.

Reducing waste is a critical but often under-prioritized policy area. Post-harvest losses and food waste account for up to a third of global food production

Governments should strengthen regulations to address food waste in the supply chain, including addressing unwanted 'bycatch' of fish. Donors should support efforts in developing countries to improve agricultural storage and infrastructure to minimize food losses. Global civil society and national government could collaborate in global campaigns to raise awareness and encourage behavioural change around food waste.

In addition to product labelling, data and information will increasingly be provided in real time to businesses and consumers. There is growing evidence that data-based decision-making can improve the performance of organizations.[434] Governments could provide incentives to utilities companies to make data available, so that companies or communities can develop innovative efficiency solutions.

Public finance is critical to create public goods and correct market failures. In developing countries, public finance will need to be complemented by appropriately targeted ODA. Opportunities include reducing post-harvest losses, investing in infrastructure, addressing information asymmetries and improving access to data.

6.3.3 Rewiring the industrial sector toward a circular economy

Efficiency measures, while essential, are only part of the solution, not least because of the projected demand growth. Some sectors can increase their resilience by delivering value in ways that are less dependent on resource inputs and raw materials. This 'dematerialization' is now a serious prospect as a result of innovations in materials science and engineering. These include lightweight structures and high-performance materials, which reduce material use in or the energy needs of buildings and vehicles.

A key question is how to align incentives throughout the supply chain so that, from the design stage to customer engagement, companies actively consider the use of sustainable materials and features such as durability and reparability at the core of their product strategy. Production and consumption often take place in different countries with inputs from multiple companies around the world. Supply chains may have to be reorganized so that information and material flow in both directions to facilitate reuse and remanufacturing.

Governments should support innovation in areas such as remanufacturing, cradle-to-cradle or 'circular economy' approaches, including in large-scale industrial pilots. Cross-border piloting of circular economy models, building on the leadership of China, Japan and South Korea, could be the basis of closer cooperation between governments as well as in the private sector. The EU is preparing new rules on eco design and remanufacturing and is an obvious partner for these three Asian countries. Working together on standards, innovation and global supply chain management, they could create and shape global markets for circular economy goods and approaches, while addressing domestic pressures.

Clear metrics and resource accounting tools that are straightforward to implement would help to encourage the participation of small and medium-sized businesses. Small businesses will also need guidance in areas such as the recovery, reuse and remanufacture of goods and materials. Companies are already exploring how to reflect resource costs properly in profit and loss statements; this process could be accelerated through the involvement of the major accountancy firms and investor groups.

Industry bodies could play a key role in facilitating dialogue between pioneering companies and other organizations and sharing best practice

Moving towards circular-economy solutions almost by definition involves multiple companies, often in different sectors. Industry bodies could play a key role in facilitating dialogue between pioneering companies and other organizations and sharing best practice, as can other cross-sectoral hubs and networks. These new business models may pose a challenge to existing competition policy, as companies become engaged at different points in the supply chain.

Last but not least, a shift to a sharing or rental model from a 'one product, one owner' approach could be under way. The most common example today is car-sharing, but commercial enterprises are exploring everything from household equipment to toys to farmyard equipment.[435] For companies, this implies different business models to provide long-term service rather than sale of goods.

To transform agricultural production, the key frontier is sub-Saharan Africa where yields are a fraction of those achieved in developed economies and there are significant reserves of arable land. Closing the yield gap offers a major opportunity not only to increase but crucially to diversify global production: currently global food security is heavily dependent on only two major net exporting regions in North and South America. Significant investment in the right areas is needed, however, as discussed in Section 3.4. Estimates suggest the investment shortfall in developing-country agriculture is in the region of $80–90 billion a year.[436]

Many poor countries with underdeveloped agricultural potential are currently attracting considerable resource-seeking investments in infrastructure for roads, railways and telecommunications. Leveraging these investments in rural areas could help address agricultural infrastructure deficits while helping to prevent the migration of labour to urban areas.

The innovation and diffusion of new technologies and practices are critical to reinvigorate yield growth in developed countries, reduce reliance on fertilizers and other chemical inputs, and increase tolerance to pests, diseases and the impacts of climate change such as drought and high temperatures. There are huge opportunities associated with increasing access to existing technologies and practices, as well as incorporating local knowledge. However, worldwide and in the longer term, sustainable intensification of agriculture is unlikely to be achieved with existing technologies and approaches alone. A step change in productivity in regions such as sub-Saharan Africa will require increased public investment, particularly in developing countries, and innovative approaches to funding R&D for the creation of global public goods, including public-private partnerships to harness the resources and expertise of the private sector.

6.4 Reinvigorating rules-based governance for a polycentric world

The challenge of establishing a rules-based system for the production, consumption and trade of resources is immense, not least because it amounts to a comprehensive rewiring of the global economy. Despite the potential obstacles, it remains critical to seek pathways that will steer countries towards mutually advantageous models of cooperation, even though the appetite for enhanced global governance remains low.

Establishing a rules-based system for the production, consumption and trade of resources amounts to a comprehensive rewiring of the global economy

6.4.1 Avoiding major trade wars

China suspended exports of all rare earths to Japan in September 2010 after a Japanese navy vessel arrested a Chinese fishing boat captain near disputed islands in the East China Sea. Exports resumed two months later, but the incident revealed the extent of Japanese dependence on Chinese rare earths. Following the incident, Japan began negotiating supply agreements with Vietnam, Mongolia and Australia to develop new mines.[437]

China's dominance over supplies of rare earths makes this an extreme case. Yet the concentration of suppliers for other metals and minerals points to a future with escalated use of export restraints, where key producer countries – whether it is iron ore from Australia and Brazil, copper from Chile and Peru, niobium from Brazil or nickel from Russia, Indonesia and the Philippines – use their market dominance to support domestic industries or try to influence prices (see Section 5.3.1).[438]

These developments are pointing to a new era where trade could emerge as the major frontline for natural resources conflicts. The independent monitoring project Global Trade Alert suggests that nearly 1,500 protectionist measures have been implemented since January 2008.[439] This is despite the G20's proclamation in 2008 of 'the critical importance of rejecting protectionism and not turning inward in times of financial uncertainty' and promises to refrain from 'raising new barriers to investment or to trade in goods and services, imposing new export restrictions, or implementing … WTO inconsistent measures to stimulate exports'.[440] According to the WTO, more than one-third of notified export restrictions are in resource sectors, where export taxes on natural resources appear to be twice as likely as export taxes in other sectors. Trade-restrictive measures imposed since 2008 now cover nearly 3% of world merchandise trade, and almost 4% of G20 trade, according to the WTO's Director-General Pascal Lamy.[441]

To date, the major economies have largely avoided taking – or been unable to take – resource trade disputes to the WTO court – not least because the majority of measures introduced are not well covered by enforceable rules.[442] Only 20% of disputes brought by the countries shown in Figure 6.1 and Figure 6.2 are in resource sectors. Of these, the US brings the most resource-sector cases against its nearest economic rivals, but it is also subject to the most complaints by others when it comes to resource sectors (Figure 6.2). Agriculture is the resource sector with the most trade cases, followed by metals and chemicals.

Figure 6.1: Trade disputes in resource and non-resource sectors, 2002–12

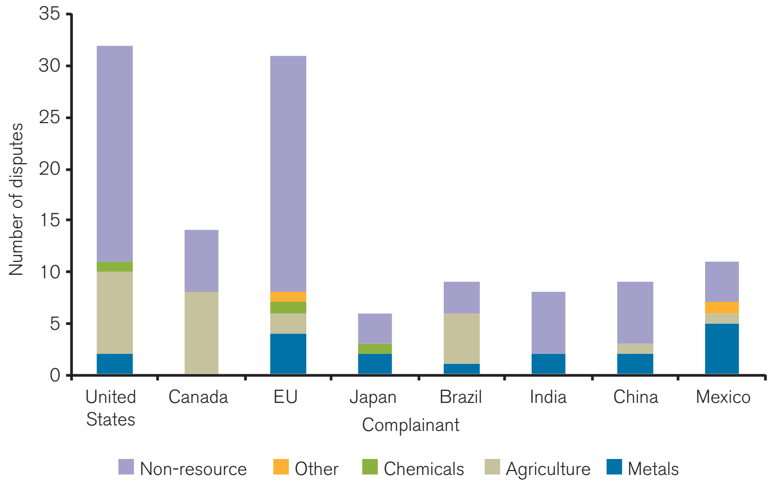
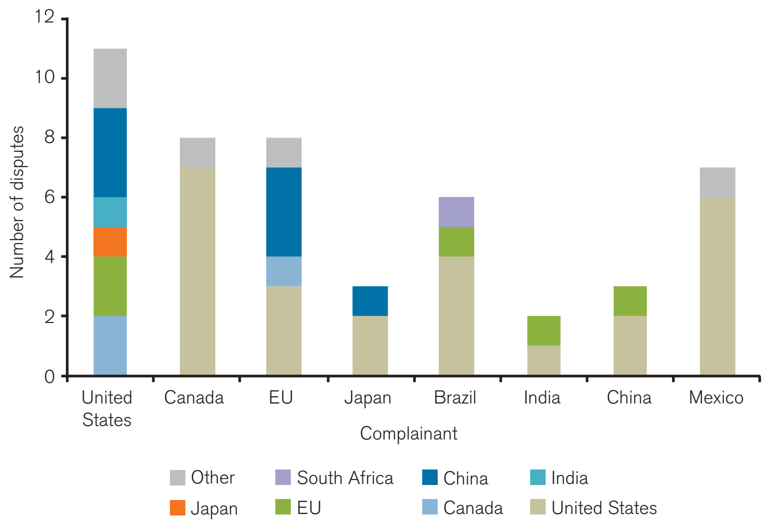


Figure 6.2: Trade disputes in resource sectors between major economies, 2002–12



Source: Compiled by Chatham House from WTO database (2012).

With the production of essential resources in a handful of countries, large exporters can wield tremendous power over consuming countries

With the production of essential resources concentrated in a handful of countries (see Chapter 2), large exporters can wield tremendous power over consuming countries. Over 80% of exports from 21 countries are in natural resources, according to the *World Trade Report*. However, for nine of these

Chapter 6

countries, resource exports amount to over 50% of GDP, and their dependence on these exports yields a different set of imperatives, especially when it comes to pricing.[443] Another hot area relates to subsidies, especially of green energy. Today, there are many contentious trade disputes over wind and solar subsidies, involving all the major economies including Canada, China, India, the EU and the US.

At a time when the stalled Doha-round negotiations are calling into question the prospect of further rule-making in the multilateral trading system, the spectre of an era of trade wars over resource access is threatening to overwhelm the dispute settlement regime at the WTO. If negotiations for new rules remain a thorny prospect, the international community – in addition to using bilateral trade negotiations to advance trade-related gains – must consider other options to build trust or to strengthen common understanding in critical areas such as export restrictions – especially the use of such measures in the midst of commodity price spikes or crisis. This could take the form of a range of plurilateral negotiations and agreements. Others, including Jim Bacchus, the former Chairman of the Appellate Body of the WTO, have publicly called for negotiations on exemptions for green energy. That the Doha Round has shown no signs of revival means that even these plurilateral deals will remain a medium-term objective.

6.4.2 Building 'coalitions of the committed' on resource governance

To break the impasse, a new club of principal resource-producing and resource-consuming countries could help fill the governance vacuum through a refreshed process of dialogue to establish informal rules and norms for the governance of resources and scarcities. This report proposes the establishment of a Resources 30 or R30 in the first instance, with membership based on a country's (or group of countries') systemic significance as a resource producer or consumer. Balance could be sought across different resource classes (food, energy, metals) and between consumers and producers. As such, the R30 would reflect global resource patterns, and provide a space for discussions where mutual interests are based upon interdependency rather than opportunities for collusion.

A new club of key producers and consumers, Resources 30 or R30, could help fill the governance vacuum through a refreshed process of dialogue to establish informal rules and norms

One possible list of members is provided in Table 6.1. The legitimacy of the club would inevitably be called into question, as has that of the G8 and the G20. The R30 should therefore engage other countries – such as emerging producers and consumers or vulnerable countries – in its dialogues as appropriate. The methodology used to select these R30 candidates is provided in Annex 8.

Table 6.1: Candidates for the Resource 30 (R30)

R30	Key producer	Key consumer	Key exporter	Key importer	Description
Australia	●		●		Key mining country especially for coal and iron ore. Also an expanding gas producer and a large agricultural exporter.
Brazil	●	●	●		Key agricultural producer and iron ore exporter. Expanding oil producer with significant reserves in offshore pre-salt fields. Large consumer especially of agricultural products, with fast growing energy and metal consumption.
Canada	●		●	●	Expanding (mainly unconventional) oil and gas producer. Major farming and mining industry. Large importer of both unprocessed and intermediate oil and metal products.
Chile	●		●		Largest copper producer today. Responsible for a third of world production.
China (incl. Hong Kong)	●	●	●	●	Major and fast-growing coal, metal, and food producer and consumer. Top importer of metals and forestry products, and fast-growing importer of fossil fuels and select agricultural products. Large exporter of metals and agricultural and fishery products.
EU27	●	●	●	●	Key consumer and importer of fossil fuels and metals. Major producer, exporter, and importer of agricultural and fisheries products.
France				●	Large importer mainly of fossil fuels.
Germany				●	Large economy with significant industrial sector, which is dependent on imports especially of fossil fuels, metals and minerals.
India	●	●	●	●	Major agricultural producer as well as large iron ore, bauxite and coal miner. Large exporter especially of iron ore. Expanding economy with major growth potential and rapid growth in import demand, especially for fossil fuels.
Indonesia	●	●	●	●	Key producer and exporter for coal, selected metals and many agricultural and forestry products such as palm oil. Large importer of fossil fuels. Expanding consumer with large growth potential due to size of its population.
Iran			●		Key oil and gas producer and exporter, with second largest conventional gas reserves.
Italy				●	Large importer of metals, fossil fuels and agricultural products.
Japan		●	●	●	Key consumer and importer of fossil fuels and metals, mainly for its large industrial sector, as well as significant importer of agricultural products. Large fisheries sector.
Malaysia			●		Key producer, consumer and exporter of palm oil. Importer of metals, agricultural products, and petroleum products.
Mexico			●	●	Large exporter of fossil fuels and select agricultural products. Heavily reliant on imports, especially for select agricultural and forestry products.
Netherlands				●	Resource trading hub for Europe centred on the third largest port in the world. Significant importer for fossil fuels and selected agricultural commodities.
Nigeria			●		Significant producer and exporter of petroleum and petroleum products.
Norway			●		Large (mainly offshore) oil and gas producer. Large fisheries sector.
Russia	●	●	●		Key oil and gas producer with large, mainly Arctic and sub-Arctic reserves. Major producer and exporter of metals (such as steel and nickel) and agricultural products (especially wheat).
Saudi Arabia	●		●		World's largest petroleum producer and exporter with the world's largest oil reserves. Growing importer of agricultural products.
Singapore			●	●	Large fossil fuel refining and trading hub.
South Korea			●	●	Large and resource-intense industrial sector, heavily reliant in particular on fossil fuels and metal imports. Significant exporter of refined oil and processed metals and large importer of agricultural products.
Spain				●	Large importer mainly of fossil fuels but also select metals and agricultural products.
Switzerland				●	Large importer of fossil fuels and significant trading and processing hub for metals.
Thailand				●	Large and growing importer of metals and fossil fuels for its expanding manufacturing sector. Large producer and exporter of rice and other agricultural products.
Turkey				●	Large fossil fuel importer and growing importer of metals and agricultural products. World's largest iron and steel scrap importer as raw material for its expanding steel industry.
UAE			●		Key oil producer and exporter. Growing importer of agricultural products.
United Kingdom				●	Large but declining oil and gas producer. Large Importer of fossil fuels and metals, especially gold.
United States	●	●	●	●	Key agricultural and fossil fuel producer and a large mining sector. Key exporter of agricultural products and large importer of metals. Key fossil fuel importer but with falling import dependence due to consumption peak and expanding (unconventional) production.
Venezuela			●		Large producer and key oil and gas exporter.

6.4.3 An agenda for targeted resources dialogues

The G20 has suffered from significant mission creep, as its remit has expanded far beyond its initial focus of financial regulation. In many respects, its effectiveness has declined as its agenda has spread beyond financial and macroeconomic policy coordination into resource-related issues such as fossil fuel subsidies, export controls, green growth and food price volatility. To avoid this problem, new resource dialogue – whether through the R30 or existing international institutions – would need a clear purpose or mission related to the sustainable stewardship of resources for the global good, and a well-defined agenda. Like-minded countries would benefit from tackling key areas for a more cooperative resources future, including the following.

Dialogue on managing price volatility could provide a starting point for new types of resource dialogues. To date, there remains little buy-in for many of the proposed mechanisms to manage price volatility in food or energy. These dialogues could be conducted on sectoral lines, with the inputs of experts, businesses and international organizations, and with a specific goal of seeking sector-specific solutions. Another potential area for cooperative engagement involves improving the data and transparency for resources, through standardizing the collection and sharing of data on resource endowments, stocks and trade figures.

Dialogue on managing price volatility could provide a starting point for new types of resource dialogues

Tackling export controls – for food products in particular – could become one of the potential plurilateral initiatives. An informal agreement to refrain from the imposition of export controls, or even establishing a process for dealing with them, could provide much-needed breathing space for states at times of food crisis, for example. This could consist of a time-limited process for review of newly imposed controls, and the initiation of dialogues with affected importer countries. Similar process could also be initiated *vis-à-vis* the subsidies agenda. Removing perverse subsidies and incorporating externalities in resource pricing remain politically sensitive and challenging for most countries. The question is whether or not a sub-group of states could move together to avoid competitiveness loss and other domestic political repercussions.

The proliferation of state-owned enterprises in the resource sphere has also compounded the challenge. These SOEs are not a monolithic group, though their presence frequently sparks controversy. Agreeing common standards for resource-seeking investments is also critical, as water and land stress may continue to spearhead new rounds of FDI in frontier regions. A foundation for these already exists in the many elements of best practice and lessons learned in the public domain. These might also include guidelines for best practice in domestic institutions in emerging producer states.

Engagement with emerging producer states is needed as a matter of urgency. Many of them could make a sizeable contribution to meeting future supply needs, even though they may not be 'systemic' producers today. These are typically poorer countries with unfavourable investment climates and weak governance, vulnerable to environmental stress.

Recommendations

1. Managing volatility – smart interventions	
Better responses to oil shocks	Specific measures to respond to local shortages in a way that mitigates the resource price impact on global markets. This could take place through existing fora (IEA, G20 and IEF) or among new 'coalitions of the committed'. More dialogues should take place between IEA countries and emerging economies on options for a global 'emergency response mechanism' for oil or to coordinate oil stockholding.
'Virtual reserves' for food	A club of major grain-based and oilseed-based biofuel-producing countries could collectively purchase call options from their biofuel industries. This arrangement would act like a virtual global food reserve. These contracts could specify a trigger – based on a price index – which when activated would obligate the producer to release feedstock back into food chains. Wider participation of nation-states and large private-sector stockholders in AMIS and the implementation of appropriate measures will help prevent global stock-to-use ratios breaching crisis thresholds.
Making speciality metal markets work	Stronger regulation of over-the-counter-trade in speciality metals as well as safeguards against anti-competitive practices will help ease market tensions and bottlenecks. Global data and transparency on metals production, trade and stock levels must be enhanced. Traders could be required to submit stock levels on a regular basis. The work of existing study groups for zinc, copper and other metals should expand to include production data and be brought together into one publicly accessible hub.
Link early-warning systems to triggers for early action	There should be clear decision-making and risk-management processes in international organizations and donor governments to respond to Early Warning Systems (EWS), with accountability for action clearly assigned to specific institutions as well as personnel. AMIS member countries, for example, could agree robust institutions with accepted rules and frameworks for triggering decision-making processes, evaluating response options and agreeing specific actions.
2. Resilience, governance and new frontiers	
Safeguarding ecological frontiers	Criteria – including for moratoria – should be established on resource production or extraction, especially in areas of significant biodiversity or ecological sensitivity such as the deep sea or the Arctic, where effective mitigation efforts or remedies are not available or affordable. Extreme engineering options are likely to become increasingly popular in a resource-constrained world. For this reason, relevant ministries, businesses and industry associations should discuss and implement (national or local) governance mechanisms and best practice on extreme responses such as weather modification.
Investing in social and environmental resilience in producing regions	Donor governments, recipient governments and international financial institutions could develop a multilateral global reinsurance mechanism to underwrite safety net liabilities in poor countries. Water-sharing agreements at catchment level need to provide flexibility and adaptability against future environmental changes. Also important are efforts to strengthen collection and monitoring of water-related data. Donors should support the roll-out of drip irrigation in rural areas, as should investors in land transfers. There should be closer integration of humanitarian and development activities as well as innovative arrangements to increase flexibility of donor funding lines. The post-2015 development framework should explicitly address risk and include indicators on resilience and reducing vulnerability for at risk groups. There should be global support for poor mineral producer countries to strengthen national revenue stabilization mechanisms to limit exposure to international price volatility.
Strengthening institutions and transparency	Governments, companies and donors should support existing efforts to increase transparency in the resource sectors and scale up engagement with officials and businesses from emerging economies. Capacity within civil society and among communities as well as independent media should be strengthened. Land management regimes in producing countries must be strengthened – from legislation on tenure, land titling and property rights to strong judicial institutions (that can work constructively with traditional systems where relevant).

Making data and information work	An annual State of the World's Resources report or an international resources data bank could be launched to standardize in a transparent manner the collection and sharing of data on resource endowments, stocks and trade figures. Scaling up capacity within civil society and among communities as well as local media is also critical.
3. Sustainability, efficiency and pricing	
Getting the prices right	The elimination of environmentally perverse subsidies is a clear global priority; any multilateral plan of action will require a clear timeline, concrete support for poorer states in efforts to reform resource pricing as well as effective channels and fora to share experience and technical expertise. Governments and businesses should support national efforts to implement environmental accounting practices and tools to assess natural wealth. Financial incentive mechanisms such as payments for ecosystem services (PES) could be integrated into existing frameworks – carbon markets, resource-related taxation, waste management and watershed management.
Responding to the efficiency challenge	Clear policy incentives, government procurement rules, market creation schemes and pricing structures that reflects the full environmental and social impacts are needed at the national level to incentivize higher resource productivity and efficiency. Governments from the major economies should agree a clear pathway for incremental improvements in resource efficiency standards to reward the best in class and to drive innovation and secure investment. Regulation to address food waste in the supply chain must be stepped up, including addressing unwanted 'bycatch' of fish. Donors should support efforts to improve agricultural storage and infrastructure to minimize food losses. Civil society and governments could collaborate in awareness raising campaigns to encourage behavioural change.
Rewiring the industrial sector toward a circular economy	Leading countries such as the EU, China, Japan and South Korea should pursue a resource management policy agenda through creating an alliance on ultra-resource productivity and the circular economy. Industry bodies and national associations could facilitate the sharing of best practice. Innovative models should be replicated or scaled up to support agricultural R&D in developing countries, through for example public private partnerships, to speed up the adoption and diffusion of appropriate new technologies. Developing country governments should examine opportunities, through national policies and dialogues with investors, to leverage non-agricultural infrastructure investments to create spill-overs for agricultural development.
4. Reinvigorating the rules-based governance for a polycentric world	
Building 'coalitions of the committed' on resource governance	To galvanize innovative thinking to change the status quo, this report proposes a new club of the world's principal resource-producing and -consuming countries to fill existing governance gaps on resource and scarcities governance. This 'Resources 30' or R-30 grouping, conceived as a 'coalition of the committed', would comprise leaders and officials from countries of systemic significance as resource producers, consumers, importers or exporters. The R30 could provide an informal but dedicated forum where governments and stakeholders can address specific resource-related issues, including tackling price volatility at the sectoral level, devising guidelines on the use of export restrictions, and encouraging transparency of state-owned enterprises, etc. Other stakeholders could also be invited to engage in an expert or observer capacity. The findings of these meetings could feed into existing international institutions.
Avoiding major trade wars	Informal guidelines on forgoing the use of export restrictions in times of commodity price crisis could be adopted as either an informal pledge or a plurilateral agreement at the WTO. Governments should address other potential flashpoints such as longer term exports controls, subsidies and investment rules through plurilateral negotiations among a 'coalition of the committed' at the World Trade Organization. A new 'Resources Round' of trade negotiations could be launched in the medium term.

7 Conclusions

7. Conclusions

This report provides clear evidence that the political economy of natural resources is increasingly shaped by larger, structural shifts under way – whether in the natural environment, in the relationship between resource systems or in the distribution of global income and power. Changes in resource geographies, shifting consumer power, concentration of ownership as well as the rise of state capitalism are all new factors for the world to contend with, together with ever-looming environment threats, especially climate change and water scarcities. All these moving pieces are changing the rules of the game, undermining assumptions about the sustainability of resource-intensive growth models.

Much has been made of the increasing securitization of resource politics as national assessments have begun to take greater account of energy, food and water insecurity. The real threat to global stability does not necessarily lie in securitizing resource assessments but in the potential for militarized responses. Such responses fail to address the causes of scarcity and volatility and create new 'security dilemmas' and 'spirals of insecurity'.[444] The recent attention given to critical minerals by the US Department of Defense in the light of the rare earth disputes,[445] the role played by armed forces in protecting oil and gas pipelines[446] as well as shipping,[447] and counterterrorism and counterinsurgency activities[448] aimed at denying illegal resource revenues to paramilitary groups all point to an increasingly militarized response to resource insecurity.

Looking forward, resource politics, not environmental preservation, are set to dominate the global agenda

Looking forward, resource politics, not environmental preservation, are set to dominate the global agenda. And these dynamics will play themselves out across a range of frontlines – from trade wars, climate negotiations, market manipulation strategies and aggressive industrial policies to scrambles for frontier areas. The key question is whether the world is equipped to move to a new global equilibrium under stress conditions in a collective manner. It will involve collaborative efforts to manage perceptions, expectations and fears of resource scarcity, politicization and securitization to avoid worst-case scenarios. Pressing questions that can only be addressed through joint action include:

- How can overreactions in response to resource-related threats be limited?
- How can unintended or indirect consequences of unilateral action on resources (e.g. closing borders) be mitigated?
- How can the resilience of the most vulnerable groups be strengthened?
- How can environmental considerations be mainstreamed in resource diplomacy and accounting?

For some natural resources in some places, investment and technological change may solve, at least temporarily, problems of availability and access. But on the global scale, the scope and size of changes in resource consumption, and their environmental impacts, risk overwhelming the ability of states, markets and technology to adapt. As Chapters 2 and 4 describe, tight markets for a number of resources are likely to perpetuate price volatility until at least 2020, with a range of direct and indirect impacts on both consuming and producing countries. Meanwhile, fears of 'running out' or impulses to protect minority vested interests and ignorance of the complex, dynamic and adaptive nature of global resource markets are leading states to pursue poorly designed and short-sighted policies which will undermine, not reinforce, the conditions for collective prosperity, sustainability and security.

Poorly designed and short-sighted policies will undermine, not reinforce, the conditions for collective prosperity, sustainability and security

Many of the likely political and economic realignments are already under way, as described in Chapter 4. Importer states such as many Middle Eastern countries (for food) or China (for most raw materials), keen to guarantee access in an era of potential resource scarcity, are seeking to build economic and trade relationships with the major producing regions. The result is a substantial reconfiguration of the political economy of global resource trade and international affairs. Recognizing their water and climatic constraints in the wake of fast-growing populations, Gulf countries are attempting to ensure food security through large-scale land deals in Africa and Southeast Asia. Other similar examples include Chinese engagement in extractive industries in Africa and Australia, or in agriculture in Latin America.

In turn, producer countries have responded to this new scramble for resources with policy measures of their own. Export restrictions, including taxes, quotas and outright export bans, have been used to protect supplies of key crops, including in particular rice and wheat; over 30 countries have used these kinds of measures since the 2008 food price crisis. The use of export controls on raw materials or semi-processed products may become more common in the future with the revival of industrial policy. Cartels such as OPEC for oil, and dominant producers such as China for rare earths, may find it expedient to restrict exports to drive up prices or demonstrate political power. In food products, regional cartels may emerge around wheat, rice, palm oil or soybean production if commitments to free markets continue to erode.

The combination and amplification of these pressures in an integrated world add to the challenge. Interdependencies together with the just-in-time global economy mean that local risks have systemic implications. The 2010 heat wave that wiped out large swathes of the Black Sea wheat harvest and triggered export controls in Russia and Ukraine provided a crucial spark for the initial social unrest that became the Arab uprisings. Spiking international wheat prices provided the transmission vector. The 2011 Japanese tsunami and its aftermath had serious impacts on global production chains in the short term. As governments re-evaluate the nuclear option in response, the longer-term consequences for worldwide energy policies and gas and coal consumption are only beginning to become apparent. In 2005, Hurricane Katrina's impact on US refining capacity triggered a spike in oil prices that led the IEA to authorize a release from its strategic reserve. The price implications of a shock to a more significant production, refining or transport node could quite conceivably render the IEA's emergency response mechanism impotent.

The frontiers of resource production are shifting. Some, like unconventional hydrocarbons in the advanced economies, have comparatively robust accountability mechanisms and environmental protection legislation, even though the long-term environmental impacts remain controversial. Others, such as mining or biofuels, will increasingly be found in poorer countries with high levels of poverty, weak governance and greater vulnerability to climate change – and more still in extremely sensitive ecological areas of global significance including the Arctic. As new production from these regions comes online, systemic vulnerabilities and economic fortunes will change.

The future course of resource governance has profound implications for Africa. As a region, Africa is a significant net exporter of resources, largely thanks to a handful of oil producers and the fact that domestic resource consumption is extremely low – itself a symptom of underdevelopment. Despite enviable resource endowments, Africa's path to development is far from assured. Many countries remain highly vulnerable to volatility in international energy and food prices. Rapid population growth, stagnant food production and climate change pose huge threats. Major investments are needed in agriculture, infrastructure and climate adaptation, among others. The ability of governments to adjudicate between and harness resource-seeking investments – in land, metals and fossil fuels – for inclusive and sustainable development will be key to Africa's future success.

It appears there is some way to go. Despite much of the hype surrounding 'land grabs' and the 'New Scramble for Africa', many agricultural or resource-seeking investments remain speculative in nature or have yet to commence production: African countries are conspicuous by their absence from lists of major resource producers, and figure only sparsely in lists of emerging producers. Moreover serious questions surround the transparency of many resource-related investments in land, metals and oil.

The hard truth is that many of the fundamental conditions that gave rise to the tight markets in the past ten years remain

With the maturation of technologies around non-conventional gas and oil (e.g. shale gas), as well as the global economic downturn, some analysts are suggesting that the 'super-cycle' of resource boom (especially in extractive industries) over the past ten years is coming to an end, and that many of the resource-related tensions will ease.[449] The hard truth is that many of the fundamental conditions that gave rise to the tight markets in the past ten years remain – and that lower prices in the meantime may simply trigger another bout of resource gluts in the large and growing developing countries. The world is only one or two bad harvests away from another global food crisis.[450]

Policies that only tinker at the margin without fundamentally reshaping resource politics along the way may prove detrimental in the medium term, especially if this potential respite (from slowed growth and the gas bonanza) does not persist. Fundamental realignments of the global political economy towards sustainable resource production and consumption are needed. This means getting not only the prices and the economics right, but also the politics of international cooperation.

Annex 1: Chatham House Resource Trade Database

Structure and content

To improve understanding of global flows of natural resources, Chatham House has developed a database tracking bilateral trade in natural resources and resource products between more than 200 countries and territories between 1998 and 2010. The database covers the weight and value of trade in over 1,200 different types of natural resources and resource products –including agricultural, fishery, and forestry products, fossil fuels and metals. It allows for a detailed examination of new and growing resource-related dependencies among countries and regions, and flows of resources through global value chains.

The principal sources for the Chatham House database are the International Merchandise Trade Statistics (IMTS), which are collected by national customs authorities and available through the United Nations Commodity Trade Statistics Database (UN COMTRADE).[451] Specifically, we rely on the International Trade Database at the Product Level (BACI), a particular version of COMTRADE statistics that has been developed by the French Research Centre on International Economics (CEPII).[452] BACI reconciles the raw data on trade flows reported separately by importers and exporters in COMTRADE. This method relies principally on adjustments for transport costs and on assigning a score to countries that estimates the reliability of the data that they report. This score is then used as weight when averaging COMTRADE data obtained from the importing and exporting reporter into a single data point in BACI.

The Chatham House database, like COMTRADE and BACI, is organized according to the Convention on the Harmonized Commodity Description and Coding System (or HS nomenclature), which assigns 6-digit codes to different types of traded products in a hierarchical structure. The first two digits (HS-2) identify the chapter the goods are classified in, e.g. *26 = Ores, slag and ash*. The next two digits (HS-4) identify groupings within that chapter, e.g. *26.01 = Iron ores and concentrates, roasted iron pyrites*. The next two digits (HS-6) are even more specific, e.g. *26.01.11 Iron ore, concentrate, not iron pyrites, unagglomerated.*[453] HS nomenclature has evolved historically as a pragmatic taxonomy of the broad range of products that are traded globally. Products that have a long history of being traded extensively are captured in much greater detail than products that are traded less frequently. For example, there is a single HS code associated to rare earths, while there are several hundred codes associated to steel and steel products.[454]

As in the case of other international merchandise trade statistics, an individual entry into the Chatham House database consists of the aggregate value and weight flowing from one country to another in an individual 6-digit code over the period of a year. Data are reported in 1000 US dollars and metric tons. The aggregate value and weight of crude petroleum oils (HS-96 code 270900) exported from Saudi Arabia to China in 2003 (14.59 million tonnes worth $2.87 billion) would, for example, constitute one such data point. Any crude petroleum that would be exported back from China to Saudi Arabia in the same year would be captured in a separate data point. In total, the Chatham House database contains over 12 million data points for the years 1998 to 2010.

IMT statistics and HS nomenclature include not only natural resources but all types of traded goods, including manufactures. In order to track resource trade flows, only HS codes identifiable as raw materials or relatively undifferentiated intermediate products were selected into the database. For example, both wheat and wheat flours were included, while bakery wares were excluded. Traded waste products, such as metal scrap or wood pulp, are also included. It should be noted that natural resources typically go through incremental stages of processing and value addition and HS nomenclature does not always capture these different stages with much granularity. As a result, not all HS codes can be classified unambiguously as 'natural resources' or be allocated to specific types of resources. 1,253 HS codes were selected in this way out of the over 5,000 HS codes available in BACI.

These 1253 HS codes were then reorganized to allow for the tracking of specific resources along the value chain. This is necessary because the common HS hierarchy is mainly organized around different types of products, rather than the materials that they consist of. For example, in COMTRADE ores and concentrates of various metals are classified in the chapter with the two-digit HS code 26, while refined metals and metal products are part of a different set or chapter (two-digit HS codes 72-83). In contrast to this, the Chatham House database groups HS codes by different types of resources. Copper ores and concentrates, various intermediate copper products (such as mattes, bars or wires) and copper scrap are, for example, all classified into a single 'copper' category. This allows for the tracking of global copper trade (or other individual types of resources) at different stages in the value chain. These individual resources are then further organized into groups such as non-ferrous metals, cereals or oilseeds.[455]

Data quality and identification of outliers

Given well-known issues with data quality in IMT statistics[456] and the size of the dataset, the identification and treatment of outliers is a central challenge for the reliable tracking of global resource flows. The reconciliation of exporter and importer reporting in BACI provides a significant improvement, but it does not provide an assessment of the reliability of the entire database or of individual data points.

To address this issue, Chatham House has developed a novel measure of data quality for IMT statistics that works through comparing value-weight ratios (or prices per ton) of individual data points. This method is based on the assumption that in a given year, resources belonging to the same six-digit product group can be expected to trade at roughly similar prices per ton, irrespective of the country pair that trades them. One per cent of the total value of global trade flows was excluded from the database after this process.

A detailed methodology for assessing data quality and the removal of outliers is available from www.chathamhouse.org/resourcesfutures/method.

Annex 2: Global Resources Trade 2000–10

Table A2.1 Global resource trade by type and year, 2000–10 (million tonnes)

Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cereals	282.2	281.4	296.8	291.7	297.2	327.4	339.6	360.9	389.7	369.5	378.8
Oil seeds	157.2	173.3	178.2	196.2	194.7	217.3	226.5	241.3	264.7	253.6	288.2
Vegetables, fruit, nuts	113.8	122.0	123.2	131.2	139.6	147.2	156.1	164.9	165.2	166.4	177.1
Fish, meat, dairy	67.8	70.5	74.1	77.1	80.2	85.8	90.1	94.0	96.7	97.6	104.2
Other agricultural products	133.0	138.9	142.3	145.9	154.2	164.9	170.5	175.0	178.1	175.8	198.6
Agricultural products	**753.9**	**786.1**	**814.6**	**842.1**	**866.0**	**942.6**	**982.9**	**1,036.0**	**1,094.3**	**1,062.9**	**1,146.9**
Crude and refined oil	2,463.8	2,492.0	2,403.0	2,570.5	2,837.9	3,202.4	3,323.6	2,943.9	3,103.0	2,962.7	3,344.9
Coal	672.0	731.3	725.5	794.5	899.0	912.4	981.7	1,074.4	1,139.8	1,047.1	1,161.6
Natural gas and LNG	417.6	428.4	481.9	547.4	628.2	714.7	742.4	781.6	809.2	573.9	650.7
Fuel wood and charcoal	2.4	2.3	2.8	3.9	3.7	4.3	4.7	4.9	5.1	5.9	6.1
Fossil fuels	**3,555.9**	**3,654.1**	**3,613.2**	**3,916.4**	**4,368.8**	**4,833.8**	**5,052.3**	**4,804.7**	**5,057.1**	**4,589.5**	**5,163.3**
Wood pulp, chips and waste products	92.5	94.1	94.4	104.9	115.2	125.3	133.8	142.5	146.4	140.8	156.8
Lumber and sawn wood	155.8	146.1	168.0	163.3	173.5	177.3	174.3	174.4	147.2	115.1	153.8
Board and plywood	33.4	35.3	35.8	41.0	45.5	48.7	49.7	42.1	42.4	34.1	41.9
Forestry products	**281.7**	**275.5**	**298.2**	**309.1**	**334.3**	**351.3**	**357.9**	**358.9**	**335.9**	**290.0**	**352.6**
Iron and steel	901.6	889.9	938.9	1,024.7	1,084.9	1,250.2	1,333.6	1,439.2	1,485.1	1,387.0	1,614.1
Non-ferrous	144.6	150.7	153.9	157.6	162.1	182.0	201.4	206.6	189.3	159.0	173.0
Speciality metals	19.1	19.5	20.7	22.8	27.2	29.7	29.2	31.1	35.8	27.1	37.9
Precious metals	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Metals and ores	**1,065.3**	**1,060.1**	**1,113.4**	**1,205.2**	**1,274.3**	**1,462.0**	**1,564.2**	**1,677.0**	**1,710.3**	**1,573.2**	**1,825.1**

Table A2.2: Global resource trade by type and year, 2000–10 ($ bn)

Category	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cereals	54.2	56.7	60.5	69.3	81.2	85.2	93.7	127.5	174.9	138.4	145.1
Oil seeds	42.4	43.9	50.2	64.2	75.2	75.9	82.2	110.9	162.3	134.7	158.6
Vegetables, fruit, nuts	128.0	133.2	136.6	155.8	179.0	197.2	213.1	247.5	286.6	254.4	286.2
Fish, meat, dairy	71.2	74.0	80.1	95.0	107.1	118.6	131.2	155.0	174.0	160.0	180.3
Other agricultural products	142.3	144.9	150.2	168.5	187.7	202.6	223.6	248.7	270.6	247.5	298.8
Agricultural products	**580.3**	**597.5**	**627.7**	**721.3**	**817.9**	**882.0**	**967.5**	**1,138.5**	**1,339.1**	**1,182.5**	**1,367.9**
Crude and refined oil	495.1	428.9	433.0	537.6	749.0	1,097.3	1,359.6	1,489.5	2,155.5	1,286.6	1,850.3
Coal	73.0	75.7	72.7	102.6	126.3	168.2	206.7	214.6	314.8	217.0	269.4
Natural gas and LNG	21.2	25.7	25.7	29.3	48.0	58.9	63.8	72.0	123.8	94.3	119.6
Fuel wood and charcoal	0.3	0.3	0.3	0.5	0.5	0.6	0.7	0.8	0.9	1.0	1.0
Fossil fuels	**589.7**	**530.7**	**531.8**	**670.1**	**923.8**	**1,325.0**	**1,630.8**	**1,776.9**	**2,595.0**	**1,598.9**	**2,240.4**
Wood pulp, chips and waste products	27.43	22.12	21.94	25.64	29.50	31.37	35.60	43.38	48.69	36.63	52.24
Lumber and sawn wood	33.63	31.82	33.21	36.06	42.90	48.76	45.07	57.94	53.95	39.06	49.06
Board and plywood	14.67	14.15	15.81	19.14	24.63	26.52	27.34	26.77	30.19	22.29	26.70
Forestry products	**75.7**	**68.1**	**71.0**	**80.8**	**97.0**	**106.7**	**108.0**	**128.1**	**132.8**	**98.0**	**128.0**
Iron and steel	140.4	129.4	140.7	182.3	274.2	324.0	374.1	477.8	592.4	339.8	487.2
Non-ferrous	123.5	116.2	115.7	134.3	190.7	229.6	355.6	431.4	403.7	270.6	398.5
Speciality metals	39.4	40.2	44.0	55.8	65.1	78.8	105.4	138.7	188.4	174.4	220.7
Precious metals	15.8	15.4	14.5	16.5	29.9	42.3	45.6	59.9	77.5	32.7	50.2
Metals and ores	**319.2**	**301.1**	**314.9**	**389.0**	**559.8**	**674.6**	**880.6**	**1,107.7**	**1,262.0**	**817.5**	**1,156.7**

Annex 3: Top 20 Resource Importers and Exporters

The following two tables show the top-20 largest exporters and importers of resources, calculated on the basis of the Chatham House Resource Trade Database (see Annex 1). Data refer to 2010 and to global trade excluding intra-EU trade streams. The EU has been added to the tables for reference.

Table A3.1: Top 20 resource importers in 2010

Rank	Resource importers	Value ($ bn)	Weight (mt)	% of global resource imports	
1	EU27	760.4	1433.6	19.6	18.7
2	US	499.3	768.9	12.9	10.1
3	China	427.7	1385.9	11.0	18.1
4	Japan	295.8	724.2	7.6	9.5
5	Germany	233.7	326.7	6.0	6.1
6	Taiwan	231.8	463.1	4.8	5.8
7	Netherlands	192.0	321.9	3.7	4.0
8	South Korea	186.0	445.6	3.2	2.9
9	Italy	178.3	294.8	2.9	3.0
10	United Kingdom	164.3	215.0	2.7	2.1
11	France	154.7	231.6	2.5	2.3
12	India	142.5	306.1	2.5	2.0
13	Belgium	104.3	162.2	2.2	1.7
14	Spain	101.0	175.4	1.9	1.8
15	Singapore	95.8	150.2	1.7	0.4
16	Canada	86.8	130.9	1.7	1.7
17	Switzerland	65.9	30.9	1.6	1.6
18	Turkey	62.8	123.0	1.6	1.3
19	Thailand	61.1	98.1	1.5	0.7
20	Hong Kong	56.4	53.4	1.4	1.2

Table A3.2: Top 20 resource exporters in 2010

Rank	Resource exporters	Value ($ bn)	Weight (mt)	% of global resource exports	
1	Saudi Arabia	311.8	573.5	8.0	7.5
2	Russia	304.6	671.4	7.9	8.8
3	EU27	282.1	316.6	7.3	4.1
4	US	259.1	468.5	6.7	6.1
5	Canada	187.1	337.5	4.8	4.4
6	Australia	171.0	822.8	4.4	10.8
7	Brazil	136.6	489.4	3.5	6.4
8	China	117.4	125.6	3.0	1.6
9	Iran	105.5	222.3	2.7	2.9
10	Norway	100.0	182.9	2.6	2.4
11	UAE	95.9	154.0	2.5	2.0
12	Indonesia	91.8	376.0	2.4	4.9
13	India	85.0	208.3	2.2	2.7
14	Japan	77.8	74.8	2.0	1.0
15	Mexico	74.8	109.2	1.9	1.4
16	Nigeria	72.9	136.5	1.9	1.8
17	South Korea	68.6	71.0	1.8	0.9
18	Malaysia	67.4	103.0	1.7	1.4
19	Chile	63.2	39.2	1.6	0.5
20	Singapore	59.1	78.3	1.5	1.0

Annex 4: Top Bilateral Trade Relationships by Sector

The following tables show the largest bilateral trade relationships for agricultural and fishery products, fossil fuels, metals and ores and forestry products. The data are calculated from the Chatham House Resource Trade Database. Intra-EU trade is ignored and the trading block is treated as a single entity. As these calculations aggregate trade flows by sector, they typically contain a mix of various individual commodities. The first column of the chapter comments on the commodity that dominates the trade flow.

Table A4.1: Largest bilateral resource trade relationships in agricultural and fishery products

Rank	Trade stream dominated by	Exporter	Importer	Value ($ bn)
1	Soybeans	US	China	11.6
2	Soybeans	Brazil	China	7.9
3	Soybeans	Brazil	EU27	5.9
4	Wine and beer	EU27	US	5.0
5	Cereals (maize and wheat)	US	Japan	4.5
6	Soybeans	Argentina	China	4.5
7	Soybeans	Argentina	EU27	4.5
8	Coffee and tobacco	Brazil	EU27	3.7
9	Meat and dairy	EU27	Russia	3.5
10	Palm oil	Indonesia	India	3.3
11	Cocoa	Côte d'Ivoire	EU27	2.8
12	Palm oil	Indonesia	EU27	2.8
13	Meat	US	Japan	2.8
14	Fish and seafood	China	Japan	2.7
15	Fruit, vegetables, nuts	China	Japan	2.7
16	Palm oil	Malaysia	China	2.7
17	Fruit, vegetables, nuts	US	EU27	2.6
18	Fruit, vegetables, nuts	EU27	Russia	2.6
19	Fish and seafood	China	US	2.5
20	Palm oil	Indonesia	China	2.4

Table A4.2: Largest bilateral resource trade relationships in fossil fuels

Rank	Trade stream dominated by	Exporter	Importer	Value ($ bn)
1	Crude oil	Russia	EU27	97.4
2	Refined oil	Russia	EU27	35.9
3	Crude oil	Saudi Arabia	Japan	28.9
4	Crude oil	Libya	EU27	28.8
5	Crude oil	Iran	Taiwan	28.4
6	Crude oil	Saudi Arabia	US	27.4
7	Crude oil	Venezuela	US	26.6
8	Crude oil	Nigeria	US	26.4
9	Crude oil	Saudi Arabia	China	22.8
10	Crude oil	Saudi Arabia	South Korea	20.3
11	Crude oil	Angola	China	20.1
12	Crude oil	UAE	Japan	19.9
13	Crude oil	EU27	US	16.1
14	Crude oil	Kazakhstan	EU27	16.0
15	Gas	Russia	EU27	15.4
16	Crude oil	Iran	EU27	14.0
17	Crude oil	Saudi Arabia	EU27	13.1
18	Hard coal and coke	Australia	Japan	12.9
19	Crude oil	Azerbaijan	EU27	12.6
20	Crude oil	Nigeria	EU27	12.4

Rank	Trade stream dominated by	Exporter	Importer	Value ($ bn)
21	Fish and seafood	Thailand	US	2.3
22	Meat	Brazil	EU27	2.3
23	Orange juice, fruit and vegetables	Brazil	EU27	2.2
24	Cotton	India	China	2.2
25	Beef and dairy	Australia	Japan	2.2
26	Leather	EU27	Hong Kong	2.1
27	Vegetables and fruit	China	EU27	2.1
28	Cotton	US	China	2.1
29	Fish and seafood	China	EU27	2.1
30	Soybeans	US	EU27	2.1

Rank	Trade stream dominated by	Exporter	Importer	Value ($ bn)
21	Refined oil	Saudi Arabia	Taiwan	11.8
22	Crude oil	Qatar	Japan	11.2
23	Crude oil	Iraq	US	11.1
24	Gas	Algeria	EU27	10.8
25	Crude oil	Iran	China	10.8
26	Crude oil	Saudi Arabia	India	10.7
27	Crude oil	Angola	US	10.4
28	Crude oil	Algeria	US	10.1
29	Crude oil	Colombia	US	9.9
30	Crude oil	Saudi Arabia	Taiwan	9.0

Table A4.3: Largest bilateral resource trade relationships in metals and ores

Rank	Trade stream dominated by	Exporter	Importer	Value ($ bn)
1	Iron ore	Australia	China	30.5
2	Copper	Chile	China	14.9
3	Gold	Switzerland	India	14.6
4	Iron ore	Brazil	China	13.6
5	Iron and steel	Japan	China	9.0
6	Iron ore	Australia	Japan	8.3
7	Gold	Canada	EU27	8.2
8	Iron ore	India	China	8.2
9	Gold	US	EU27	6.9
10	Iron and steel	Russia	EU27	6.6
11	Iron ore	Brazil	EU27	6.6
12	Copper	Chile	EU27	6.4
13	Iron and steel	China	South Korea	5.6
14	Copper	EU27	China	5.5

Table A4.4: Largest bilateral resource trade relationships in forestry products

Rank	Trade stream dominated by	Exporter	Importer	Value ($ bn)
1	Wood pulp, chips and particles	Brazil	EU27	2.8
2	Wood waste and waste products	US	China	1.9
3	Wood pulp, chips and particles	US	EU27	1.5
4	Logs and roughly treated wood	Russia	China	1.4
5	Wood pulp, chips and particles	Canada	China	1.4
6	Wood waste and waste products	EU27	China	1.3
7	Wood pulp, chips and particles	Brazil	China	1.1
8	Wood pulp, chips and particles	US	China	1.1
9	Board and plywood	China	US	1.1
10	Board and plywood	Malaysia	Japan	0.9
11	Wood pulp, chips and particles	Brazil	US	0.9
12	Wood pulp, chips and particles	Chile	EU27	0.8
13	Wood pulp, chips and particles	Australia	Japan	0.8
14	Wood pulp, chips and particles	Indonesia	China	0.8

Rank	Trade stream dominated by	Exporter	Importer	Value ($ bn)
15	Nickel	Russia	EU27	5.4
16	Iron and steel	EU27	US	5.3
17	Gold	UAE	India	5.3
18	Iron and steel	Ukraine	EU27	5.0
19	Copper	Chile	Japan	5.0
20	Gold	Australia	EU27	4.7
21	Iron ore	Australia	South Korea	4.6
22	Iron and steel	Japan	Thailand	4.6
23	Gold	US	Switzerland	4.3
24	Iron and steel	South Korea	China	4.0
25	Gold	Switzerland	Thailand	4.0
26	Gold	Peru	Switzerland	3.8
27	Iron and steel	China	EU27	3.5
28	Copper	Zambia	Switzerland	3.5
29	Copper	Russia	EU27	3.5
30	Iron ore	Brazil	Japan	3.4

Rank	Trade stream dominated by	Exporter	Importer	Value ($ bn)
15	Sawn wood	EU27	Japan	0.8
16	Sawn wood	Russia	EU27	0.8
17	Sawn wood	Russia	China	0.7
18	Sawn wood	Canada	Japan	0.7
19	Board and plywood	Indonesia	Japan	0.7
20	Wood waste and waste products	Canada	China	0.7
21	Sawn wood	Canada	China	0.7
22	Wood pulp, chips and particles	Chile	China	0.7
23	Wood waste and waste products	Japan	China	0.7
24	Sawn wood	EU27	Egypt	0.7
25	Wood pulp, chips and particles	EU27	China	0.6
26	Logs and roughly treated wood	US	China	0.6
27	Sawn wood	US	EU27	0.6
28	Logs and roughly treated wood	New Zealand	China	0.6
29	Wood pulp, chips and particles	Russia	China	0.6
30	Wood pulp, chips and particles	US	Japan	0.5

Annex 5: Composition of Trade in 2010

Composition by weight and value

Figure A5.1 and Figure A5.2 depict the composition of global resource trade by value and volume in 2010. Fossil fuels (oil, gas and coal) are the most traded of all resources (61% by weight and 49% by value); oil alone accounts for roughly 40% of total resource trade. Fish, meat and dairy are the most valuable of traded food products, followed by fruit and vegetables, oilseeds (e.g. soybeans and palm oil) and cereals (e.g. maize, wheat and rice). 42% of global metals trade consists of iron and steel, with non-ferrous bulk metals (such as aluminium, copper and zinc) making up another third (34%).

Figure A5.1: Composition of resources trade by weight, 2010

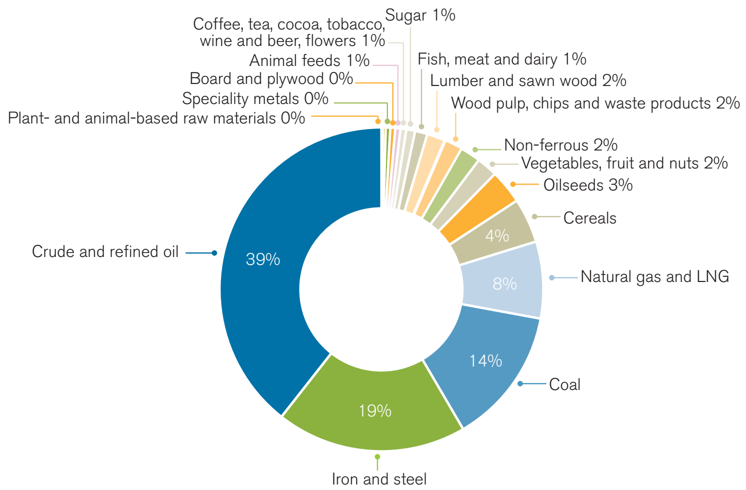
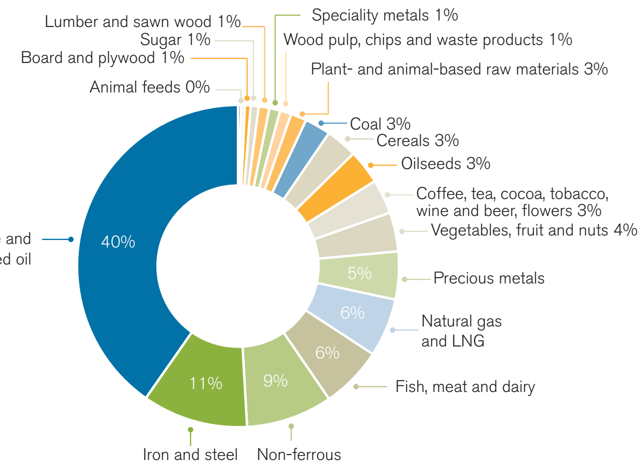


Figure A5.2: Composition of resources trade by value, 2010



Source: Chatham House Resource Trade Database.

Trade composition: imports and exports by region and sector

The pie charts in Figures A5.3–A5.8 show the share of different world regions in exports and imports in 2010, respectively for fossil fuels, agricultural and fishery products and metals and ores.

Figure A5.3: Share of global imports in fossil fuels, 2010

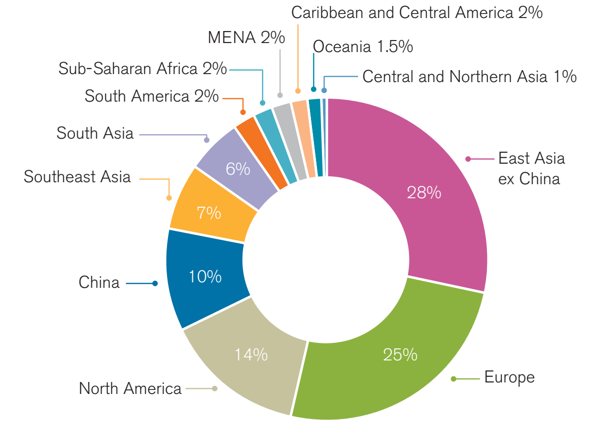


Figure A5.4: Share of global exports in fossil fuels, 2010

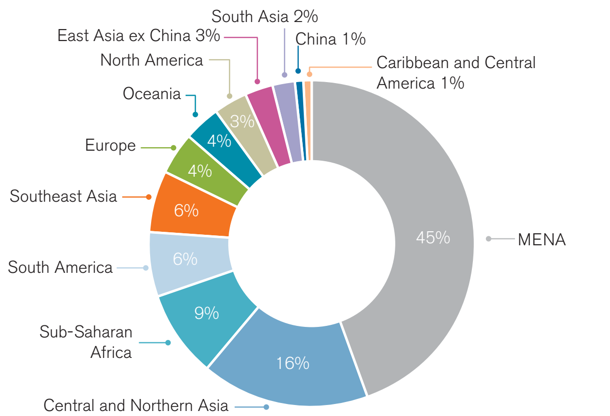


Figure A5.5: Share of global imports in agricultural and fishery products, 2010

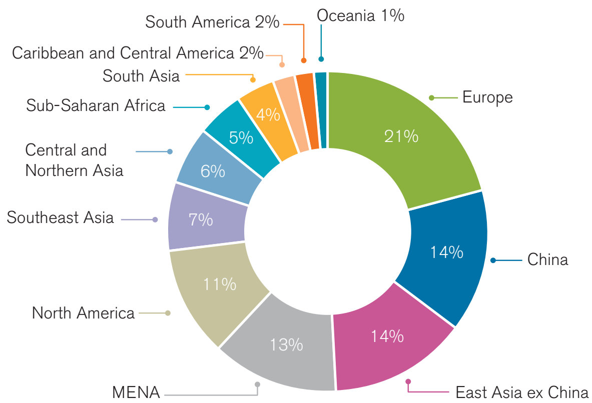


Figure A5.6: Share of global exports in agricultural and fishery products, 2010

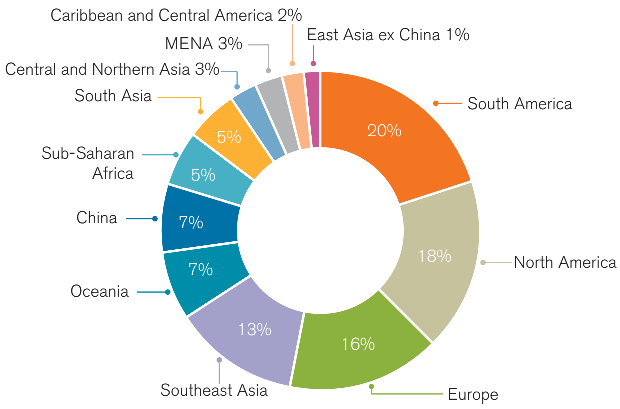


Figure A5.7: Share of global imports in metals and ores, 2010

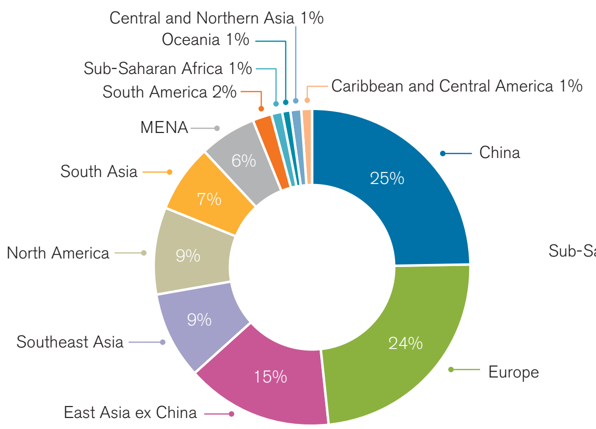
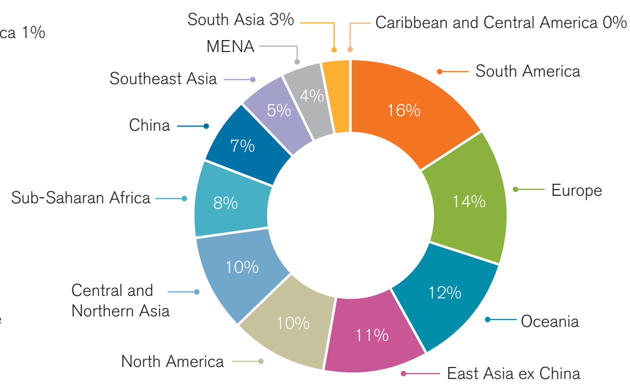


Figure A5.8: Share of global exports in metals and ores, 2010



Source: Chatham House analysis of UNCTAD data.

Annex 6: Emerging Consumer and Producer Countries

The tables show emerging producers and consumers for different types of commodities, together with a description of key projections (if available), driving factors and major obstacles that may hamper further growth. Countries have been identified on the basis of the pace of their production or consumption growth respectively, but have only been included if their size allows them to have a meaningful impact on global consumption and production patterns (at least 1% of current global consumption or production respectively). Countries that are very small producers or have not yet entered production are only included if major investments are currently taking place that are likely to make these countries large-scale producers over the course of the next ten years.

Table A6.1: Emerging producers for key commodities

Commodity	Emerging producers	Percentage share of global production, 2010	Percentage compound annual growth rate, 2000–10	Description
Maize	Indonesia	2	7	Growing production mainly through yield improvements to satisfy fast-rising domestic demand.
	Ukraine	1	12	Rapid growth through ongoing modernization of the agricultural sector with the support of foreign investment. With some of the most fertile lands in the world, there is large potential for further yield improvement.
Wheat	Iran	2	6	Growth is backed by heavy public investment with production mainly aimed at the large and fast-growing domestic market.
	Brazil	1	14	Traditionally not a wheat producer, the world's second largest importer is actively promoting wheat cultivation in order to cut imports and decrease exposure to wheat price fluctuations.
Rice	Burma (Myanmar)	5	5	Production continues to struggle within a weakly developed agricultural sector, but the country – once Asia's largest rice exporter – has the potential to re-emerge as a major player.
	Cambodia	1	7	Production has expanded through yield improvements and increased land-use. The government plans to further double rice production on 2010 levels by 2015.[457] However, lack of investment, especially into further yield improvements, could impede growth.
Soybeans	Paraguay	3	10	The world's fourth largest exporter has experienced booming production backed by large-scale foreign direct investment (FDI).
	Ukraine	1	39	Rapid growth as farmers have been switching to the profitable crop. Growth is supported by the ongoing modernization of the agricultural sector, large-scale foreign investment, and high domestic and export demand growth.
	Uruguay	1	75	Production has been expanding extremely fast. Growth has been backed by large-scale FDI, especially from the soybean sector in neighbouring Argentina, due to large differences in export taxes.[458]

Commodity	Emerging producers	Percentage share of global production, 2010	Percentage compound annual growth rate, 2000–10	Description
Timber	DRC	2	2	Two-thirds covered by one of the largest tropical forests in the world, the DRC's has enormous potential as a producer. Illegal logging is widespread. Political instability and war, as well as inefficient and unsustainable management practices, have fuelled deforestation and slowed sustainable production growth.
	Chile	1	3	Forestry is a key sector for the country's economy, supported by large forests and high yields due to Chile's favourable climate. Large, export-oriented production that has seen steady growth.
	Ghana	1	6	Both legal and illegal production has increased rapidly over the past decade, driven by fast-growing domestic and international demand. Forest depletion and government efforts to curtail illegal logging may slow future production growth.
	Uruguay	0	8	Production has been growing rapidly and is mainly based on forest plantations that have enjoyed strong policy support in the past. The forestry sector is however increasingly competing with fast-expanding soybean production for land resources, which may slow future production growth.
Aluminium	India	4	9	Rich bauxite deposits and booming domestic demand are fuelling production growth, with ambitious plans to scale production from 1.7 million tons in 2011 to 4.7 million tons per year by 2017.[459] Poor energy infrastructure and environmental concerns may, however, restrict the pace of future growth.
	Brazil	4	2	Abundant availability of bauxite and hydro-energy, as well as fast-growing domestic demand, are likely to fuel future growth.
	UAE	3	12	Rapid growth has been fuelled by cheap and abundant energy supplies and strong government support. Rising domestic demand for non-industrial energy use may constrain long-term growth.
	Bahrain	2	6	Well-established sector profiting from low, subsidized gas prices. Rising production costs of gas in Bahrain may constrain future competitiveness and trigger a greater focus on downstream growth.
	Iceland	2	13	Growth has been actively supported by the government and fuelled by abundant and cheap geothermal and hydro power, with further large-scale expansion being planned.
	Mozambique	1	26	Growth has been fuelled by one large-scale smelter operation. Although further near-term expansion is likely to be limited, abundant fossil energy and growing FDI could spur further expansion in the longer term.
Iron ore	Ukraine	3	3	Mature but steadily growing second-tier producer.
	South Africa	3	6	Mature but growing second-tier producer. Future growth could be constrained by lack of infrastructure, political unrest and energy constraints.
	Iran	1	8	Strong domestic and export demand and abundant reserves have encouraged growth of the sector. Future demand growth may be constrained by tightening international sanctions.
	Guinea	0	0	The first iron ore mine only went into production in 2012,[460] but some of the largest iron ore mines in the world are under construction in the country and could make it a significant exporter within the decade. Political instability and infrastructural challenges, however, remain important obstacles.
Copper	Zambia	4	11	Endowed with some of the highest-quality reserves in the world, Zambia's copper industry has been booming, with output returning to previous peak outputs of the 1970s. Production is likely to continue to expand with the help of large-scale foreign investment.

Commodity	Emerging producers	Percentage share of global production, 2010	Percentage compound annual growth rate, 2000–10	Description
Copper	DRC	2	34	Despite continued political instability, copper production from large, high-grade reserves has grown rapidly. Fast growth is forecast to continue but hinges on overcoming infrastructure constraints and maintaining political stability.
	Brazil	1	21	Large-scale investment and high prices have led to fast production growth. New projects could more than double output by 2015 from 2010 levels.[461]
	Iran	2	7	Copper output has been increasing rapidly based on significant reserves and state-backed investment. The government has ambitious plans to further scale production from currently over 200 kt to 700 kt.[462] Inefficiencies and tightening international sanctions could constrain further growth.
	Laos	1	21	Large Chinese and Australian investments have led to fast production growth and ongoing exploration efforts. Proximity to the Chinese market, government support and considerable reserves are likely to fuel further growth.
	Mongolia	0	0	The country contains large undeveloped copper reserves, which are under development through a joint venture between the government and foreign investors, with production scheduled to start in 2013. Political instability and lack of transport infrastructure could constrain future growth.
Crude oil	Brazil	3	6	Increasing exploitation of ultra-deep water deposits has encouraged oil production growth, with production expected to increase further with the exploitation of large pre-salt deposits in the Atlantic Ocean.
	Angola	2	10	Oil production has been increasing rapidly due to the improving security situation and large-scale foreign investment. New deep-water offshore oil discoveries are likely to further boost production in the future.
	East Africa	n/a	n/a	A large stretch of oil and gas-prone geology has been estimated to run from Somalia to Mozambique. Significant oil discoveries have been made in South Sudan in the past and more recently in Northern Uganda, Northern Kenya, Madagascar (including tar sands) and off-shore Mozambique. While some oil development will be impeded by governance, infrastructure and security issues, the area is attracting increasing investment from medium-sized and major international oil companies.
Gas	China	3	13	Determined government efforts to exploit domestic offshore gas reserves have led to steady production growth, but future production will increasingly depend on the development of yet unexploited coal-bed methane and shale gas reserves.
	Saudi Arabia	3	6	Mature gas producer, with most gas production occurring as by-product of oil production and therefore limited by depletion policy and OPEC quotas. Rising domestic energy demand is encouraging rapid development of non-associated gas fields with a 35% production increase over 2010 levels targeted by 2015.
	Egypt	2	13	Production has increased through heavy investment and new gas discoveries. Further growth will depend on the ability to attract continued foreign investment against the backdrop of recent political instability.
	East Africa			Large gas fields have already been discovered in onshore Ethiopia and coastal areas of Tanzania and Mozambique. The geology suggests more may be found. LNG facilities are planned to take East African gas to Asian markets and possibly to the Arabian Gulf.

Commodity	Emerging producers	Percentage share of global production, 2010	Percentage compound annual growth rate, 2000–10	Description
Coal	Indonesia	5	16	Proximity to fast-growing Asian coal markets, domestic demand growth and large coal reserves have led to a production boom. Large-scale mining and infrastructure investments and growing import dependence in China and India are likely to fuel continued fast growth, though export restrictions could slow development.
	Colombia	1	7	An improving security situation and high global demand have led to heavy investments by Western multinationals into the sector and related infrastructure. Fast growth has been continuing and the Colombian government expects further growth by over 20% between 2012 and 2014.[463]
	Vietnam	1	14	Booming domestic demand for power production is driving coal production growth, with the government targeting to increase production further by 15% in the next three years alone.[464]
	Mongolia	0.3	17	Export-oriented coal mining in Mongolia is growing quickly, led by the development of Tavan Tolgoi, one of the world's largest undeveloped coal deposits. Water constraints and political instability may, however, restrict future production growth.
	Mozambique	0	9	Large-scale foreign investment has been attracted by high-quality reserves and improving political stability. According to government plans, coal production by 2020 could reach 100 million tons, up from just 1 million tons in 2011.[465]

Table A6.2: Emerging consumers for key commodities

Commodity	Emerging consumers	Share of global consumption, 2010	Compound annual growth rate, 2000–10	Description
Maize	Indonesia	2%	6%	Mature consumer with steadily rising consumption levels for both staple food and as feed in livestock industries, due to population growth and rising incomes.
	Nigeria	1%	3%	Growth is driven by demand for human consumption and as poultry feed. Rising incomes and strong population growth are likely to result in sustained growth.
	Philippines	1%	4%	Steady growth is driven by demand for human consumption and as poultry feed.
	Iran	1%	10%	Rapid growth is based on mainly on higher feed demand in the livestock sector, which results from increasing meat consumption due to population growth and rising incomes.
	Vietnam	1%	10%	Maize is mainly used as feed in the livestock industry with growth driven by large demand growth.
Wheat	Pakistan	4%	2%	Mature consumer with steady growth due to expanding population.
	Egypt	3%	3%	Mature consumer with steady consumption increases due to population growth.
Rice	Vietnam	5%	2%	Growth coming mainly from increasing incomes, rising population and growing use in food and beverage industries.
	Thailand	3%	3%	Mature consumer with growth fuelled mainly by rising incomes and growing use in feed and processed food industries.
	Philippines	3%	3%	Growth coming mainly from increasing incomes, rising population and growing use in food and beverage industries.

Commodity	Emerging consumers	Share of global consumption, 2010	Compound annual growth rate, 2000–10	Description
Soybeans	Russia	1%	14%	Consumption growth is mainly driven by growing use in processed foods and the fast-growing and modernizing livestock industry.
	Paraguay	1%	6%	Soybean consumption mainly as feed is growing rapidly due to abundant domestic availability of soybeans and booming livestock industries.
	Iran	1%	10%	Consumption is fuelled by population growth and a greater use as feed in the expanding livestock sector due to increased meat consumption. Tightening sanctions could undermine further growth.
	Ukraine	0%	34%	Soybean consumption is fuelled by growing domestic production and a greater use in the expanding livestock sector.
	Egypt	0%	19%	Soybean demand is growing due to its greater use as both feed and edible oil. Consumption of the latter is being encouraged by subsidies.
	Syria	0%	24%	Growing meat demand, greater use of soybeans as poultry feed, and increasing substitution of olive oil with cheap soybean oil is driving consumption growth. Further growth could be disrupted by continued political instability.
Palm oil	Pakistan	4%	6%	Population growth and expanding food-processing industries are fuelling demand growth.
	Thailand	3%	9%	The use of palm-oil based biofuels has been encouraged by the government to reduce the country's high import-dependency on fossil fuels.
	Bangladesh	2%	28%	Rapid population growth and rising incomes are fuelling demand for palm oil, the main edible oil in Bangladesh.
	Iran	1%	25%	Rising incomes and a growing population have fuelled edible oil consumption, with palm oil increasingly substituting soybean oil due to changing government regulations.
	Russia	1%	17%	Growing consumption has been driven mainly by expanding use food and other industries.
	Vietnam	1%	19%	Population growth and rapidly rising incomes are contributing to demand growth, with palm oil mainly used for human consumption.
	South Africa	1%	36%	Demand has mainly been growing due to greater use in food and other industries and as a substitute of more expensive sunflower oils.
	UAE	1%	45%	Consumption is growing extremely fast due to rising demand as edible oil and product in processed foods and many export-oriented processing industries.
Steel	Brazil	2%	5%	Steel consumption of Brazil's expanding economy is growing steadily. Booming infrastructure and the expanding oil and gas sectors are likely to drive further consumption growth.
	Turkey	2%	7%	Turkish steel demand has grown due to booming construction, expanding infrastructure and double-digit economic growth.
	Iran	1%	6%	A booming construction sector has been the key driver for mainly domestically supplied steel products. Political uncertainty and tightening economic sanctions may curtail growth in the short to medium term.
	Thailand	1%	8%	Domestic steel consumption in Thailand has grown due to fast economic growth and reconstruction efforts in the wake of the 2004 tsunami. The demand has been driven primarily by the construction and export-oriented automotive industries.
	Vietnam	1%	16%	Rapid urbanization, large-scale infrastructure projects and a booming manufacturing sector are the main drivers of steel consumption growth.

Commodity	Emerging consumers	Share of global consumption, 2010	Compound annual growth rate, 2000–10	Description
Timber	Chile	1%	3%	Steadily growing timber demand due to the fast expanding domestic economy and abundant domestic supply.
	Ghana	1%	6%	Fast population growth and rising incomes create rapid demand growth, especially in the construction sector. Owing to efforts to rein in illegal logging, the country may soon become a net importer of timber.
Crude oil	India	4%	4%	Rapid economic growth and an expanding domestic refining industry have led to growing crude demand. Government subsidies for diesel and kerosene further contribute to growth. Increasing demand in the transportation sector and difficulties in implementing further fuel price reform are likely to sustain growth.
	Saudi Arabia	3%	6%	Strong economic growth, large fuel subsidies, inefficient power generation, and growing desalination requirements have fuelled oil demand growth. Plans to increase efficiency, to develop public transport and to diversify the power mix could reduce growth in the future.
	Iran	2%	4%	The fast-growing transportation sector has been the main driver of demand for petroleum products. The removal of consumption subsidies in late 2010 and tightening economic sanctions could significantly reduce future growth rates.
	Russia	3%	2%	A mature consumer; demand for crude oil has been mainly driven by expanding domestic refining capacity rather than growing demand for petroleum products.
	Brazil	3%	2%	Brazilian energy consumption has grown significantly due to fast economic growth. Booming domestic production may further encourage consumption growth especially in the transportation sector.
Gas	China	3%	15%	Rapid economic growth, regulated gas prices and attempts by the government to increase the role of gas in the energy mix have contributed to high demand growth and are likely to sustain it in the future.
	India	2%	11%	Power generation, petrochemical and fertilizer industries have fuelled the growth in domestic consumption. Attempts to diversify India's energy supply and a push to expand domestic gas production are likely to contribute to future demand growth.
	Saudi Arabia	3%	6%	Large consumption subsidies, a focus on expanding the petrochemicals industry and growing domestic power demand are driving domestic gas consumption growth. This is likely to continue in the medium term as attempts are made to diversify the power generation mix away from oil.
	UAE	2%	7%	High energy demand growth, large consumption subsidies and strong dependence on gas have fuelled rapid demand growth. These factors are likely to sustain high demand growth, although energy efficiency measures, the reduction of subsidies and attempts to diversify the country's energy mix away from gas may slow future demand growth.
	Mexico	2%	4%	Gas consumption has been growing steadily as the country's energy demand grows and oil has increasingly been substituted with natural gas. Future consumption growth is likely to be sustained by this trend, and be supported by efforts to reduce greenhouse gas emissions.
	Egypt	1%	10%	Natural gas discoveries have prompted the government to promote the use of natural gas, especially in the transport, power generation and industrial sectors. The use of natural gas as a fuel for vehicles and power generation is likely to expand steadily.

Commodity	Emerging consumers	Share of global consumption, 2010	Compound annual growth rate, 2000–10	Description
Gas	Thailand	1%	8%	Heavy dependence on oil imports and substantial domestic natural gas reserves have led the government to introduce gas consumption subsidies in the transportation and domestic sector. A growing number of petrochemical plants are also contributing to high growth.
	South Korea	1%	9%	Gas consumption is expanding due to fast economic growth and attempts to reduce the country's reliance on CO_2-intensive energy sources. Further increases will be likely if a Russian pipeline route to the Korean Peninsula is agreed in 2013/14.
Coal	Kazakhstan	1%	6%	Demand from electricity producers and the steel industry has been driving consumption growth. Rising energy demand and abundant domestic supplies are likely to fuel further growth.
	Indonesia	1%	9%	With demand outpacing power production capacity and abundant domestic supplies, coal has been tapped as the fuel for new power generation capacity. A booming economy and government support for domestic consumption over exports are likely to fuel further demand growth.
	Turkey	1%	2%	Demand growth has been mainly fuelled by growing energy consumption and the country's booming steel sector.
	Vietnam	0%	12%	Abundant domestic supplies and expanding demand both from heavy industries and the power sector are fuelling consumption growth, which is likely to be sustained as the country continues to industrialize.

Annex 7: Key Statistics for the R30

Figure A7.1: Key statistics for the R30

	Population, 2011 (millions)	GDP, PPP, 2011 (billions)	Resource imports 2010 ($ bn)	Resource imports 2010 (mt)	Resource exports 2010 ($ bn)	Resource exports 2010 (mt)
Australia	22.6	892	42	46	171	823
Brazil	196.7	2,305	46	85	137	489
Canada	34.5	1,394	87	131	187	337
Chile	17.3	299	16	30	63	39
China (incl. Hong Kong, SAR)	1,351.2	11,733	463	1423	115	116
European Union	503.7	14,093	760	1434	282	317
France	65.4	2,290	73	140	27	34
Germany	81.7	3,205	97	175	42	33
India	1,241.5	4,534	143	306	85	208
Indonesia	242.3	1,131	50	80	92	376
Iran	74.8	840	24	41	106	222
Italy	60.8	2,001	113	230	34	29
Japan	127.8	4,383	296	724	78	75
Malaysia	28.9	450	44	86	67	103
Mexico	114.8	1,753	56	89	75	109
Netherlands	16.7	715	122	224	37	45
Nigeria	162.5	411	14	21	73	137
Norway	5	306	16	19	100	183
Russia	141.9	3,016	45	63	305	671
Saudi Arabia	28.1	686	27	45	312	573
Singapore	5.2	317	96	150	59	78
South Korea	49.8	1,506	186	446	69	71
Spain	46.2	1,499	64	128	19	18
Switzerland	7.9	389	66	31	47	14
Thailand	69.5	605	61	98	44	46
Turkey	73.6	1,289	63	123	32	39
UAE	7.9	381	30	39	96	154
United Kingdom	62.6	2,223	104	164	32	43
United States	311.6	15,094	499	769	259	468
Venezuela	29.3	376	7	10	58	126

Annex 8: Selection of the Proposed R30 Countries

The methodology for the selection of the R30 candidates is based on calculations of a country's current position in the production, consumption and trade in resources. The list presented in Chapter 6 is based on four criteria which identify countries that are systemically important producers, consumers, exporters and importers of natural resources. All criteria and assumptions for the selection would be subject to debate, and alternative approaches are discussed under each criterion.

Calculations are based on 2010 data, the latest year for which comprehensive data for all criteria are available.[466] Export and import statistics for natural resources are from the Chatham House Resource Trade Database (see Annex 1). The import and export calculations do not include intra-EU trade flows and do not distinguish between China and Hong Kong (given the importance of Hong Kong as a transit hub for imports into and exports from China).

Key resource producers. Countries are included if they contribute at least 10% of global production in at least two specific resources. China, the US, the EU, India, Brazil, Russia, Australia, Canada and Indonesia meet this threshold. Saudi Arabia and Chile are also included because they are key producers in a single resource category (12% of crude oil and 34% of copper respectively). A stronger focus on single commodities in the methodology might have added Argentina (for soybeans), Malaysia (for palm oil), Peru (for zinc and copper) and Morocco (for phosphates). An alternative approach could take into account resource endowments and future production potential, which might add the DRC, for example.

Key resource consumers. Countries are included if they account for at least 5% of global demand for at least two key resources. The threshold is lower than for producers because global resource consumption is less concentrated than production. Key consumers include the US, China, India and the EU as well as Brazil, Russia, Japan and Indonesia. An alternative approach could consider population size and potential for growth in per capita resource consumption – adding countries such as Pakistan, Bangladesh and Nigeria.

Key resource importers. Countries among the top 20 importers of natural resources by value are included. Beyond the key consumers this adds Mexico, a number of East Asian and Southeast Asian countries (including South Korea, Singapore, Thailand and Hong Kong), as well as several European countries (the Netherlands, Italy, the UK, Germany, France, Spain, Switzerland and Turkey). An alternative approach with a focus on specific resources might have identified others such as Egypt, owing to its large imports of wheat and other food.

Key resource exporters. Countries among the top 20 exporters of natural resources by value are included. Beyond the key producers, this adds key oil and gas exporters including Saudi Arabia, Iran, Norway, the UAE, Nigeria, and Venezuela. Chile and Malaysia are also included (the former for copper, the latter for both palm oil and petroleum products). An alternative approach with a focus on specific resources might have identified South Africa, a key metals exporter, or the Ukraine for its wheat exports.

Annex 9: Measuring Vulnerability to Price Swings for Resource Exporters and Food Importers

A9.1 Vulnerability to food price surges

The vulnerability of countries to high food prices is assessed on the basis of three indicators:

1. Average share of income spent on food (based on World Bank data)
2. Prevalence of undernourishment in a country's population (based on FAO data); and
3. Degree of food import dependence (based on FAO data).

Undernourishment data are included to reflect the fact that food security depends on a diverse set of factors as well as income, including income inequality, the strength of social protection frameworks and the presence of marginalized groups in society.

This approach identifies a number of countries as vulnerable that are not captured by other methods that have a greater weighting on income. These are countries with relatively high levels of average income per capita (such as Angola or China) or relatively low food import-dependence (such as Zambia, Bolivia, Burma or Guatemala).

Countries are scored on the five-point scale as follows:

Table A9.1

Extremely vulnerable	• Countries with very *high prevalence* of undernourishment (>35%) • Countries with *high prevalence* of undernourishment (≥20%) that are heavily food-import- dependent (≥50%) • Countries where households spend more than 70% on food	Angola, Antigua and Barbuda, Armenia, Botswana, Burma, Burundi, Cambodia, Central African Republic, Chad, Comoros, DRC, Djibouti, Dominican Republic, Eritrea, Ethiopia, Grenada, Haiti, Madagascar, Mongolia, Mozambique, Palestine, Rwanda, Sri Lanka, Tajikistan, Yemen and Zambia

Highly vulnerable	• Countries with *high prevalence* of undernourishment (≥20%)
	  • that are net-food importers
	  • or where households spend more than 50% on food
	• Countries with *moderate prevalence* of undernourishment (≥10%) that
	  • are either heavily food-import- dependent countries (≥50%)
	  • or where households spend more than 50% on food
		Afghanistan, Azerbaijan, Bangladesh, Cameroon, Cape Verde, Cuba, North Korea, Gambia, Guinea-Bissau, Kenya, Laos, Lesotho, Liberia, Malawi, Maldives, Mali, Nepal, Pakistan, Panama, Saint Kitts and Nevis, Senegal, Sierra Leone, Solomon Islands, Sudan, Timor-Leste, Togo, Trinidad and Tobago, Uganda, Tanzania, Vietnam and Zimbabwe

Vulnerable	• Countries with *high prevalence* of undernourishment (≥20%)
	  • that are net-food exporters
	  • and where households spend less than 50% on food
	• Countries with *moderate prevalence* of undernourishment (≥10%) that are net food importers
	• Countries where households spend more than 50% on food
		Albania, Algeria, Benin, Bolivia, China, Congo, Egypt, Macedonia, Georgia, Ghana, Guatemala, Guinea, Honduras, India, Jamaica, Kyrgyzstan, Namibia, Nicaragua, Niger, Nigeria, Peru, Philippines, Samoa, Suriname, Ukraine and Uzbekistan

Moderately vulnerable	• Countries with *moderate prevalence* of undernourishment (≥10%)
	  • that are net-food exporters
	  • and where households spend less than 50% on food
	• Countries with *low prevalence* of undernourishment (>10%) that are net-food importers
	• Net food-importing countries with low undernourishment (>5%)
		Bahamas, Burkina Faso, Chile, Colombia, Côte d'Ivoire, Ecuador, El Salvador, Gabon, Indonesia, Iraq, Jordan, Kiribati, Kuwait, Mauritania, Mauritius, Morocco, Netherlands Antilles, New Caledonia, Paraguay, Saint Lucia, Saint Vincent and the Grenadines, São Tomé and Príncipe, Seychelles, Swaziland, Syria, Thailand, Turkmenistan and Western Sahara

A9.2: Vulnerability of producers to price swings

Producer countries will be particularly exposed to macroeconomic shocks from commodity price fluctuations when i) their economies are particularly dependent on exports and ii) commodities account for a significant share of exports. To identify potentially vulnerable countries, we measure both the percentage share of exports in GDP (using data from the World Bank) and the share of primary commodities in merchandise exports (data are calculated from trade statistics available at the Merchandise Trade Matrix of UNCTADSTAT). We then score the vulnerability of resource producer countries to macroeconomic shocks from commodity price fluctuations by identifying the most open economies with the highest share commodities in their export basket (see Table A9.1). Brazil, despite the large share of commodities in exports, is, for example, not part of this group because it is a relatively closed economy and exports constitute only a limited share of its GDP (12% in 2011).

Table A9.2: Criteria for scoring the vulnerability of producers to international commodity price fluctuations

Exposure of producers to international commodity price fluctuations	Share of exports in GDP	Share of primary commodities in exports	Countries
High	≥30%	≥70%	Algeria, Angola, Azerbaijan, Belize, Bolivia, Botswana, Chad, Chile, Congo, Côte d'Ivoire, DRC, Djibouti, Ecuador, Gabon, Guinea, Guyana, Iraq, Kazakhstan, Libya, Maldives, Mauritania, Mongolia, Montenegro, Mozambique, Nigeria, Papua New Guinea, Paraguay, Russia, Seychelles, Solomon Islands, Turkmenistan, Vanuatu and Zambia
Medium	≥20%	≥50%	Argentina, Aruba, Australia, Bahrain, Brunei Darussalam, Cape Verde, Egypt, Equatorial Guinea, Fiji, Ghana, Guatemala, Iceland, Indonesia, Islamic Iran, Jamaica, Kenya, Kuwait, Kyrgyzstan, Laos, Liberia, Madagascar, Mali, Namibia, Netherlands Antilles, New Zealand, Nicaragua, Norway, Oman, Peru, Qatar, Saint Lucia, Saudi Arabia, Senegal, South Africa, Suriname, Syrian Arab Republic, Togo, Trinidad and Tobago, Uganda, United Arab Emirates, Tanzania, Uruguay, Uzbekistan, Venezuela, Yemen and Zimbabwe

Countries that are classified as high-income countries by the World Bank are excluded from the highly exposed category even if commodities make up more than 70% of exports and exports constitute more than 30% of GDP (they are instead included in the medium category). This is based on the assumption that that large public and private savings in these countries cushion them from the worst effects of such price fluctuations. Such counties include, for example, Norway, Iceland, Australia, New Zealand, Saudi Arabia and a number of Gulf states.

There are 79 countries worldwide for which exports constitute at least 20% of GDP and commodities make up at least half of exports. Of these countries, 15 of which are in Africa, 33 are identified as highly exposed to resource price volatility, with more than 70% of exports consisting of resources, and exports being at least 30% of GDP. For most of these countries it is a mixture of metals, minerals and fuels that leads to the very high share of commodities in exports. There are however a few countries where agricultural products contribute significantly to exports, including, for example, Paraguay, Belize, Côte d'Ivoire and Ecuador, as well as a number of smaller island states.

Annex 10: Measuring Price Volatility in Commodity Prices

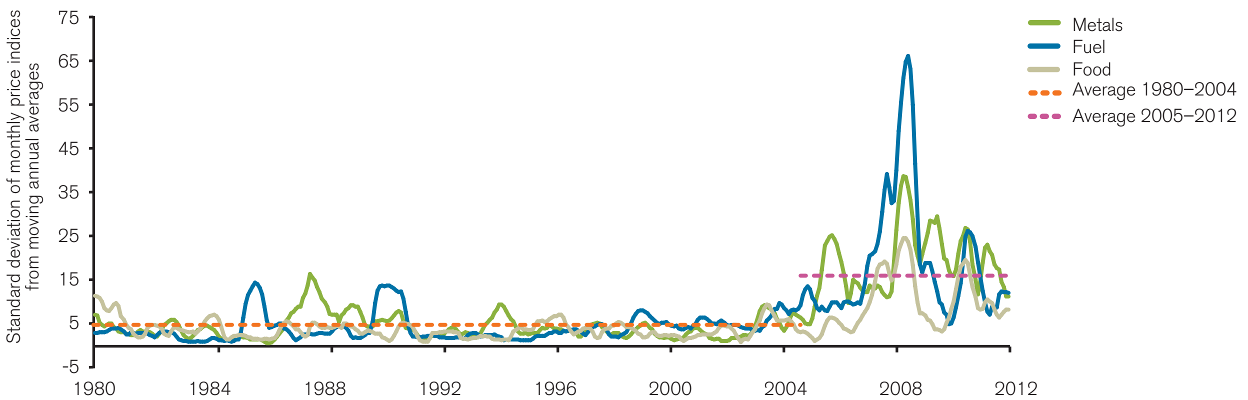
Although it is commonly asserted that commodity prices are becoming more volatile, trends in commodity price volatility have received much less rigorous attention than trends in price levels, in both the policy and academic literatures.[467] Measuring volatility in commodity prices is both technically challenging and complicated by the fragmented nature of global resource markets.[468] Existing studies have highlighted large differences in price volatilities across different commodities. They also emphasize the sensitivity of findings to the selection of datasets and empirical models.

As part of the analysis of volatility in this report, Chatham House used the IMF's summary indices of world market prices for fuel, food and metal commodities, which are available on a monthly basis between January 1980 and October 2012 (the base year is 2005). These provide a consistent and comprehensive data source, covering a relatively long time period.[469]

Volatility in the IMF indices is measured here as the standard deviation of monthly values from moving annual averages (i.e. volatility in June 2000 is measured as the standard deviation of monthly prices between January and December 2000, volatility in July 2000 is measured as the standard deviation of prices between February 2000 and January 2001, etc.). Standard deviations allow for assessment of the broad trends in volatility while avoiding strong assumptions about the behaviour of commodity prices and the extent to which market participants can predict price developments. They should, however, be treated as a crude approximation of actual price volatility as they do not adjust for predictable seasonal fluctuations and other factors.[470]

Volatility in these monthly commodity price indices has increased considerably over the past decade (see Figure A10.1). In 2005 there was a marked break in the trend. Although volatility is down from the peak in 2008, it remains at historically high levels. Moreover previous episodes of relatively high price volatility since 1980 have been more short-lived. The standard deviation for the three indices averaged 4.1 between 1980 and 2005 and exceeded 10 on only four occasions. In contrast, it averages 15.1 since 2005 and peaked during the financial crisis at 24.6 for food prices, 38.7 for metals and 66.0 for fossil fuel prices.

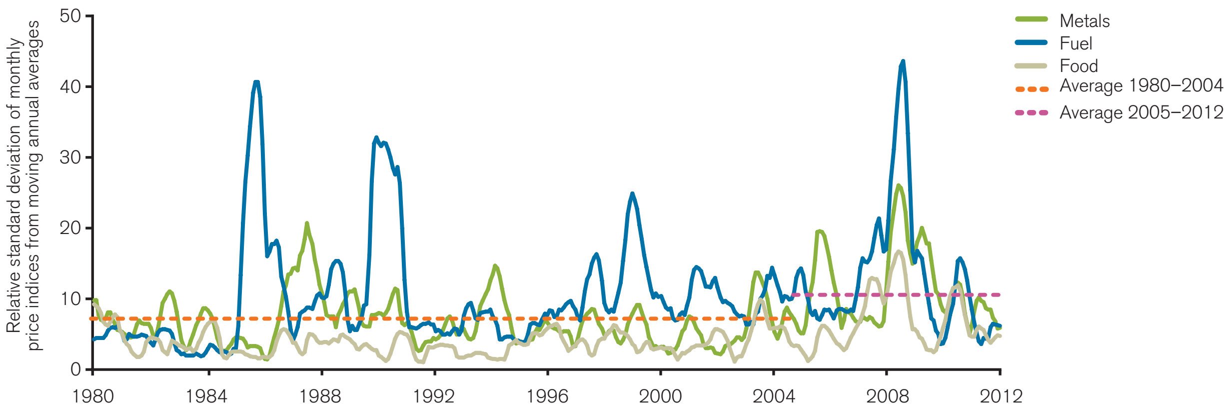
Figure A10.1: Absolute standard deviations of monthly IMF price indices from moving annual averages



Source: Chatham House based on IMF (2012).

While the absolute size of price fluctuations has seen large increases in recent years, the relative size of these shocks in proportion to prevailing price levels increased to a smaller extent. The relative standard deviation of the three indices between 1980 and 2005 averaged 6.9%. Since 2005 they have averaged 10.4% – still a 50% increase, but considerably smaller than the change in absolute standard deviations. Similarly, the volatility peaks during the economic crisis still stand out, but are of a comparable order of magnitude to volatility during other large shocks such as the Kuwait invasion and the Gulf War in 1990/91 or the OPEC price collapse in 1986. Figure A10.2 shows the evolution of relative standard deviations, which measure deviations as a percentage of the average price level.[471]

Figure A10.2: Relative standard deviations of monthly IMF price indices from moving annual averages



Source: Chatham House based on IMF (2012).

Both absolute and relative standard deviations highlight substantial differences in the degree of volatility between different commodities, with metal and especially energy price volatility tending to exceed food price volatility.

Annex 11: Key Data Sources

This report relies on a variety of data sources for production, consumption and price statistics for individual commodities. The following sources are used throughout the report.

Database	Website	Description
BACI International Trade Database at the Product Level	http://www.cepii.com/anglaisgraph/bdd/baci.htm	Bilateral international merchandise statistics for more than 200 countries, 1995 to 2010.
BP Statistical Review of World Energy 2012	www.bp.com/statisticalreview	Fossil fuel production, consumption and price statistics and projections since 1965.
FAO ForesSTAT	faostat.fao.org/site/626/default.aspx	Production and consumption of timber and other forestry products since 1960.
UN COMTRADE	http://comtrade.un.org/db/	Detailed bilateral international merchandise trade statistics since 1962.
FAOSTAT	faostat.fao.org/	Production, consumption and trade statistics and forecasts of crops, meat, and dairy since 1960.
FOA Fishery and Aquaculture Statistics Yearbook	http://www.fao.org/fishery/publications/yearbooks/en	Production and consumption of fish and other fishery statistics going back to the 1950s.
IMF Primary Commodity Prices	http://www.imf.org/external/np/res/commod/index.aspx	Monthly world market prices for commodities and summary price indices since 1980.
International Energy Agency Statistics and World Energy Outlook, 2010 to 2012	http://www.iea.org/stats/index.asp	Data and projections on the production, consumption and prices for energy and fossil fuels.
OECD-FAO Agricultural Outlook Database	www.oecd.org/site/oecd-faoagriculturaloutlook/	Data and projections on the consumption and production of key cereals and meat since 1970.
SERI Global Material Flows Database	http://www.materialflows.net/	Comprehensive dataset of global material extraction, 1980–2009.
Steel Statistical Yearbook	http://www.worldsteel.org/statistics/statistics-archive/yearbook-archive.html	Comprehensive statistics on the production use and trade of iron ore and steel.
World Bank World Development Indicators	http://data.worldbank.org/data-catalog/world-development-indicators	Wide variety of data, e.g. on GDP, population, income and spending.
UNCTADSTAT	http://unctadstat.unctad.org/	Statistics on prices and trade of commodities since 1960.
US Energy Information Administration	http://www.eia.gov/	Detailed statistics on fossil fuel production and consumption.
USDA Production, Supply and Distribution Statistics (PSD)	www.fas.usda.gov/psdonline/	Statistics on the production and consumption of major agricultural products to 1960.
USGS Minerals Yearbook	http://minerals.usgs.gov/minerals/pubs/commodity/myb/	International production statistics for most minerals and metals going back to 1932.

Endnotes

1. Introduction

1 See Dobbs, R., Oppenheim, J., Thompson, F., Brinkman, M. and Zornes, M. (2011), *Resource Revolution: Meeting the World's Energy, Materials, Food and Water Needs,* McKinsey Global Institute, www.mckinsey.com/insights/mgi/research/natural_resources/resource_revolution.

2 World Bank (2009), *Global Economic Prospects: Commodities at Crossroads*, p. 4, http://siteresources.worldbank.org/INTGEP2009/Resources/10363_WebPDF-w47.pdf.

3 Organisation for Economic Co-operation and Development (OECD) and FAO (2011), *OECD-FAO Agricultural Outlook 2011–2020*, http://dx.doi.org/10.1787/agr_outlook-2011-en.

4 FAO (2006), *World Agriculture: Towards 2030/2050* (Rome: FAO), www.fao.org/fileadmin/user_upload/esag/docs/Interim_report_AT2050web.pdf.

5 Calculations based on FAO (2012), *The State of World Fisheries and Aquaculture 2012* (Rome: FAO) and UN population statistics (2010 update, medium variant), http://esa.un.org/wpp/Documentation/pdf/WPP2010_Highlights.pdf.

6 2030 cereal price increase of order of 70–90% compared with 2010 modelled prices rising to order of 100–170% after effects of climate change. Willenbockel, D. (2011), 'Exploring Food Price Scenarios Towards 2030 with a Global Multi-Region Model', *Oxfam International Research Report* (Oxford: Oxfam International).

7 FAO (2006), *World Agriculture: Towards 2030/2050.*

8 Ibid.

9 Calculations based on FAO (2012), *The State of World Fisheries and Aquaculture 2012* and UN population statistics (2010 update, medium variant), http://esa.un.org/wpp/Documentation/pdf/WPP2010_Highlights.pdf.

10 Demand growth estimates have been taken from various industry sources: copper at 2.5% p.a. (Trench, A. (2010), 'The China Influence – Commodity Markets to 2012 and Beyond', Australian Resources Chinese Investment Conference, Adelaide, July); iron ore at 3.6.–3.8% (Exhibit 9, p. 35, of Dobbs et al. (2011), *Resource Revolution*. McKinsey Global Institute and Henry, M. (2011), 'Growth and Evolution of Commodities Demand', presentation on behalf of BHP Billiton, 4 May); aluminium at 4.1% (Menzie, W.D., Barry, J.J., Bleiwas, D.I., Bray, E.L., Goonan, T.G. and Matos, G. (2010), 'The Global Flow of Aluminum from 2006 through 2025', US Geological Survey Open-File Report 2010–1256). For zinc and nickel demand growth estimates see, for example, Mulshaw, S. (2011), 'Here Comes the Flood! The Outlook for Nickel', presentation at the International Nickel Study Group, 12 April, www.insg.org/presents/Mr_Mulshaw_Apr11.pdf; and Thurtell, D. (2011), 'Yuan Very Hungry Dragon: A Five-Year Outlook For Zinc', Citi presentation at the International Lead Zinc Study Group, 28 September. It is difficult to assess the reliability and robustness of these forecasts as the underlying assumptions in terms of growth projections or per-country breakdowns are generally not publicly available and may at times be influenced by commercial interests.

11 'Supply gap' refers here to the gap between projected demand and estimated supply from existing mines and mining projects with firm commitments that are highly likely to come into production. Estimates for demand and supply are taken from CRU: presentation, Trench (2010) 'The China Influence'. Demand growth for primary copper is estimated at an average of 2.5% p.a. If supply from probable and possible (as opposed to committed) projects were to be taken into account, the supply gap for 2020 and 2030 would be narrowed to roughly 10% and 30% respectively. No demand destruction is assumed. It should be noted that these projections are subject to large margins of uncertainty.

12 See, for example, Kingsnorth, D.J. (2011), *Rare Earths: Reducing our Dependence on China*, Tables 3 and 8 (Mt Claremont, Western Australia: IMCOA). Kingsnorth projects rare earths to be in deficit until at least 2016.

13 See note 34.

14 Ibid.

15 See for example, Waughray, D. and Workman, J.G. (eds) (2011), *Water Security: The Water-Food-Energy-Climate Nexus* (Washington, DC: Covelo Press); Hoff, H. (2011), *Understanding the Nexus: Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus* (Stockholm: Stockholm Environment Institute), p. 5; Andrews-Speed, P., Bleischwitz, R., Boersma, T., Johnson, C., Kemp, G. and VanDeveer, S. (2012), *The Global Resource Nexus: The Struggles for Land, Energy, Food, Water, and Minerals* (Washington, DC: German Marshall Fund); European Report on Development (2012), *Confronting Scarcity: Managing Water, Energy and Land for Inclusive and Sustainable Growth* (Brussels: European Union). Following a high-profile conference on the subject in Bonn in 2011, the German government together with a variety of stakeholders has developed a web-based platform to promote a number of initiatives, including a three-year action plan by the multilateral development banks on water and food security, available at: www.water-energy-food.org/en/home.html.

16 The World Energy Council suggested that use in 2005 was in the order of 1.6 trillion cubic metres, 80% of which was used in producing traditional biomass, with 257 billion cubic metres associated with commercial energy and electricity production. This compared with Aquastat's assessment of total freshwater withdrawal of water at a similar period of around 3.8 trillion cubic metres. Aquastat further suggested that 0.7 trillion m^3 of water are used globally in industrial processes. See World Energy Council (2010), *Water for Energy*, www.worldenergy.org/documents/water_energy_1.pdf; and Food and Agriculture Organization of the United Nations (FAO) (2012), *Aquastat: FAO's Information System on Water and Agriculture*, www.fao.org/nr/water/aquastat/main/index.stm.

17 FAO (2012), *Aquastat: FAO's Information System on Water and Agriculture.*

18 Saudi Arabia will phase out domestic production by 2016 through the gradual unwinding of subsidies and import controls. See England, A. and Blas, J. (2008), 'Water fears lead Saudis to end grain output', *Financial*

Times, 27 February, www.ft.com/cms/s/0/f02c1e94-e4d6-11dc-a495-0000779fd2ac.html#axzz24wdVnrhu.

19 Organisation for Economic Co-operation and Development (OECD) and FAO (2011), *OECD-FAO Agricultural Outlook 2011–2020*, http://dx.doi.org/10.1787/agr_outlook-2011-en.

20 Malthus, T. (1798), *An Essay on the Principle of Population*, Chapter VII.

21 Hubbert, M.K. (1956), 'Nuclear Energy and the Fossil Fuels', presentation given at the Spring Meeting of the Southern District Division of Production, American Petroleum Institute, San Antonio, Texas, 7–9 March, http://energycrisis.biz/hubbert/1956/1956.pdf.

22 Ehrlich, P. (1968), *The Population Bomb* (New York: Ballantine Books).

23 Meadows, D.H. et al. (1972), *Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books).

24 See Dobbs et al. (2011), *Resource Revolution.*

25 Today 600 million people in 21 countries are affected. Cited in US National Intelligence Council (2008), *Global Trends 2025: A Transformed World* (Washington, DC: US Government Printing Office), www.aicpa.org/research/cpahorizons2025/globalforces/downloadabledocuments/globaltrends.pdf.

26 Between 1980 and 2008, it found global production of maize and wheat to be 3.8% and 5.5% lower respectively as a result of warming. Lobell, D.B., Schlenker, W. and Costa-Roberts, J. (2011), 'Climate Trends and Global Crop Production Since 1980', *Science*, Vol. 333, No. 6042, pp. 616–20.

27 Myers, N. (2002), 'Environmental refugees: a growing phenomenon of the 21st century', *Philosophical Transactions: Biological Sciences*, Vol. 357, No. 1420, pp. 609–13.

28 The IPCC assessment is that many types of extreme events have become more common since 1950. In future, in most regions both precipitation and heat events are likely to become more common than today in the 2046–81 time horizon, with an even clearer signal by 2100. See Intergovernmental Panel on Climate Change (IPCC) (2012), 'Summary for Policymakers', in Field, C.B., Barros, V., Stocker, T.F., Qin, D. et al. (eds), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (Cambridge University Press), pp. 1–19 (future trends) and p. 111 (historical trends), www.ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf.

29 Paskal, C. (2010), *Global Warring: How Environmental, Economic, and Political Crises will Redraw the World Map* (New York: Palgrave Macmillan).

2. More, More and More

30 Deloitte and US Council on Competitiveness (2010), *Global Manufacturing Competitiveness Index*, pp. 13–16, www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/Manufacturing/DTT_Global_Manufacturing_Competiveness_Index_6_23_2010.pdf.

31 Dittrich, M., Giljum, S., Lutter, S. and Polzin, C. (2012), *Green Economies Around the World? Implications of Resource Use for Development and the Environment* (Vienna: Sustainable Europe Research Institute (SERI)).

32 Data from World Resources Institute Earth Trends meat consumption database, http://earthtrends.wri.org/.

33 Stockholm International Water Institute, International Food Policy Research Institute, World Conservation Union and International Water Management Institute (2005), *Let it Reign: The New Water Paradigm for Global Food Security,* a report commissioned by the Swedish International Development Cooperation Agency as input into the Commission on Sustainable Development (CSD) and its 2004–05 focus on water and related issues, available at www.siwi.org/documents/Resources/Policy_Briefs/CSD_Let_it_Reign_2005.pdf.

34 In the low scenario the population will have reached a plateau by this time, and declines in later decades, relieving pressure on resources. But in the high scenario the population will continue to climb to over 15 billion by the end of the century.

35 There may be profound discontinuities in current growth pathways. Nevertheless, there is wide agreement on a general trend towards a 'great convergence' of per capita incomes after their 'great divergence' over the past two centuries. China is currently driving this trend, but India and other developing countries are expected to follow.

36 Selected recent projections for China's GDP growth:

Source	Annual growth rate (%)	Period
China's official GDP target	7	12th Five Year Plan (2011–15)
Development Research Centre of the State Council/World Bank (2012)	8.6/7.0	2011–15/ 2016–20
Tsinghua University (2011)	8	2010–20
HSBC (2012)	9–9.5/8–8.5	2011–15/ 2016–20
McKinsey and Company (2012)	7.8	2010–20
Economist (2011)	7.75	2010–20

World Bank and Development Research Center, State Council of the People's Republic of China (2012), *China 2030: Building a Modern, Harmonious, and Creative High-Income Society* (Washington, DC: World Bank) p. 9, www.worldbank.org/content/dam/Worldbank/document/China-2030-complete.pdf. Tsinghua University (2011), 'China 2030: Approaching Common Wealth'. HSBC, quoted in China Daily, (2012), 'HSBC lowers China's GDP forecast', 29 September, www.chinadaily.com.cn/china/2012-08/29/content_15717533.htm. McKinsey (2012), *Meet the 2020 Chinese Consumer*, p. 9, www.mckinseychina.com/wp-content/uploads/2012/03/mckinsey-meet-the-2020-consumer.pdf. Economist (2011), 'The Dating Game', www.economist.com/blogs/dailychart/2010/12/save_date.

37 According to a recent World Bank analysis, for example: 'In 2011 China's consumption contributed more to GDP growth than investments for the first time since records of GDP began in 1952. Some observers see this as the start of a trend in domestic rebalancing, and associate this with a more permanent growth slowdown in China. The China 2030 report the World Bank and the DRC released earlier this year [2012], projects that rebalancing and a gradual slowdown in China's growth will happen over the next two decades, and is indeed desirable for more balanced, inclusive growth. However, it seems too early to tell whether the tide has already turned.' World Bank (2012), 'East Asia and Pacific Data Monitor: October 2012', www.worldbank.org/content/dam/Worldbank/document/EAP-Data-Monitor-October-2012.pdf. The *Financial Times* also reported a third quarter growth figure for China of 7.4%. See *Financial Times* (2012), 'Chinese economy expands c7.4% in Q3', 18 October.

38 China Council for International Cooperation on Environment and Development (CCICED) Task Force (2011), *China's Low Carbon Industrialisation Strategy:* CCICED Task Force Report, http://content.lib.sfu.ca/cdm/singleitem/collection/cciced/id/1306.

39 FAO (2009), *How to Feed the World in 2050.*

40 FAO (2012), *The State of World Fisheries and Aquaculture 2012*, p. 1 (2010 data) and p. 172 (2030 data). Per capita consumption is expanding. It was 18.6kg in 2010, but could climb to 19.6kg in 2020, according to the FAO. This would increase consumption by 22 million tonnes compared with 2010.

41 Delgado, C. L., Wada, N. et al. (2003), *Outlook for Fish to 2020: Meeting Global Demand* (Washington, DC: International Food Policy Research Institute and Penang: WorldFish Center), www.ifpri.org/sites/default/files/pubs/pubs/fpr/pr15.pdf; OECD (2008), *Environmental Outlook to 2030*, p. 423, www.oecd.org/environment/environmentalindicatorsmodellingandoutlooks/oecdenvironmentaloutlookto2030.htm.

42 Bailis, R., Chatellier, J.L. and Ghilardi, A. (2012), 'Ecological Sustainability of Woodfuel as an Energy Source in Rural Communities', Chapter 18 of Ingram, J.C, DeClerck., F. and Rumbaitis del Rio, C. (2012), *Integrating Ecology and Poverty Reduction: Ecological Dimensions* (New York: Springer Publishing).

43 Pepke, E. (2012), 'Global Wood Markets: Consumption, Production and Trade', presentation at the International Forestry and Global Issues Conference, Nancy, 17 April.

44 FAO (2009), *State of the World's Forests 2009* (Rome: FAO), ftp://ftp.fao.org/docrep/fao/011/i0350e/i0350e.pdf.

45 Clay, J. (2004), World Agriculture and the Environment: A Commodity-by-Commodity Guide to Impacts and Practices (Washington, DC: Island Press), http://wwf.panda.org/what_we_do/footprint/agriculture/beef/environmental_impacts/habitat_conversion/.

46 Ellen MacArthur Foundation (2011), *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition,* www.thecirculareconomy.org/.

47 FAO (2011), *Current World Fertilizer Trends and Outlook to 2015* (Rome: FAO).

48 The FAO projects a 2% increase; see ibid. The International Fertilizer Organization (IFA) projects a 2.4% increase; see Heffer, P. and Prud'homme, M. (2011), *Fertilizer Outlook 2011–2015*, IFA.

49 The breakdown is an FAO projection and therefore based on the 2% annual growth.

50 Calculations based on the IFA database (accessed September 2012).

51 This was mainly due to the closure of several domestic mines because of unsafe conditions.

52 BHP Billiton (2011), 'Steelmaking Materials Briefing', presentation by Marcus Randolph, 30 September, http://www.bhpbilliton.com/home/investors/reports/documents/110930%20steelmaking%20materials%20briefing_combined.pdf.

53 Data taken from Lennon, Jim (2012), 'Base Metals Outlook: Drivers on the Supply and Demand Side', presentation, February 2012, Macquarie Commodities Research, www.macquarie.com/dafiles/Internet/mgl/msg/iConference/documents/18_JimLennon_Presentation.pdf .

54 McKay, H., Sheng, Y. and Song, L. (2010), 'China's Metal Intensity in Comparative Perspective', in Garnaut, R., Golley, J. and Song L. (eds), *China: The Next Twenty Years of Reform and Development* (Canberra: Australia National University E Press).

55 See International Monetary Fund (IMF)(2006), *World Economic Outlook*, Chapter 5, www.imf.org/external/pubs/ft/weo/2006/02/pdf/weo0906.pdf; Radetski, M. (2006), 'The Anatomy of the Three Commodity Booms', *Resource Policy*, Vol. 31, pp. 56–64; Gottschalk, R. and Prates, D. (2006), 'East Asia's Growing Demand for Primary Commodities – Macroeconomic Challenges for Latin America', UNCTAD D-24 Discussion Paper Series, http://archive.unctad.org/en/docs/gdsmdpbg2420061_en.pdf; Winters, L.A. and Yusuf, S. (eds) (2007), *Dancing with Giants: China, India, and the Global Economy* (Washington, DC: World Bank); and Streifel, S. (2006), *Impact of China and India on Global Commodity Markets*, World Bank working paper, http://siteresources.worldbank.org/INTCHIINDGLOECO/Resources/ChinaIndiaCommodityImpact.pdf.

56 OECD (2010), *Perspectives on Global Development 2010: Shifting Wealth* (Paris: OECD), p. 23.

57 Deloitte and US Council on Competitiveness (2010), *Global Manufacturing Competitiveness Index*, pp. 13–16, www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/Manufacturing/DTT_Global_Manufacturing_Competiveness_Index_6_23_2010.pdf.

58 Physical trade in resources has increased considerably. Yet with rising resource prices, the value of these trade flows has increased even more quickly – partly reflecting global price inflation but more importantly owing to a substantial upward shift in real prices for most types of natural resources in the last decade.

59 Det Norske Veritas (2012), 'Commercial and Strategic Opportunities for LNG in China', presentation, www.norway.cn/Global/SiteFolders/webbeij/DNV%20-%20China%20LNG%20Final%20Report.pdf.

60 *The Economic Times* (2012), 'India's coal imports projected at 185 MT by 2017', 16 July, http://articles.economictimes.indiatimes.com/2012-07-16/news/32698225_1_production-target-coal-imports-coal-india.

61 International Energy Agency (IEA) (2011), *World Energy Outlook 2011*, p. 103. Domestic production and demand-side policies could have dramatic effects on Chinese and Indian import profiles, but it is likely that domestic extraction, processing and transportation constraints coupled with significant coal-fired generation capacity increases will lead to greater levels of coal imports to China and India between 2012 and 2035.

62 Ericsson, M. (2012), 'EU & critical raw materials – implications for the industry', presentation at the From Sustainable Mining to Ecodesign Conference in Helsinki, 29 August, slide 11, www.vtt.fi/files/events/GWW2012/FromSustainableMiningToEcodesign_Ericsson.pdf.

63 According to the US Geological Survey, the so-called 'rare earths' are a group of 17 elements composed of scandium, yttrium and the lanthanides (this is the most common definition, but there is some debate about which elements should be included). Rare earths are in fact relatively abundant in the Earth's crust, but they are not often found as concentrated, mineable ore deposits. See USGS website: http://minerals.usgs.gov/minerals/pubs/commodity/rare_earths/.

64 Beeson, M., Soko, M. and Yong, W. (2011), 'The New Resource Politics: Can Australia and South Africa Accommodate China?', *International Affairs*, Vol. 87, No. 6, pp. 1365–84.

65 Barboza, D. (2010), 'Rio Tinto executive admits to taking two bribes', *New York Times*, 26 March, www.nytimes.com/2010/03/27/world/asia/27riotinto.html.

66 *The Economic Times* (2012), 'India's steel import may touch 50 mn tonnes by 2020', 13 April, http://articles.economictimes.indiatimes.com/2012-04-13/news/31337560_1_steel-production-steel-imports-million-tonnes.

67 Rakotoarisoa, M. A., Iafrate, M. and Paschali, M. (2011), *Why Has Africa Become a Net Food Importer? Explaining Africa Agricultural and Food Trade Deficits* (Rome: FAO), www.fao.org/docrep/015/i2497e/i2497e00.pdf. Examples are selected on the basis of Table 6. Angola has the highest food import dependence but is able to finance this via oil exports.

68 FAO (2012), *State of World Fisheries and Aquaculture 2012*.

69 Worm, B. et al. (2006), 'Impacts of Biodiversity Loss on Ocean Ecosystem Services', *Science*, Vol. 314, No. 5800, pp. 787–90.

70 OECD and FAO (2011), *OECD-FAO Agricultural Outlook 2011–2020*, http://dx.doi.org/10.1787/agr_outlook-2011-en.

71 FAO (2012), *State of World Fisheries and Aquaculture 2012*.

72 Data in this section are calculated from FAO FishStat Plus.

73 FAO (2010), *Global Forest Resources Assessment 2010: Main Report* (Rome: FAO), p. 121.

74 Pepke, E. (2010), 'Growing Trade of Wood and Paper Products', presentation to UNECE/FAO workshop on 'Emerging Trade Measures in Timber Markets', March, http://timber.unece.org/fileadmin/DAM/meetings/01Pepke.pdf.

75 Nomura Global Economics (2010), *The Ascent of Asia*, www.nomura.com/europe/resources/pdf/nomura%20-%20the%20ascent%20of%20asia.pdf.

76 Projection of soybean harvested area in Latin America and the US in 2020 is based on Masuda, T. and Goldsmith, P. D. (2009), 'World Soybean Production: Area Harvested, Yield, and Long-Term Projections', *International Food and Agribusiness Management Review*, Vol. 12, No. 4. Share of ethanol in US corn production figures is based on USDA (2012), *USDA Agricultural Projections to 2021*, www.ers.usda.gov/media/273343/oce121_2_.pdf.

3. The Coming Resources Crunch

77 In addition, unproven and unidentified reserve figures are by definition probabilistic.

78 IEA (2011), *World Energy Outlook 2011*, p. 103.

79 Ibid, pp. 125–26.

80 The *BP Statistical Review of World Energy 2012* puts Iraq's reserves at 143 billion barrels, placing it fifth in the world after Venezuela, Saudi Arabia, Canada and Iran. This is in line with official statements from Iraqi officials.

81 Stevens, P. (2008, 2009), *The Coming Oil Supply Crunch* (London: Chatham House), www.chathamhouse.org/publications/papers/view/108872

82 Mitchell, J.V. and Stevens, P. (2008), *Ending Dependence: Hard Choices for Oil Exporting States* (London: Chatham House), www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/0708oildependence.pdf.

83 US Energy Information Administration (EIA) database: petroleum net imports/exports, accessed July 2012.

84 OECD and IEA (2012), *Medium-Term Gas Market Report 2012* (Paris: OECD).

85 IEA (2011), *World Energy Outlook 2011*.

86 Froggatt, A. and Lahn, G. (2010), *Sustainable Energy Security: Strategic Risks and Opportunities for Business*, Chatham House and Lloyd's 360° Risk Insight White Report, www.lloyds.com/~/media/Lloyds/Reports/360%20Energy%20Security/7238_Lloyds_360_Energy_Pages.pdf.

87 Ibid.

88 Chazan, G. (2012), 'Opec's price hawks press Saudi on output', *Financial Times*, 12 June, www.ft.com/cms/s/0/c2d19494-b496-11e1-bb2e-00144feabdc0.html#axzz20Of1dcs0.

89 In Venezuela, net oil exports have declined as domestic consumption has increased 39% since 2001. See US EIA (2012), *Country Report: Venezuela*, www.eia.gov/countries/analysisbriefs/Venezuela/venezuela.pdf. For a recent academic assessment of OPEC countries' domestic consumption and potential impacts on exports, see Gately, D., Al-Yousef, N. and Al-Sheikh, H.M.H. (2012), *The Rapid Growth of OPEC's Domestic Oil Consumption* (New York University), www.econ.nyu.edu/dept/courses/gately/OPEC_Consumption_Gately_AlYousef_AlSheikh_April2012.pdf.

90 Bazilian, M. and Onyeji, I. (2012), 'Fossil Fuel Subsidy Removal and Inadequate Public Power Supply: Implications for Businesses', *Energy Policy*, Vol. 45, pp. 1–5; *The Guardian* (2012), 'Nigeria restores fuel subsidy to quell nationwide protests', 16 January, www.guardian.co.uk/world/2012/jan/16/nigeria-restores-fuel-subsidy-protests.

91 Lahn, G. and Stevens, P. (2011), *Burning Oil to Keep Cool: The Hidden Energy Crisis in Saudi Arabia* (London: Chatham House).

92 Chazan, G. (2012), 'Saudi Arabia: Kingdom's power broker role at risk', *Financial Times*, 28 March, www.ft.com/cms/s/0/d50b7efa-6e9a-11e1-a82d-00144feab49a.html#axzz2B3rJSQ00.

93 Fattouh, B. and Stern, J. (eds) (2011), *Natural Gas Markets in the Middle East* (Oxford University Press).

94 Trembath, A., Jenkins, J., Nordhaus, T. and Shellenberger, M. (2012), *Where the Shale Gas Revolution Came From: Government's Role in Development of Hydraulic Fracturing in Shale*, Breakthrough Institute Energy & Climate Program, http://thebreakthrough.org/blog/Where_the_Shale_Gas_Revolution_Came_From.pdf.

95 A total of $33bn in capital investment for 2010, according to IHS Global Insight (2011), *The Economic and Employment Contributions of Shale Gas in the United States*, p. 2, http://anga.us/media/235626/shale-gas-economic-impact-dec-2011.pdf.

96 US EIA (2012), 'What is the role of coal in the United States?', Energy in Brief article, www.eia.gov/energy_in_brief/role_coal_us.cfm.

97 This is likely given current low prices of gas and the fact that globally, previous constraints on consuming gas are disappearing. See Stevens (2010), *The Shale Gas Revolution.*

98 For example, see Helm, D. (2012), 'EU Energy Policy and the Role of Gas in Decarbonisation', presentation to the Flame Conference in Amsterdam on 17 April, www.dieterhelm.co.uk/sites/default/files/FLAME%20D%20Helm.pdf.

99 US EIA (2012), 'Carbon Dioxide Emissions From Energy Consumption by Source', *Monthly Energy Review,* August, www.eia.gov/totalenergy/data/monthly/#environment. Lacey, S. (2012), 'U.S. Coal Generation Drops 19 Percent In One Year, Leaving Coal With 36 Percent Share Of Electricity', US DOE, http://thinkprogress.org/climate/2012/05/14/483432/us-coal-generation-drops-19-percent-in-one-year-leaving-coal-with-36-percent-share-of-electricity/?mobile=nc.

100 In March 2012, Poland, which had been extremely bullish over shale gas prospects, reduced its estimates of technically recoverable resources from the EIA's original estimate of 5,300 bcm to around one-tenth – 346–768 bcm.

101 Up-to-date data on shale gas production in the United States are surprisingly difficult to find.

102 This is discussed in detail in Stevens, P. (2010), *The Shale Gas Revolution: Hype and Reality* (London: Chatham House).

103 Some of this excess capacity has been absorbed as a result of the increased gas demand for power generation after the events in Fukushima.

104 Between 2004 and 2009 the average price was $6.68.

105 See, for example, Howarth, R. W., Santoro, R. and Ingraffea, A. (2011), 'Methane and the Greenhouse-gas Footprint of Natural Gas from Shale Formations', *Climatic Change*, Vol. 106, No. 4; Osborn, S.G., Vengosh, A., Warner, N. R. and Jackson, R.B. (2011), 'Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing', *Proceedings of the National Academy of Sciences*, Vol. 108, No. 20, www.pnas.org/content/108/20/8172.full.pdf.

106 A major study is currently being undertaken by the Environmental Protection Agency, with the initial results expected at the end of 2012 and a full report by mid-2014. So far, smaller impact assessments appear to be concluding that problems arise from poor well completion rather than fracking itself.

107 Medlock, K.B., Jaffe, A.M. and Hartley, P.R. (2011), *Shale Gas and U.S. National Security* (Houston: James A. Baker III Institute for Public Policy), www.bakerinstitute.org/publications/EF-pub-DOEShaleGas-07192011.pdf.

108 Stevens, P. (2012), '*The 'Shale Gas Revolution': Developments and Changes* (London: Chatham House). Additional analysis in this box was provided by Paul Stevens and Glada Lahn.

109 This is defined as solar PV in the countries reaching 'socket parity', i.e. 'the point where a household can make 5% or more return on investment in a PV system just by using the energy generated to replace household energy consumption', in Bazilian, M., Onyeji, I. et al. (2012), *Re-considering the Economics of Photovoltaic Power*, Bloomberg New Energy Finance White Paper, p. 12, www.bnef.com/WhitePapers/download/82.

110 Bloomberg New Energy Finance (2011), 'Onshore wind energy to reach parity with fossil-fuel electricity by 2016', http://bnef.com/PressReleases/view/172.

111 CCICED Task Force (2011), *China's Low Carbon Industrialisation Strategy*. In comparison with coal, the gas sector also benefits from carbon pricing and other climate-related policies in key markets, owing to its lower emissions per unit of energy.

112 Bloomberg New Energy Finance (2012), 'Investment, Infrastructure & Innovation for Green Growth', presentation at the OECD by Michael Liebreich, Chief Executive Officer, www.bnef.com/free-publications/presentations/.

113 IEA (2011), *World Energy Outlook 2011*, p. 118.

114 Foresight (2011), *The Future of Food and Farming, Final Project Report* (London: The Government Office for Science), www.bis.gov.uk/foresight/our-work/projects/current-projects/global-food-and-farming-futures/reports-and-publications.

115 Royal Academy of Engineering (2010), 'Global Water Security: An Engineering Perspective', p. 18.

116 Ibid.

117 See Table 1 in Bellarby, J., Foereid, B., Hastings, A. and Smith, P. (2008), 'Cool Farming: Climate Impacts of Agriculture and Mitigation Potential', www.greenpeace.org/international/en/publications/reports/cool-farming-full-report/. Data are from IEA (2007), *Tracking Industrial Energy Efficiency and CO_2 Emissions* (Paris: IEA), p. 60. Ammonia is combined with hydrogen to produce nitrogen fertilizers. In 2007, 77% of ammonia was produced using natural gas steam reforming, while 14% was from coal reforming, mainly from China.

118 See Tirado, R. and Allsopp, M. (2012), 'Phosphorus in Agriculture: Problems and Solutions', Greenpeace Research Laboratories Technical Report (Review) 02-2012; Van Kauwenbergh, S. (2010), 'World Phosphate Rock Reserves and Resources', International Fertilizer Development Center (IFDC); UNEP (2011), 'Phosphorus and Food Production', *UNEP Yearbook 2011*, pp. 35–45; Production and reserve data are obtained from the USGS mineral commodity summaries, available at http://minerals.usgs.gov/minerals/pubs/commodity/.

119 Lobell et al. (2011), 'Climate Trends and Global Crop Production Since 1980'.

120 The baseline is the average yield in the 1998–2002 period. For a regional breakdown including the case of wheat in Southern Africa, see Lobell, D.B., Burke, M.B., Tebaldi, C., Mastrandrea, M.D., Falcon, W.P. and Naylor, R.L. (2008), 'Prioritizing Climate Change Adaptation Needs for Food Security in 2030', *Science*, Vol. 319, No. 5863, pp. 607–10. Another regional breakdown is available in Cline, W.R. (2007), *Global Warming and Agriculture: Impact Estimates by Country*, Center for Global Development (Washington, DC: Center for Global Development), p. 250.

121 The Royal Society (2009), *Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture* (London: Royal Society), http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/4294967719.pdf.

122 Mueller, N.D., Gerber, J.S., Johnston, M., Ray, D.K., Ramankutty, N. and Foley, J.A. (2012), 'Closing Yield Gaps Through Nutrient and Water Management', *Nature*, published online 29 August, www.nature.com/nature/journal/vaop/ncurrent/full/nature11420.html?WT.ec_id=NATURE-20120830.

123 Ibid.

124 Literature reviews indicate a typical IRR above 40%; see, for example, Piese, J. and Thirtle, C. (2010), 'Agricultural R&D, Technology and Productivity', *Philosophical Transactions of the Royal Society*, Vol. 365, No. 1554, pp. 3035–47.

125 Gustavsson, J., Cederberg, C. and Sonesson, U. (2011), *Global Food Losses and Food Waste: Extent, Causes and Prevention* (Rome: FAO), www.fao.org/docrep/014/mb060e/mb060e00.pdf.

126 Kader, A.A. (2003), 'A Perspective on Postharvest Horticulture (1978–2003)', *HortScience*, Vol. 38, No. 5, pp. 1004–08.

127 Despite this rapid export growth, former Soviet Union countries remain net importers of agricultural products in value terms owing to their high-value imports mainly of meat, fruits and vegetables as well as tea and coffee.

128 2030 Water Resources Group (2009), 'Charting Our Water Future: Economic Frameworks to Inform Decision-making', The Barilla Group, The Coca-Cola Company, The International Finance Corporation, McKinsey & Company, Nestlé S.A., New Holland Agriculture, SABMiller plc, Standard Chartered Bank, and Syngenta AG.

129 Wada, Y., van Beek, L., van Kempen, C., Reckman, J., Vasak, S. and Bierkens, M. (2010), 'Global Depletion of Groundwater Resources', *Geophysical Research Letters*, Vol. 37, No. L20402, p. 2.

130 Beltran, J.M. and Koo-Oshima S. (eds) (2006), *Water Desalination for Agricultural Applications,* Proceedings of the Food and Agriculture Organization Expert Consultation on Water Desalination for Agricultural Applications on 26–27 April 2004, Rome, ftp://ftp.fao.org/agl/aglw/docs/lwdp5_e.pdf.

131 World Bank (2010), *Deep Wells and Prudence: Towards Pragmatic Action for Addressing Groundwater Overexploitation in India* (Washington, DC: World Bank).

132 According to India's National Assessment in 2004, as cited in World Bank (2012), 'India Groundwater: A Valuable but Diminishing Resource', 6 March, www.worldbank.org/en/news/2012/03/06/india-groundwater-critical-diminishing.

133 Output from existing mines has deteriorated faster than anticipated and ambitious expansion projects have experienced chronic delays and cost overruns. Production numbers are taken from USGS Mineral Commodity Summaries, Copper, Issues 2002 to 2012, http://minerals.usgs.gov/minerals/pubs/commodity/copper/.

134 Antofagasta Plc (2012), 'Copper Industry', presentation at the Santander 16th Annual Latin American Conference, January, Cancún, www.antofagasta.co.uk/pdf/presentations/Aplc201101_Santander%20Conference_Final.pdf.

135 Citi (2011), Sainsbury, C., Wilkins, C., Haddad, D., Seeney, D. et al., *Generation Next: A Look at Future Greenfield Growth Project.*

136 Ibid.

137 Norgate, T.E. and Jahanshahi, S. (2011), 'Reducing the Greenhouse Gas Footprint of Primary Metal Production: Where Should the Focus Be?', *Minerals Engineering*, Vol. 24, No. 14, p. 1564.

138 IEA (2011), *World Energy Outlook 2011.*

139 Thomas, H. (2012), 'Difficult times for miners as costs rise', *Financial Times*, 29 May, www.ft.com/cms/s/0/b7e419ea-a996-11e1-9972-00144feabdc0.html#axzz24wdVnrhu.

140 Principal sources are IMF commodity price statistics, UNCTAD commodity price statistics, various editions of the USGS Minerals Yearbook, FAOSTAT, IEA and. Other sources include *BP Statistical Review of World Energy*, and the World Potato Council. Data on speciality metals and minerals have been generously shared by Simon Moores at Industrial Minerals.

141 IEA (2010), *World Energy Outlook 2010*, pp. 139–40.

142 FAO, International Fund for Agricultural Development (IFAD) and World Food Programme (WFP) (2011), *The State of Food Insecurity in the World: How Does International Price Volatility Affect Domestic Economies and Food Security?* (Rome: FAO), www.fao.org/docrep/014/i2330e/i2330e00.htm.

143 Foster, V. and Briceño-Garmendia, C. (2009), *Africa's Infrastructure: A Time for Transformation* (Washington, DC: World Bank), http://siteresources.worldbank.org/INTAFRICA/Resources/aicd_overview_english_no-embargo.pdf.

4. Critical Uncertainties and Environmental Fault Lines

144 Rustad, S.A. and Binningsbø, H.M. (2012), 'A Price Worth Fighting For? Natural Resources and Conflict Recurrence', *Journal of Peace Research*, Vol. 49, No. 4, pp. 531–46. Even in studies that have found that the control of resources has not been the primary factor in the recurrence of civil conflict, resource politics has still been identified as a major element alongside others such as grievance and exclusionary behaviour. On this point, see Call, C.T. (2010), 'Liberia's War Recurrence: Grievance over Greed', *Civil Wars*, Vol. 12, No. 4, pp. 347–69.

145 Ross, M.L. (2004), 'How Do Natural Resources Influence Civil War? Evidence from Thirteen Cases', *International Organization*, Vol. 58, No. 1, pp. 35–67; Lujala, P. (2010), 'The Spoils of Nature: Armed Civil Conflict and Rebel Access to Natural Resources', *Journal of Peace Research*, Vol. 47, No. 1, pp. 15–28.

146 Sirin, C.V. (2011), 'Scarcity-Induced Domestic Conflict: Examining the Interactive Effects of Environmental Scarcity and "Ethnic" Population Pressures', *Civil Wars*, Vol. 13, No. 2, pp. 122–40.

147 See Dobbs, R., Oppenheim, J., Thompson, F., Brinkman, M. and Zornes, M. (2011), *Resource Revolution: Meeting the World's Energy, Materials, Food and Water Needs,* McKinsey Global Institute, www.mckinsey.com/insights/mgi/research/natural_resources/resource_revolution.

148 United Nations Conference on Trade and Development (UNCTAD) (2011), *Recent Developments in Key Commodity Markets: Trends and Challenges*, http://unctad.org/en/docs/cimem2d19_en.pdf.

149 IEA (2011), *Oil Market Report: 15 March 2011*, http://omrpublic.iea.org/omrarchive/15mar11full.pdf.

150 For example, see Stevens, P. (2012), *An Embargo on Iranian Crude Oil Exports: How Likely and with What Impact?* (London: Chatham House).

151 Mayer, G. (2012), 'U.S. predicts receding food price threat', *Financial Times*, 23 February, www.ft.com/cms/s/0/54cf1176-5e40-11e1-85f6-00144feabdc0.html#axzz24wdVnrhu.

152 In economics this relationship is referred to as Engel's Law.

153 Data on the share of commodities in exports are taken from UNCTADSTAT. Data for exports as percentage of GDP are taken from the World Bank Database, http://data.worldbank.org/indicator/NE.EXP.GNFS.ZS.

154 Blass, J. (2012) 'China buyers defer raw material cargos', *Financial Times*, 20 May, www.ft.com/cms/s/0/a1f5ddda-a26b-11e1-a605-00144feabdc0.html#axzz24wdVnrhu.

155 Revathy, L.N. (2011), 'Price volatility leading to more defaults in cotton contracts', *The Hindu Business Line*, 26 September, www.thehindubusinessline.com/industry-and-economy/agri-biz/article2487560.ece.

156 On the relationship between the Naxalite rebellion and resource scarcity and allocation see Hoelscher, K., Miklian, J. and Vadlamannati, K.C. (2012), 'Hearts and Mines: A District-level Analysis of the Maoist Conflict in India', *International Area Studies Review*, Vol. 15, No. 2, pp. 141–60.

157 Tortilla is a staple food in Mexico. Prices rose by three to four times during 2006–07 in some parts of the country, leading to protests and riots. *Washington Post*, 'A culinary and cultural staple in crisis', 7 January 2007, www.washingtonpost.com/wp-dyn/content/article/2007/01/26/AR2007012601896.html.

158 See Annex 9 for the food vulnerability methodology used in this chart and data sources.

159 See the Uppsala Conflict Data Program, www.pcr.uu.se/research/UCDP/; and the International Institute for Strategic Studies Armed Conflict Database, www.iiss.org/acd.

160 Johnstone, S. and Mazo, J. (2011), 'Global Warming and the Arab Spring', *Survival*, Vol. 53, No. 2, pp. 11–17.

161 Elliot, L. (2011), 'Rising food and oil prices are biggest threat to recovery, says World Bank', *The Guardian*, 8 June, www.guardian.co.uk/business/2011/jun/08/food-oil-prices-biggest-threat-recovery.

162 Strategy, Policy, and Review Department, Fiscal Affairs Department, and Research Department, in collaboration with the African Department and the Asia and Pacific Department of International Monetary Fund (IMF) (2011), *Managing Global Growth Risks and Commodity Price Shocks – Vulnerabilities and Policy Challenges for Low-Income Countries*, International Monetary Fund, www.imf.org/external/np/pp/eng/2011/092111.pdf.

163 Bredenkamp, H. (2011), *Commodity Price Volatility: Impact and Policy Challenges for LICs*, International Monetary Fund (IMF) (2011), http://www.imf.org/external/np/seminars/eng/2011/lic/pdf/hb.pdf.

164 United Nations Conference on Trade and Development (UNCTAD) (2002), 'The Impact of High Energy Prices on Trade and Development', http://archive.unctad.org/Templates/Page.asp?intItemID=4005&lang=1.

165 Trikki, T. and Affes, Y. (2011), 'Managing Commodity Price Volatility in Africa', *Africa Economic Brief*, Vol. 2, No. 12.

166 Audretsch, D. B., Keilbach, M., and Lehmann, E. (2006), *Entrepreneurship and Economic Growth* (New York: Oxford University Press).

167 Lee, B., Iliev, I. and Preston, F. (2009), *Who Owns Our Low Carbon Future? Energy Technologies and Intellectual Property* (London: Chatham House). www.chathamhouse.org/publications/papers/view/109124.

168 Ibid.

169 Ibid.

170 US National Intelligence Council (2011), *Impacts of Technology on Freshwater Availability to 2040*, US National Intelligence Council Report NICR 2011-01.

171 The *IEA's 2011 World Energy Outlook* provides 2035 energy demand shares for 'other renewables', which includes all renewable energies except hydro and biomass. Under the three scenarios, the shares are: 3% (Current Policies), 4% (New Policies), 8% (450 ppm).

172 Mitchell, J.V (2012), *What Next for the Oil and Gas Industry?* (London: Chatham House), http://www.chathamhouse.org/publications/papers/view/186327. Recent projections from the IEA and other mainstream data sources are relatively pessimistic on the future uptake of electric vehicles. According to BP, for example, 'sales of plug-in vehicles, including full battery electric vehicle (BEVs), are forecast to be 8% of sales in 2030'. See BP (2012), *BP Energy Outlook 2030*, January, www.

bp.com/liveassets/bp_internet/globalbp/STAGING/global_assets/downloads/O/2012_2030_energy_outlook_booklet.pdf.

173 Solar production data from the Earth Policy Institute, 'Annual Solar Photovoltaics Production by Country, 1995–2010', www.earth-policy.org/data_center/C23.

174 De la Tour, A., Glachant, M. and Meniere, Y. (2010), 'Innovation and International Technology Transfer: The Case of the Chinese Photovoltaic Industry', *Energy Policy,* Vol. 39, No. 2, pp. 761–70.

175 Ching-Yan W. and Mathews, J.A. (2012), 'Knowledge Flows in the Solar Photovoltaic Industry: Insights from Patenting by Taiwan, Korea, and China', *Research Policy*, Vol. 41, No. 3, pp. 524–40.

176 Lee et al. (2009), *Who Owns our Low Carbon Future?*

177 Ibid.

178 Ibid.

179 Lemaux, P. (2008), 'Genetically Engineered Plants and Foods: A Scientist's Analysis of the Issues (Part I)', *Annual Review of Plant Biology*, Vol. 59, No. 1, pp. 771–812.

180 James, C. (2011), *Global Status of Commercialized Biotech/GM Crops: 2011* (Ithaca, New York: International Service for the Acquisition of Agri-Biotech Applications).

181 Conway, G. (2012), *One Billion Hungry: Can We Feed the World?* (Ithaca: Cornell University Press).

182 World Water Assessment Programme (2009), *The United Nations World Water Development Report 3: Water in a Changing World* (Paris: UNESCO and London: Earthscan).

183 2030 Water Resources Group (2009), 'Charting our Water Future'.

184 Meinzen-Dick, R. and Appasamy, P.P. (2011), *Finding the Source: Urbanization and Intersectoral Competition for Water* (Washington, DC: Woodrow Wilson Center for Scholars), www.wilsoncenter.org/publication/finding-the-source-urbanization-and-intersectoral-competition-for-water.

185 FAO (2012), *The State of the World's Land and Water Resources for Food and Agriculture* (SOLAW): *Global Distribution of Physical Water Scarcity by Major River Basin* (Rome: FAO).

186 Vörösmarty, C, McIntyre P., Gessner M., at al. (2010), 'Global Threats to Human Water Security and River Biodiversity', *Nature,* Vol. 467, pp. 555–61.

187 Government of the United Arab Emirates (2011), *Food Security and Water G20 White Paper*, www.uaeg20.ae/usr/pages/en/Food%20and%20Water%20Security%20policy.pdf.

188 Tir, J. and Stinnett, D.M. (2012), 'Weathering Climate Change: Can Institutions Mitigate International Water Conflict?', *Journal of Peace Research*, Vol. 49, No.1, pp. 211–25.

189 Particularly when relations between these states are characterized by power asymmetries. See Zeitoun, M. and Allan, J.A. (2008), 'Applying Hegemony and Power Theory to Transboundary Water Analysis', *Water Policy,* Vol. 10, No. 2, pp. 3–12, http://www.uea.ac.uk/polopoly_fs/1.147022!ZeitounAllan_Power_Hegemony_Theory_HH_Special_Issue.pdf.

190 Zeitoun, M. (2008), *Power and Water in the Middle East: The Hidden Politics of the Palestinian-Israeli Water Conflict* (London and New York: I.B. Tauris); for a discussion of the importance of cooperative approaches to water management, particularly in terms of adaptation, in the history of this conflict see Fischendler, I., Dinar, S. and Katz, D. (2011), 'The Politics of Unilateral Environmentalism: Cooperation and Conflict over Water Management along the Israeli-Palestinian Border', *Global Environmental Politics*, Vol. 11, No. 1, pp. 36–61.

191 Mekonnen, M.M. and Hoekstra, A.Y. (2010), 'The Green, Blue and Grey Water Footprint of Crops and Derived Crop Products', *Value of Water Research Report Series*, No. 47 (Delft, the Netherlands: UNESCO-IHE).

192 FAO (2011), *Aquastat Water Withdrawal by Region*, www.fao.org/nr/water/aquastat/dbase/AquastatWorldDataEng_20101129.pdf.

193 OECD (2012), *World Environmental Outlook to 2050* (Paris: OECD), p. 217; BRIICS countries: Brazil, Russia, India, Indonesia, China, South Africa.

194 Strzepek, K. and Boehlert, B. (2010), 'Competition for Water for the Food System', *Philosophical Transactions of the Royal Society,* Vol. 365, No. 1554, pp. 2927–40.

195 Wada, Y. et al. (2010), 'Global Depletion of Groundwater Resources', p. 2.

196 Strzepekand Boehlert (2010), 'Competition for Water for the Food System'.

197 World Energy Council (2010), *Water for Energy* (London: World Energy Council) www.worldenergy.org/publications/2849.asp.

198 Kumar, A., Schei, T., Ahenkorah, A., et al. (2011), 'Hydropower', Chapter 5 in Edenhofer, O. , Pichs-Madruga, R., Sokona, Y. et al. (eds), *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge University Press), http://srren.ipcc-wg3.de/report/IPCC_SRREN_Ch05.pdf.

199 Conway, D. and Schipper, E.L. (2011), 'Adaptation to Climate Change in Africa: Challenges and Opportunities Identified from Ethiopia', *Global Environmental Change*, Vol. 21, No. 1, pp. 227–37.

200 Bloomberg New Energy Finance (2012), *Water Research Note: Thirsty Coal Dries Up China's Water Supplies*, https://www.dropbox.com/s/464jwiabfvn7w6e/bnef_rn_water_and_coal_china_2012_02_08.pdf.

201 Sauer, A., Klop, P. and Agrawal, S. (2010), *Over Heating: Financial Risks from Water Constraints on Power Generation in Asia – India, Malaysia, Philippines, Thailand, Vietnam* (Washington, DC: World Resources Institute and HSBC), http://pdf.wri.org/over_heating_asia.pdf.

202 Global Water Intelligence (2009), 'A New Dawn for Desalination in Chile', *Global Water Intelligence*, Vol. 10, No. 12.

203 Gleick, P. (2010), 'China and Water', Chapter 5 in *The World's Water: 2008–2009* (6th edn) (Washington, DC: Island Press).

204 See Dobbs et al. (2011), *Resource Revolution.*

205 For Peru, see Cabitza, M. (2012), 'Peru mine disputes mar President Humala's first year', *BBC News*, 28 July, www.bbc.co.uk/news/world-latin-america-18980109.

206 See, for example, Circle of Blue (2012), 'Protests Break Out After India's Supreme Court Rules in Favor of Downstream State in Cauvery River Dispute', www.circleofblue.org/waternews/2012/world/protests-break-out-after-indias-supreme-court-rules-in-favor-of-downstream-state-in-cauvery-river-dispute/.

207 Odom, O. and Wolf, A.T. (2011), 'Institutional Resilience and Climate Variability in International Water Treaties: the Jordan River Basin as "Proof-of-concept"', *Hydrological Sciences Journal*, Vol. 56, No. 4, pp. 703–10.

208 Okavango River Basin Agreement (2007), Art. 3.

209 See OKACOM (2010), *OKACOM Protocol on Hydrological Data Sharing for the Okavango River Basin*, The Permanent Okavango River Basin Water Commission, Art. 14.

210 The target covers information about water infrastructure investment planning and implementation (financial, technical, and socio-economic impacts); and methods and tools for improving transparency and accountability within the water sector, by 2018. See Akhmouch, A. (2012), *Synthesis Report for the Condition for Success 1: Good*

Governance, OECD Water Governance Programme, www.oecd.org/gov/regionaldevelopment/49827425.pdf.

211 Katz, D. (2011), 'Hydro-Political Hyperbole: Examining Incentives for Overemphasizing the Risks of Water Wars', *Global Environmental Politics,* Vol. 1, No. 1, pp. 12--35; Selby, J. (2005), 'The Geopolitics of Water in the Middle East: Fantasies and Realities', *Third World Quarterly*, Vol. 26, No. 2, pp. 329–49; Wolf, A.T. (1999), '"Water Wars" and Water Reality: Conflict and Cooperation Along International Waterways', pp. 251–65 in Lonergan, S. C. (ed), *Environmental Change, Adaptation, and Human Security* (Dordrecht: Kluwer Academic).

212 Tir, J. and Stinnett, D. M. (2012), 'Weathering Climate Change'.

213 Zala, B. (forthcoming), 'The Strategic Dimensions of Water: From National Security to Sustainable Security', in Lankford, B.A., Bakker, K., Zeitoun, M. and Conway, D. (eds), *Water Security: Principles, Perspectives and Practices* (London: Earthscan).

214 US National Intelligence Council (2012), *Global Water Security*, Office of the Director of National Intelligence, www.dni.gov/files/documents/Newsroom/Press%20Releases/ICA_Global%20Water%20Security.pdf; Development Concepts and Doctrine Centre (DCDC)(2010), *Global Strategic Trends – Out to 2040* (4th edn) (Shrivenham: UK Ministry of Defence).

215 See the case study on Syria in IPCC (2012), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (Cambridge University Press), http://www.ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf. See also Landis, J. (2012), 'The Syrian Uprising of 2011: Why the Asad Regime Is Likely to Survive to 2013', Journal Essay, Middle East Policy Council, http://www.mepc.org/journal/middle-east-policy-archives/syrian-uprising-2011-why-asad-regime-likely-survive-2013?print.

216 Substantiated using IPCC (2012), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (Cambridge University Press), www.ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf.

217 United Nations Environment Programme (UNEP) (2012), *Global Environment Outlook 5: Summary for Policy Makers* (Rome: UNEP), www.unep.org/geo/pdfs/GEO5_SPM_English.pdf.

218 Rockström, J. et al. (2009), 'A Safe Operating Space for Humanity', *Nature*, Vol. 461, No. 282, pp. 472–75.

219 For reports by non-governmental organizations, see German Advisory Council on Global Change (WBGU) (2007), *Climate Change as a Security Risk* (London: Earthscan); Mabey, N. and Mitchell, J.V. (2010), *Investing for an Uncertain Future: Priorities for UK Energy and Climate Security* (London: Chatham House); Campbell, K.M. et al. (2007), *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change* (Washington, DC: CSIS and CNAS); Smith, D. and Vivekananda, J. (2007), *A Climate of Conflict: The Links Between Climate Change, Peace and War* (London: International Alert), http://reliefweb.int/sites/reliefweb.int/files/resources/16A12BCAEAD0E411852573AE007570A3-International%20Alert_Climate%20of%20Conflict_07.pdf; Mabey, N. et al. (2011), *Degrees of Risk: Defining a Risk Management Framework for Climate Security* (London and Washington, DC: E3G), www.e3g.org/images/uploads/Degrees%20of%20Risk_Defining%20a%20Risk%20Management%20Framework%20for%20Climate%20Security_Full%20Report.pdf; Paskal, C. (2007), *How Climate Change is Pushing the Boundaries of Security and Foreign Policy* (London: Chatham House) and Paskal, C. (2010), *Global Warring: How Environmental, Economic and Political Crises will Redraw the World Map* (New York: Palgrave Macmillan). For reports by national government agencies, see US National Intelligence Council (2009), *India: The Impacts of Climate Change to 2030*, US National Intelligence Council Conference Report, www.dni.gov/files/documents/2009%20Conference%20Report_India_The%20Impact%20of%20Climate%20Change%20to%202030.pdf; US National Intelligence Council (2009), *China: The Impacts of Climate Change 2030*, US National Intelligence Council Conference Report, www.dni.gov/files/documents/2009%20Conference%20Report_China_The%20Impact%20of%20Climate%20Change%20to%202030.pdf; US National Intelligence Council (2009), *Russia: The Impacts of Climate Change 2030*, US National Intelligence Council Conference Report, www.dni.gov/files/documents/2009%20Conference%20Report_Russia_The%20Impact%20of%20Climate%20Change%20to%202030.pdf; Halden, P. (2007), *The Geopolitics of Climate Change: Challenges to the International System* (Stockholm: Swedish Defence Research Agency, FOI), www2.foi.se/rapp/foir2377.pdf; DCDC (2010), *Strategic Trends Programme: Global Strategic Trends – Out to 2040.* For reports by intergovernmental organizations, see United Nations (2009), *Climate Change and its Possible Security Implications*, Report of the Secretary General, http://www.un.org/ga/search/view_doc.asp?symbol=A/64/350; High Representative and European Commission (2008), *Climate Change and International Security*, Joint Paper to the European Council, www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/reports/99387.pdf.

220 CNA (2007), *National Security and the Threat of Climate Change*, www.cna.org/sites/default/files/National%20Security%20and%20the%20Threat%20of%20Climate%20Change%20-%20Print.pdf; High Representative and European Commission (2008), *Climate Change and International Security*, Joint Paper to the European Council, www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/reports/99387.pdf; United Nations (2009), *Climate Change and its Possible Security Implications*, Report of the Secretary General, http://www.unhcr.org/refworld/pdfid/4ad5e6380.pdf.

221 Dupont, A. (2008), 'The Strategic Implications of Climate Change', *Survival*, Vol. 50, No. 3, p. 46.

222 Hendrix, C.S. and Salehyan, I. (2012), 'Climate Change, Rainfall, and Social Conflict in Africa', *Journal of Peace Research*, Vol. 49, No. 1, pp. 35–50; Ember, C.R., Adem, T.A., Skoggard, I. and Jones, E.C. (2012), 'Livestock Raiding and Rainfall Variability in Northwestern Kenya', *Civil Wars*, Vol. 14, No. 2, pp. 159–81.

223 Zala, B. and Rogers, P. (2011), 'The "Other" Global Security Challenges: Socioeconomic and Environmental Realities after the War on Terror', *RUSI Journal*, Vol. 156, No. 4, p. 30; Jermy, S. (2011), *Strategy for Action: Using Force Wisely in the 21st Century* (London: Knightstone Publishing), p. 144.

224 IPCC (2007), *Fourth Assessment Report.*

225 IFAD (2012), *Tackling Land Degradation and Desertification*, www.ifad.org/events/wssd/gef/gef_ifad.htm.

226 IFAD (2010), *Desertification*, www.ifad.org/pub/factsheet/desert/e.pdf.

227 Lobell, D.B., Schlenker, W. and Costa-Roberts, J. (2011), 'Climate Trends and Global Crop Production Since 1980', *Science*, Vol. 333, No. 6042, pp. 616–20.

228 Fetzek, S. (2009), *Climate-Related Impacts on National Security in Mexico and Central America*, Royal United Services Institute Interim Report, www.rusi.org/downloads/assets/Mexico_CC_Text_-_English.pdf; African Development Bank Group (2009), *Soaring Food Prices and Africa's Vulnerability and Responses: an Update*, African Development Bank Working Series, www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/WORKING%2097.pdf.

229 IPCC (2007), *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf; E3G (2011), Mabey, N. et al., *Degrees of Risk: Defining a Risk Management Framework for Climate Security* (London and Washington, DC: E3G), http://www.e3g.org/images/uploads/Degrees%20of%20Risk_Defining%20a%20Risk%20Management%20Framework%20for%20Climate%20Security_Full%20Report.pdf.

230 Ibid.

231 Cochrane, K., De Young, C., Soto, D. and Bahri, T. (2009), *Climate Change Implications for Fisheries and Aquaculture: Overview of Current Scientific Knowledge* (Rome: FAO).

232 Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J. L. et al. (2010), 'Large-scale Redistribution of Maximum Fisheries Catch Potential in the Global Ocean under Climate Change', *Global Change Biology*, Vol. 16, No. 1, pp. 24–35.

233 For the mining industry, see e.g. Hodgkinson, J.H., Littleboy, A. Howden, M., Moffat, K. and Loechel, B. (2010), *Climate Adaptation in the Australian Mining and Exploration Industries*, CSIRO Climate Adaptation Flagship Working Paper No. 5, www.csiro.au/resources/CAF-working-papers.html; Pearce, T.D., Ford, J.D., Prno, J. Frank, D. et al. (2011), 'Climate Change and Mining in Canada', *Mitigation and Adaptation Strategies for Global Change*, Vol. 16, No. 3, pp. 347–68.

234 Minerals Council of Australia (2011), *The Economic Impact of the Carbon Pricing Scheme Assessing the Costs in a World of Fragmented Policy Action*, https://www.qrc.org.au/_dbase_upl/CIE_combined.pdf.

235 Ford, J.D., Pearce, T., Prno, J., Duerden, F. et al. (2011), 'Canary in a Coalmine: Perceptions of Climate Change Risks and Response Options among Canadian Mine Operations', *Climatic Change*, Vol. 109, No. 3, pp. 399–415.

236 Azam, S. and Q. Li (2010), 'Tailings Dam Failures: A Review of the Last One Hundred Years', *Geotechnical News*, Vol. 28, No. 4, pp. 50–53.

237 Hodgkinson et al. (2010), *Climate Adaptation in the Australian Mining and Exploration Industries*; Ford et al. (2011), 'Canary in a Coalmine'.

238 Ernst and Young (2011), *Business Risks Facing Mining and Metals 2011–2012*, www.ey.com/Publication/vwLUAssets/Business_risks_facing_mining_and_metals_2011-2012/$File/Metal_Mining_paper_02Aug11_lowres.pdf.

239 World Ocean Review (2010), 'World Ocean Review – Living with the oceans', http://worldoceanreview.com/en/order/.

240 Kasarda, J.D., Appold, S.J. and Mori, M. (2006), 'The Impact of the Air Cargo Industry on the Global Economy', presentation for the International Air Cargo Association Air Cargo Forum, Calgary, 13 September, www.tiaca.org/images/TIACA/PDF/The%20Impact%20of%20the%20Air%20Cargo%20Industry%20on%20the%20Global%20Economy.pdf.

241 Lee, B., Preston, F. and Green, G. (2012), *Preparing for High-impact, Low-probability Events: Lessons from Eyjafjallajökull* (London: Chatham House), www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/r0112_highimpact.pdf.

242 United Nations Conference on Trade and Development (UNCTAD) (2011), *Review of Maritime Transport 2011*, http://unctad.org/en/docs/rmt2011_en.pdf.

243 Ibid.

244 Kojima, M., Matthews, W. and Sexsmith, F. (2010), *Petroleum Markets in Sub-Saharan Africa,* World Bank Extractive Industries for Development Series No.15, http://siteresources.worldbank.org/INTOGMC/Resources/336099-1158588096604/eifd15_ssa_oil_markets.pdf.

245 Minot, N. (2010), *Transmission of World Food Price Changes to Markets in Sub-Saharan Africa,* International Food Policy Research Institute (IFPRI) Discussion Paper, www.ifpri.org/sites/default/files/Minot_2010.pdf.

246 Tu, J. (2011), *Industrial Organisation of the Chinese Coal Industry,* Freeman Spogli Institute For International Studies, http://carnegieendowment.org/files/China_Coal_Value_Chain_Kevin_Tu3.pdf.

247 For example, see Middleton, R. (2008), *Piracy in Somalia: Threatening Global Trade, Feeding Local Wars* (London: Chatham House), www.chathamhouse.org/sites/default/files/public/Research/Africa/1008piracysomalia.pdf.

248 Bowlus, J. (2012), *How Verbal Threats to Close Oil Transit Chokepoints Lead to Military Conflict*, Policy Brief No. 29, Global Political Trends Center, Istanbul Kültür University, www.isn.ch/isn/Digital-Library/Publications/Detail/?ots591=0c54e3b3-1e9c-be1e-2c24-a6a8c7060233&lng=en&ord582=grp1&id=136459.

249 Paskal, 2007 and 2009; Hadley Centre, 2009; Maas et al., 2010; Froggatt and Lahn (2010).

250 For further analysis see Stevens, P. (2009), *Transit Troubles: Pipelines as a Source of Conflict* (London: Chatham House) www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/r0309_pipelines.pdf.

251 This does not eliminate the risk, especially where, for example in the United States, there are strict product specifications which few refineries can manage.

252 The Abqaiq processing facility was subject to a failed terrorist attack by al-Qaeda on 24 February 2006.

253 WTO (2010), *World Trade Report 2010, www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report10_e.pdf.*

254 UNCTAD (2011), *Review of Maritime Transport 2011*.

255 The discussion in this section is built on an analysis conducted by Chatham House for the National Intelligence Council, forthcoming.

256 Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S. and Ahmed, M. (2003), *Fish to 2020: Supply and Demand in Changing Global Markets* (Washington, DC and Penang: International Food Policy Research Institute and Worldfish Center), http://www.ifpri.org/sites/default/files/pubs/pubs/books/fish2020/oc44.pdf.

257 OECD and FAO (2011), *OECD-FAO Agricultural Outlook 2011–2020*, (Paris and Rome: OECD and FAO).

258 Ibid.

5. Responses to Resource Threats: Adding Fuel to the Fire

259 IEA (2011), *World Energy Outlook 2011*, (Paris: IEA). It should be noted that the 'price gap' methodology used by the IEA to estimate subsidies to consumed products is controversial. Here, the 'subsidy' is the difference between the end-user price of fuel and the reference price (i.e. the international price for that commodity at the time). However, in certain cases – chiefly Saudi Arabia – this would not make sense because beyond a certain volume, domestically consumed oil could not be sold on the international market without affecting the international price. For further discussion of this and the Saudi fuel subsidy issue see Alyousef, Y. and Stevens, P. (2011), 'The Cost of Domestic Energy Prices to Saudi Arabia', *Energy Policy,* Vol. 31, No. 11, pp. 6900–05. In addition, it only takes into account the fuel sold at below cost to utilities, not final-use electricity prices, which some countries also subsidize.

260 OECD data from OECD.Stat.

261 Ibid.

262 See WTO website: *Subsidies and Countervailing Measures: Overview*, www.wto.org/english/tratop_e/scm_e/subs_e.htm.

263 Before 1999, there was a further category of specific subsidies – non-actionable subsidies – comprised of subsidies provided to support research, to aid disadvantaged regions, and to enable plants to be adapted to new environmental regulation. This third category was included in the SCM Agreement, provisionally for five years until the end of 1999. Since no consensus was reached on extension beyond 1999, this provision – and thus the category of non-actionable subsidies – is understood to have lapsed. Currently, therefore, specific subsidies are either prohibited

or actionable. See Hoekman, B., Mattoo, A. and English, P. (eds) (2002), *Trade, and the WTO: A Handbook* (Washington, DC: World Bank).

264 Lee, B. (2009), 'Managing the Interlocking Climate and Resource Challenges', *International Affairs*, Vol. 85, No. 6, p. 1113.

265 FAO, IFAD, IMF, OECD, UNCTAD, WFP, World Bank, WTO, International Food Policy Research Institute (IFPRI) and the United Nations High-Level Task Force on Global Food Security Crisis (UN HLTF) (2011), *Price Volatility in Food and Agricultural Markets: Policy Responses*, Report to the G20, 2 June, www.worldbank.org/foodcrisis/pdf/Interagency_Report_to_the_G20_on_Food_Price_Volatility.pdf; BBC News (2012), 'Food prices jump will hit poor, World Bank warns', 30 August, www.bbc.co.uk/news/world-19431890.

266 The Farm Subsidy Database of the Environmental Working Group (EWG) estimates that maize farmers received $81 billion in subsidies between 1995 and 2011, compared to $26 billion in subsidies to soybean farmers over the same period. For data, see http://farm.ewg.org/region.php.

267 See, for example, WWF (2011), *Soya and the Cerrado: Brazil's Forgotten Jewel*, http://assets.wwf.org.uk/downloads/soya_and_the_cerrado.pdf; Morton, D.C. et al. (2006), 'Cropland Expansion Changes Deforestation Dynamics in the Southern Brazilian Amazon', *Proceedings of the National Academy of Sciences*, Vol. 103, No. 39, pp. 14637–41; Bloomberg (2011), 'Amazon Deforestation Jumped Sixfold on Expanded Soy Planting, Brazil Says', 18 May, www.bloomberg.com/news/2011-05-18/amazon-deforestation-jumped-sixfold-on-expanded-soy-planting-brazil-says.html.

268 Sumaila, U.R., Khan, A.S., Dyck, A.J. et al. (2010), 'A Bottom-up Re-estimation of Global Fisheries Subsidies', *Journal of Bioeconomics*, Vol. 12, pp. 201–25.

269 Ibid.

270 OECD (2011), *Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels* (Paris: OECD).

271 See Global Subsidies Initiative, which has a series examining support to production in several countries, www.iisd.org/gsi/fossil-fuel-subsidies/fossil-fuels-what-cost.

272 OECD (2011), *Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels* (Paris: OECD).

273 G20 (2009), *G20 Leaders' Statement: The Pittsburgh Summit, September 24–25*, www.g20.utoronto.ca/2009/2009communique0925.html.

274 Rogers, P. (2012), 'Nigeria: The Generic Context of the Boko Haram Violence', Oxford Research Group, www.oxfordresearchgroup.org.uk/sites/default/files/AprEn12.pdf.

275 Bazilian, M. and Onyeji, I. (2012), 'Fossil Fuel Subsidy Removal and Inadequate Public Power Supply: Implications for Businesses', *Energy Policy*, Vol. 45, pp. 1–5.

276 For this and other lessons learned, see the Global Subsidies Initiative (2010), *Strategies for Reforming Fossil-Fuel Subsidies: Practical Lessons from Ghana, France and Senegal,* International Institute for Sustainable Development, www.iisd.org/gsi/sites/default/files/strategies_ffs.pdf.

277 IEA (2007), *Oil Supply Security: Emergency Response of IEA countries*, p. 32, http://books.google.co.uk/books?id=COdAuw4GVewC&pg=PA11&lpg=PA11&dq=Oil+Supply+Security:+Emergency+Response+of+IEA+countries+2007&source=bl&ots=VR47nZvZYN&sig=mLRR98f2pvIZUnT8ftz0UhZiQVE&hl=en#v=onepage&q&f=false.

278 US Department of Energy (DoE) (2012), *US Petroleum Reserves*, April, www.fossil.energy.gov/programs/reserves/.

279 Blas, J. (2012), 'Chinese defaults prompt mystery', *Financial Times*, 28 May, www.ft.com/cms/s/0/c7a61f2c-a8a1-11e1-be59-00144feabdc0.html#axzz251V2jFKD.

280 Wiggins, S. and Keats, S. (2009), *Grain Stocks and Price Spikes* (London: Overseas Development Institute), www.odi.org.uk/resources/docs/7631.pdf.

281 Lohmar, B. (2004), *China's Wheat Economy: Current Trends and Prospects for Imports*, US Department of Agriculture (USDA) Electronic Outlook Report from the Economic Research Service, WHS 04D-01, May; Yao, S. (2006), *Chinese Agricultural Reform, the WTO and FTA Negotiations*, Asia-Pacific Research and Training Network on Trade Working Paper Series, No. 15, www.unescap.org/tid/artnet/pub/wp1506.pdf.

282 Calculations based stocks and production statistics from the USDA Foreign Agricultural Service (FAS) Production, Supply & Distribution (PSD) statistics, www.fas.usda.gov/psdonline/psdQuery.aspx.

283 Wright, B.D. (2011), 'The Economics of Grain Price Volatility', *Applied Economic Perspectives and Policy*, Vol. 33, No. 1, pp. 32–58.

284 Kooroshy, J., Korteweg, R. and de Ridder, M. (2010), *Rare Earth Elements and Strategic Mineral Policy* (The Hague: The Hague Centre for Strategic Studies).

285 *Japan Today* (2010), 'Gov't to study stockpiling rare earth minerals', 2 October.

286 Kawamoto, H. (2008), 'Japan's Policies to be Adopted on Rare Metal Resources', *Science & Technology Trends Quarterly Review,* Vol. 27, pp. 57–76.

287 *People's Daily* (2010), 'China plans strategic reserves for rare metals', 3 November, http://english.peopledaily.com.cn/90001/90778/90860/7186937.html.

288 Stevens, D. (1999), 'World War II Economic Warfare: The United States, Britain, and Portuguese Wolfram', *The Historian*, Vol. 61, No. 3, pp 539–56.

289 Buijs, B. and Sievers, H. (2011), 'Critical Thinking about Critical Minerals: Assessing Risks Related to Resource Security', CIEP Briefing Paper, November, http://www.clingendael.nl/publications/2011/20111111_ciep_bgr_briefingpaper_buijs_sievers_critical_thinking_about_critical_minerals.pdf.

290 See, for example, Bremmer, I. and Johnston, R. (2008), 'The Rise and Fall of Resource Nationalism', *Survival: Global Politics and Strategy*, Vol. 51, No. 2, pp. 149–58; Joffé, G., Stevens, P., George, T., Lux, J. and Searle, C. (2009), 'Expropriation of Oil and Gas Investments: Historical, Legal, and Economic Perspectives in a New Age of Resource Nationalism', *World Energy Law & Business*, Vol. 2, No. 1, pp. 3–23.

291 Hernandez, V. (2012), 'YPF nationalism: is Argentina playing with fire?', BBC News, 17 April, www.bbc.co.uk/news/world-europe-17740393.

292 Solomon, M. (2012), *The Rise of Resource Nationalism: A Resurgence of State Control in an Era of Free Markets or the Legitimate Search for a New Equilibrium?*, Southern African Institute of Mining and Metallurgy, www.saimm.co.za/Conferences/ResourceNationalism/ResourceNationalism-20120601.pdf.

293 Ten people had been killed in clashes the previous week, including two police officers. See BBC News (2012), 'South Africa's Lonmin Marikana mine clashes killed 34', 17 August, www.bbc.co.uk/news/world-africa-19292909.

294 For a discussion, see Stevens, P. (2008), 'National Oil Companies and International Oil Companies in the Middle East: Under the Shadow of Government and the Resource Nationalism Cycle', *World Energy Law & Business*, Vol. 1, No. 1, pp. 5–30; Joffé, G. et al. (2009), 'Expropriation of Oil and Gas Investments: Historical, Legal and Economic Perspectives in a New Age of Resource Nationalism', *World Energy Law & Business*, Vol. 2, No. 1, pp. 3–23.

295 Parra-Bernal, G. and Simões, E. (2012), 'Vale wins injunction barring Brazil tax debt payment', Reuters, 9 May, www.reuters.com/article/2012/05/10/us-brazil-taxes-vale-idUSBRE84901W20120510.

296 Hammond, J. (2012), 'Kirchner Joins the Resource Wars', *The European*, 18 May, http://theeuropean-magazine.com/381-hammond-joseph/682-global-resource-nationalism.

297 UNCTAD (2011), *World Investment Report 2011: Non-equity Modes of International Production and Development*, p. x, www.unctad-docs.org/files/UNCTAD-WIR2011-Full-en.pdf.

298 Salidjanova, N. (2011), *Going Out: An Overview of China's Outward Foreign Direct Investment*, US-China Economic and Security Review Commission Staff Report, www.uscc.gov/researchpapers/2011/GoingOut.pdf.

299 OECD (2011), Overseas Investments by China's National Oil Companies: Assessing the Drivers and Impacts, http://www.oecd-ilibrary.org/docserver/download/5kgglrwdrvvd.pdf?expires=1355398133&id=id&accname=guest&checksum=7CE54CFB0661ED2E42D3BEA057FFD5AA.

300 UNCTAD (2011), *World Investment Report 2011: Non-equity Modes of International Production and Development*, p. 29, www.unctad-docs.org/files/UNCTAD-WIR2011-Full-en.pdf.

301 Ibid.

302 Dyer, G., Anderlini, J. and Sender, H. (2011), 'China's lending hits new heights', *Financial Times*, 17 January, www.ft.com/cms/s/0/488c60f4-2281-11e0-b6a2-00144feab49a.html#axzz1xUXVk3hF.

303 Wagner, J. (2012), '"Going Out": Is China's Skilful Use of Soft Power in Sub-Saharan Africa a Threat to U.S. Interests?', *Joint Force Quarterly*, Vol. 64, No. 1, pp. 99–106.

304 Export-Import Bank of India (2011), 'Indian Lines of Credit: An Instrument to Enhance India-Africa Partnership', presentation, www.indiainbusiness.nic.in/trade/presentation_loc/exim.pdf.

305 Cheung, Y-W., de Haan, J., Qian, X. and Yu, S. (2012), 'China's Outward Direct Investment in Africa', *Review of International Economics*, Vol. 20, No. 2, pp. 201–20.

306 Human Rights Watch (2011), *You'll Be Fired if You Refuse: Labor Abuses in Zambia's Chinese State-owned Copper Mines*, www.hrw.org/sites/default/files/reports/zambia1111ForWebUpload.pdf.

307 Beeson, M., Soko, M. and Yong, W. (2011), 'The New Resource Politics: Can Australia and South Africa Accommodate China?', *International Affairs,* Vol. 87, No. 6, pp. 1323–43.

308 Yao, S., Sutherland, D. and Chen, J. (2010), 'China's Outward FDI and Resource-Seeking Strategy: A Case Study on Chinalco and Rio Tinto', *Asia-Pacific Journal of Accounting & Economics*, Vol. 17, pp. 313–26.

309 Keenan, R. (2011), 'Australia Blocked Rare Earth Deal on Supply Concerns', Bloomberg, 15 February, www.bloomberg.com/news/2011-02-14/australia-blocked-china-rare-earth-takeover-on-concern-of-threat-to-supply.html.

310 PricewaterhouseCoopers (2011), *You Can't Always Get What You Want: Global Mining Deals 2010*, www.pwc.com.au/industry/energy-utilities-mining/assets/Global-Mining-Deals-Mar11.pdf.

311 Cai, P. (2012), 'China business fights political backlash', *Sydney Morning Herald*, 13 August, www.smh.com.au/business/china-business-fights-political-backlash-20120812-242ry.html.

312 Niobium is considered of strategic importance and is mainly used in the manufacturing of extremely high-strength steel (e.g. in pipelines or critical parts of bridges). According to CODEMIG, Araxá accounts for over half of world production. See http://www.codemig.com.br/site/content/parcerias/niobiumE.asp?id=17E.

313 Mitchell, J.V. (2002), *Renewing Energy Security* (London: Chatham House), www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/renewing_energy_security_mitchell_july_2002.pdf.

314 Ibid.

315 UNCTAD World Investment Forum (2012), *Sovereign Wealth Fund Round Table: Exploring the Potential of Sovereign Wealth Funds for Investment in Sustainable Development,* UNCTAD World Investment Forum 2012 Issues Note, p. 2, http://unctad-worldinvestmentforum.org/assets/2012-forum-docs/WIF-SWF-Issues-Note-11-Apr.pdf.

316 Ibid.

317 Ibid.

318 Ibid.

319 Zagema, B. (2011), *Land and Power: The Growing Scandal Surrounding the New Wave of Investments in Land* (Oxford: Oxfam), www.oxfam.org/en/grow/policy/land-and-power.

320 Deininger, K. and Byerlee, D. (2010), *Rising Global Interest in Farmland: Can it Yield Sustainable and Equitable Benefits?* (Washington, DC: World Bank), http://siteresources.worldbank.org/INTARD/Resources/ESW_Sept7_final_final.pdf.

321 Anseeuw, W., Alden Wily, L., Cotula, L. and Taylor, M. (2012), *Land Right and the Rush for Land: Findings of the Global Commercial Pressures on Land Research Project*, International Land Coalition, www.landcoalition.org/sites/default/files/publication/1205/ILC%20GSR%20report_ENG.pdf.

322 While gas has always involved long-term supply contracts, oil contracts have varied in response to security perceptions. The oil market was dominated by long-term contracts until around 1980 – but these were discredited during the price shocks of the 1970s and 1980s as producer governments ripped up the contracts, citing *force majeure*. Hence oil importers switched to short-term contracts and buying on the spot markets, which has increased global market volatility.

323 Jiang, J. and Sinton, J. (2011), *Overseas Investments by Chinese National Oil Companies: Assessing the Drivers and Impacts*, IEA, www.iea.org/publications/freepublications/publication/overseas_china.pdf.

324 Afghanistan Research and Evaluation Unit (2012), *The A to Z Guide to Afghan Assistance* (Kabul: Afghanistan Research and Evaluation Unit).

325 Global Witness (2012), *Getting to Gold: How Afghanistan's First Mining Contracts Can Support Transparency and Accountability in the Sector* (London: Global Witness); Noorani, J. (2011), *Hajigak – the Jewel of Afghan Mines* (Kabul: Integrity Watch Afghanistan).

326 Sexton, R. (2012), *Natural Resources and Conflict in Afghanistan: Seven Case Studies, Major Trends and Implications for the Transition* (Kabul: Afghanistan Watch).

327 Ibid.

328 Ibid.

329 Afghanistan Research and Evaluation Unit (2012), *The A to Z Guide to Afghan Assistance* (Kabul: Afghanistan Research and Evaluation Unit).

330 Ibid.

331 Emmerson and Lahn (2012).

332 *Petroleum Economist* (2012), 'Arctic Investment Competition Heats Up', 11 January, www.petroleum-economist.com/Article/2959654/Arctic-investment-competition-heats-up.html.

333 OECD and FAO (2011), *OECD-FAO Agricultural Outlook 2011–2020*, http://dx.doi.org/10.1787/agr_outlook-2011-en.

334 International Crisis Group (2010), *Northern Nigeria: Background to Conflict*, Africa Report No. 168, Brussels, p. 7 (note 31).

335 Ahmed, M., Salayo, N.D., Viswanathan, K.K., Garces, L.R. and Pido, M.D. (2006), *Management of Fishing Capacity and Resource Use Conflicts in Southeast Asia: A Policy Brief* (Penang: WorldFish Center Malaysia); Pomeroy, R., Parks, J., Pollnac, R. et al. (2007), 'Fish Wars: Conflict and Collaboration in Fisheries Management in Southeast Asia', *Marine Policy*, Vol. 31, No. 6, pp. 645–56.

336 Silva, M. (2010), 'Somalia: State Failure, Piracy and the Challenge to International Law', V*irginia Journal of International Law*, Vol. 50, No. 3, p. 553–78.

337 Middleton, R. (2008), *Piracy in Somalia: Threatening Global Trade, Feeding Local Wars* (London: Chatham House), http://www.chathamhouse.orgsites/default/files/public/Research/Africa/1008piracysomalia.pdf.

338 Ibid., p. 5.

339 Liss, C. (2007), *The Roots of Piracy in Southeast Asia* (Melbourne: The Nautilus Institute), http://nautilus.org/apsnet/the-roots-of-piracy-in-southeast-asia; Russell, D. (2010), *Who Rules the Waves? Piracy, Overfishing and Mining the Ocean* (London and New York: Pluto Press).

340 For a specific discussion on the potential for conflict over transit pipelines, see Stevens, P. (2009), *Transit Troubles: Pipelines as a Source of Conflict* (London: Chatham House) http://www.chathamhouse.org/sites/default/files/public/Research/mEnergy,%20Environment%2and%20Development/r0309_pipelines.pdf.

341 The analysis in this section is built on the analysis in Andrews-Speed, P., Bleischwitz, R., Boersma, T., Johnson, C., Kemp, G. and VanDeveer, S.D. (2012), *The Global Resource Nexus – The Struggles for Land, Energy, Food, Water, and Minerals* (Washington, DC: Transatlantic Academy), www.transatlanticacademy.org/sites/default/files/publications/TA%202012%20report_web_version.pdf.

342 Howard, R. (2009), *The Arctic Gold Rush: The New Race for Tomorrow's Natural Resources* (London and New York: Continuum).

343 United Press International (2012), 'Sudans on brink of all-out war over oil', 3 May, www.upi.com/Business_News/Energy-Resources/2012/05/03/Sudans-on-brink-of-all-out-war-over-oil/UPI-16581336078729/#ixzz258ktJafr.

344 Raghavan, S. (2012), 'South Sudan civilians are trapped in conflict over oil', *Washington Post,* 1 May, www.washingtonpost.com/world/south-sudan-civilians-are-trapped-in-conflict-over-oil/2012/05/01/gIQAUX6buT_story.html.

345 Wolf, A.T. (1999), '"Water Wars" and Water Reality: Conflict and Cooperation Along International Waterways', pp. 251–65 in Lonergan, S. C. (ed), *Environmental Change, Adaptation, and Human Security*, (Dordrecht: Kluwer Academic).

346 Although as Michael Renner has pointed out, the treaty 'is about separating rather than sharing, water resources'. Renner, M. (2011), *Water and Energy Dynamics in the Greater Himalayan Region: Opportunities for Environmental Peacebuilding* (Oslo: Norwegian Peacebuilding Resource Centre), p. 5.

347 *The Economist* (2011), 'South Asia's Water: Unquenchable Thirst', 19 November, p. 25.

348 Mustafa, D. (2010), *Hydropolitics in Pakistan's Indus Basin* (Washington, DC: United States Institute of Peace).

349 Reuters (2012), 'Nigeria MEND Militants Claim Niger Delta Attack', Yenagoa, Nigeria, 2 March, www.reuters.com/article/2012/03/02/nigeria-militants-idUSL5E8E21GV20120302.

350 Davison W. (2012), 'SouthWest Energy of Ethiopia Optimistic on Oil Search in Ogaden', Bloomberg, 9 May, www.bloomberg.com/news/2012-05-09/southwest-energy-of-ethiopia-optimistic-on-oil-search-in-ogaden.html; Evans, A. (2012), *Resources, Risk and Resilience: Scarcity and Climate Change in Ethiopia* (New York: New York University Center on International Cooperation), p. 39.

351 As a 2012 analysis of fiscal break-even prices by economist Ali Aissaoui puts it, 'Those [countries] whose fiscal break even prices are higher than market price … would try and persuade the opposite side to lower the aggregate production ceiling and individual output quotas either pro rata or otherwise.' See Aissaoui, A. (2012), 'Fiscal Breakeven Prices Revisited: What More Could They Tell Us About OPEC Policy Intent?', *APICORP Research: Economic Commentary*, Vol. 7, No. 8–9, www.mees.com/en/articles/5660-fiscal-break-even-prices-revisited-what-more-could-they-tel-us-about-opec-policy-intent.

352 Wright, B. and Cafiero, C. (2010), *Grain Reserves and Food Security in MENA Countries* (Washington, DC: World Bank), http://siteresources.worldbank.org/DEC/Resources/84797-1288208580656/7508096-1288208619603/Wright_Grain_Reserves_and_Food_Security_in_MENA_Countries_PAPER.pdf.

353 Food and Agriculture Organization of the United Nations (FAO) (2012), *Asia Pacific Food Situation Update*, http://www.fao.org/docrep/015/an022e/an022e00.pdf.

354 Ericsson, M. (2010), *Global Mining Towards 2030: Food for Thought for the Finnish Mineral Policy Process 2010*, Geological Survey of Finland, Report of Investigation 187.

355 This calculation is based on 2011 prices for natural resources and a 10% discount rate. These savings could further increase significantly if water and carbon emissions were to be priced efficiently. See Dobbs et al. (2011), *Resource Revolution*, pp. 71–77.

356 World Business Council for Sustainable Development (2009), *Transforming the Market: Energy Efficiency in Buildings*, www.wbcsd.org/transformingthemarketeeb.aspx.

357 World Economic Forum (2012), *More with Less: Scaling Sustainable Consumption and Resource Efficiency*, http://www3.weforum.org/docs/IP/CO/WEF_CO_ScalingSustainableConsumptionResourceEfficiency_Report_2012.pdf.

358 Herring, H. and Sorell, S. (eds) (2009), *Energy Efficiency and Sustainable Consumption: The Rebound Effect* (Basingstoke: Palgrave Macmillan).

359 Ibid.

360 Sustainable Europe Research Institute and Wuppertal Institute for Climate (2010), *Resource Use and Resource Efficiency in Asia: A Pilot Study on Trends Over the Past 25 Years*, World Resources Forum, p. 27, www.worldresourcesforum.org/files/Resource%20efficiency%20in%20Asia_final_0.pdf.

361 United Nations Economic and Social Commission for Asia and the Pacific (2012), *Low Carbon Green Growth Roadmap for Asia and the Pacific: Turning Resource Constraints and the Climate Crisis into Economic Growth Opportunities*, p. 21, www.unescap.org/esd/publications/environment/lcgg-roadmap/Roadmap_FINAL_15_6_12.pdf.

362 China Council for International Cooperation on Environment and Development (CCICED) Task Force (2011), *China's Low Carbon Industrialisation Strategy: CCICED Task Force Report*, http://content. lib.sfu.ca/cdm/singleitem/collection/cciced/id/1306.

363 Ibid.

364 Grimes, S., Donaldson, J. and Gomez, G.C. (2008), *Report on the Environmental Benefits of Recycling* (Brussels: Bureau of International Recycling (BIR)), www.bir.org/assets/Documents/publications/brochures/BIR_CO2_report.pdf.

365 Gomez, F., Guzman, J.I. and Tilton, J.E. (2007), 'Copper Recycling and Scrap Availability', *Resources Policy*, Vol. 32, No. 4, pp. 183–90.

366 If production from re-melted scrap within manufacturing processes ('new scrap') is also counted in, recycling accounts for a third of total aluminium supply.

367 UNEP (2010), *Metal Stocks in Society: Scientific Synthesis*, www.unep.org/resourcepanel/Portals/24102/PDFs/Metalstocksinsociety.pdf.

368 Chatham House calculations based on data supplied by the International Aluminium Institute.

369 European Commission (2011), *Tackling the Challenges in Commodity Markets and on Raw Materials*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on 2 February, http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/communication_en.pdf.

370 China Council for International Cooperation on Environment and Development (CCICED) Task Force (2011), *China's Low Carbon Industrialisation Strategy: CCICED Task Force Report*, http://content.lib.sfu.ca/cdm/singleitem/collection/cciced/id/1306.

371 European Commission (2011), *Japan-EU Workshop on Substitution of Critical Raw Materials*, Final Report on Workshop held in Tokyo on 21–22 November, http://ec.europa.eu/research/industrial_technologies/pdf/japan-eu-workshop_en.pdf.

372 Hitachi (2012), 'Highly efficient industrial 11kW permanent magnet synchronous motor without rare-earth metals', www.hitachi.com/New/cnews/120411.html.

373 Frost and Sullivan (2012), 'Automotive Carbon Fiber Composites to Grow at a Staggering Growth Rate until 2017', http://www.frost.com/prod/servlet/press-release.pag?Src=RSS&docid=263051000.

374 Biswas, S., Mittal, A. and Srikanth, G. (2009), *Composites – The Future Building Material*, Technology Information, Forecasting and Assessment Council of India, www.tifac.org.in/index.php?option=com_content&view=article&id=542:composites-the-future-building-material&catid=85:publications&Itemid=952.

375 CCICED Task Force (2011), *China's Low Carbon Industrialisation Strategy*.

376 Chen, G.Y., Lee, M.W. and Wang, G.J. (2010), 'Fabrication of Dye-Sensitized Solar Cells with a 3D Nanostructured Electrode', *International Journal of Photoenergy*, Vol. 2010, Article ID 585621.

377 U.S. Department of Energy (DoE) (2010), *Critical Materials Strategy*, http://energy.gov/sites/prod/files/edg/news/documents/criticalmaterialsstrategy.pdf.

378 Kingsnorth, D.J. (2011), *Rare Earths: Reducing our Dependence on China*, (Mt Claremont, Western Australia: IMCOA), Tables 3 and 8.

379 US Department of Energy (DoE) (2010), *Critical Materials Strategy*, http://energy.gov/sites/prod/files/edg/news/documents/criticalmaterialsstrategy.pdf. Note that this problem is not limited to the energy sector. New types of information and communications (ICT) technologies, for example, also rely extensively on speciality metals. The rapid diffusion of technologies such as flat screens or smart phones has caused similar market disruptions, e.g. in the case of indium which is used in flat- and touch-screens.

380 Moss, R., Tzimas, E., Kara, H., Willis, P. and Kooroshy, J. (2011), *Critical Metals in Strategic Energy Technologies – Assessing Rare Metals as Supply-Chain Bottlenecks in Low-Carbon Energy Technologies* (Petten, the Netherlands: European Commission, Joint Research Centre (JRC)), http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/22726/1/reqno_jrc65592_critical%20metals%20in%20strategic%20energy%20technologies%20%28online%29.pdf.

381 Dobbs et al. (2011), *Resource Revolution*.

382 World Economic Forum (2012), *More with Less: Scaling Sustainable Consumption and Resource Efficiency*, http://www3.weforum.org/docs/IP/CO/WEF_CO_ScalingSustainableConsumptionResourceEfficiency_Report_2012.pdf.

383 OECD (2012), *Sustainable Materials Management*, OECD Green Growth Policy Brief, www.oecd.org/env/resourceproductivityandwaste/SMM%20synthesis%20-%20policy%20brief_final%20GG.pdf.

384 Ellen MacArthur Foundation (2011), *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*, http://www.thecirculareconomy.org/.

385 Gutowski, T.G., Sahni, S., Boustani, A. and Graves, S.C. (2011), 'Remanufacturing and Energy Savings', *Environmental Science and Technology*, Vol. 45, No. 10, pp. 4540–47.

386 Food and Agriculture Organization of the United Nations (FAO) (2010), *Global Forest Resources Assessment 2010: Main Report* (Rome: FAO), http://www.fao.org/docrep/013/i1757e/i1757e.pdf.

387 Ibid.

388 For more details, see www.illegal-logging.info.

389 FAO and United Nations Economic Commission for Europe (UNECE) (2010), *Forest Products Annual Market Review* 2009–2010, p. 115, http://timber.unece.org/fileadmin/DAM/publications/sp-25.pdf.

390 UK Timber Trade Federation (2010), *UK Timber Industry Certification*, www.cpet.org.uk/files/TimberTTFreport.pdf.

391 Probos (2010), 'Market share of certified wood more than doubles', www.probos.nl/home/bosbericht_bestanden/bosberichten2010-03E.pdf

392 FAO (2010), *Global Forest Resources Assessment 2010: Main Report*.

393 Cottier, T., Malumfashi, G., Matteotti-Berkutova, S., Nartova, O., de Sépibus, J. and Bigdeli, S.Z. (2010), 'Energy in WTO Law and Policy', *World Trade Report 2010*, WTO, www.wto.org/english/res_e/publications_e/wtr10_forum_e/wtr10_7may10_e.htm.

394 Selivanova, Y. (2010), 'Trade in Energy: Challenges for International Trade Regulation', *World Trade Report 2010*, WTO, www.wto.org/english/res_e/publications_e/wtr10_forum_e/wtr10_11june10_e.htm.

395 20 countries not named in the table also took restrictive measures. For details see Sharma, R. (2011), *Food Export Restrictions: Review of the 2007–2010 Experience and Considerations for Disciplining Restrictive Measures*, FAO Commodity and Trade Policy Research Working Paper No. 32, www.fao.org/fileadmin/templates/est/PUBLICATIONS/Comm_Working_Papers/EST-WP32.pdf.

396 FAO, IFAD and WFP (2011), *The State of Food Insecurity in the World*; UNEP, International Trade Centre (ITC) and International Centre for Trade and Sustainable Development (ICTSD) (2012), *Trade and Environment Briefings: Export Restrictions*, International Centre for Trade and Sustainable Development Policy Brief No. 2, http://ictsd.org/downloads/2012/06/export-restrictions1.pdf.

397 Association of Southeast Asian Nations (ASEAN) (2011), *Joint Press Statement of the Eleventh Meeting of the ASEAN Ministers on Agriculture and Forestry and the Ministers of Agriculture of the People's Republic of China, Japan and the Republic of Korea* (11th AMAF Plus Three), http://www.asean.org/news/asean-statement-communiques/item/joint-press-statement-of-the-eleventh-meeting-of-the-asean-ministers-on-agriculture-and-forestry-and-the-ministers-of-agriculture-of-the-people-s-republic-of-china-japan-and-the-republic-of-korea-11th-amaf-plus-three.

398 Bowen, B. and Gooday, P. (1993), *The Economics of Coal Export Controls*, Australian Bureau of Agricultural and Resource Economics Research Report 93.8, http://adl.brs.gov.au/data/warehouse/pe_abarebrs99000264/rr93.8_coal_exports.pdf.

399 Price, A. and Nance, S. (2010), 'Export Barriers and the Steel Industry', *The Economic Impact of Export Restrictions on Raw Materials* (Paris: OECD).

400 Price, A., Brightbill, T., Weld, C., Capito, C. and Morgan, R. (2008), *Raw Deal: How Governmental Trade Barriers and Subsidies Are Distorting*

Global Trade in Raw Materials, report prepared by Wiley Rein LLP for the American Scrap Coalition, http://legacy.steel.org/AM/Template.cfm?Section=Home&CONTENTID=26678&TEMPLATE=/CM/ContentDisplay.cfm.

401 Blore, S. and Smillie, I. (2011), *Taming the Resource Curse: Implementing the ICGLR Certification Mechanism for Conflict-prone Mineral*s (Ottawa: Partnership Africa Canada), www.pacweb.org/Documents/icglr/PAC_Report_on_ICGLR_RCM-03-2011-eng.pdf.

402 Fontanella-Khan, J. (2011), 'India lifts Karnataka iron ore export ban', *Financial Times,* 5 April, www.ft.com/cms/s/0/fd1b30f6-5f74-11e0-bd1b-00144feab49a.html#axzz251V2jFKD.

403 Platts (2012), 'Indonesia's nickel export restrictions to support prices: Citigroup', 31 May, www.platts.com/RSSFeedDetailedNews/RSSFeed/Metals/8347036.

404 ConceptBank (2012), 'Indonesia, Vietnam curb raw minerals exports', 19 June, http://concept-bank.com/?p=902.

405 BBC News (2012), 'US, EU and Japan challenge China on rare earths at WTO', 20 March, www.bbc.co.uk/news/business-17348648.

406 See summary of dispute at www.wto.org/english/tratop_e/dispu_e/cases_e/ds394_e.htm.

6. Building a New Politics of Resources

407 See, for example, WTO (2010), *World Trade Report 2010*, p. 163, www.wto.org/english/res_e/publications_e/wtr10_e.htm; Gilbert, C. (2011), *International Agreements for Commodity Price Stabilisation: An Assessment* (Paris: OECD), http://www.oecd-ilibrary.org/docserver/download/5kg0ps7ds0jl.pdf?expires=1355314445&id=id&accname=guest&checksum=F577824D7D523172E96F96A474401B25.

408 See IEA website: http://www.iea.org/publications/freepublications/publication/name,3714,en.html.

409 Chatham House and Grantham Institute (forthcoming), *The Reform Of Global Energy Governance* (London: Chatham House).

410 See, for example, Wright, B. (2009), *International Grain Reserves: And Other Instruments to Address Volatility in Grain Markets*, Policy Research Working Paper 5028 (Washington, DC: World Bank)http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2009/08/25/000158349_20090825154655/Rendered/PDF/WPS5028.pdf.

411 Von Braun, J. et al. (2009), *Implementing Physical and Virtual Food Reserves to Protect the Poor and Prevent Market Failure*, Policy Brief 10, International Food Policy Research Institute (IFPRI), www.ifpri.org/sites/default/files/publications/bp010.pdf.

412 Wright (2009), *International Grain Reserves.*

413 Wright, B. (2011), 'Addressing the Biofuels Problem: Food Security Options for Agricultural Feedstocks', in Prakash, A. (ed.) *Safeguarding Food Security in Volatile Global Markets* (Rome: FAO), pp. 481–92.

414 Bailey, R. (forthcoming), 'The Food Versus Fuel Nexus', in Andreas Goldthau (ed.), *The Handbook of Global Energy Policy* (Weinheim: Wiley-VCH).

415 Schuemer-Cross, T. and Taylor, B.H. (2009), *The Right to Survive: The Humanitarian Challenge for the Twenty-first Century*, Oxfam International, www.oxfam.org/sites/www.oxfam.org/files/right-to-survive-report.pdf.

416 Bailey, R. (2012), *Famine Early Warning and Early Action: The Cost of Delay* (London: Chatham House).

417 Ibid.

418 Sida, L., Gray, B. and Asmare, E. (2012), *IASC Real-Time Evaluation of the Humanitarian Response to the Horn of Africa Drought Crisis: Ethiopia*, http://ochanet.unocha.org/p/Documents/IASC%20RTE%20Ethiopia%202012.pdf.

419 See, for example, Global Humanitarian Assistance (GHA) (2012), *GHA Report 2012*, Global Humanitarian Assistance, www.globalhumanitarianassistance.org/wp-content/uploads/2012/07/GHA_Report_2012-Websingle.pdf; IPCC (2012), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaption* (Cambridge University Press), www.ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf; and *The Economist* (2012), 'Natural disasters', 31 May, www.economist.com/node/21551513.

420 Venton, C. (2007), 'Justifying the Cost of Disaster Risk Reduction: A Summary of Cost-benefit Analysis', *Humanitarian Exchange Magazine*, No. 38, www.odihpn.org/humanitarian-exchange-magazine/issue-38/justifying-the-cost-of-disaster-risk-reduction-a-summary-of-cost%E2%80%93benefit-analysis.

421 Venton, C. (2012), 'The Economics of Resilience: Evidence from Kenya and Ethiopia', presentation, 28 May 2012, http://typo3.fao.org/fileadmin/user_upload/drought/docs/Economics%20of%20Resilience-Evidence%20from%20Kenya%20&%20Ethiopia%20%2819%20July%202012%29.pdf.

422 Kellet, J. and Sparks, D. (2012), *Disaster Risk Reduction: Spending Where it Should Count*, Global Humanitarian Assistance Briefing Paper, www.globalhumanitarianassistance.org/wp-content/uploads/2012/03/GHA-Disaster-Risk-Report.pdf.

423 United Nations International Strategy for Disaster Reduction (UNISDR) (2011), *Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disaster, Mid-Term Review* (Geneva: UNISDR), www.unisdr.org/we/inform/publications/18197.

424 Oxley, M. (2009), 'Building Climate Resilience – Experiences from Disaster Risk Reduction', presentation, 3 December, http://community.eldis.org/?233@@.59cdc968/7!enclosure=.59cf7098&ad=1.

425 OECD Development Assistance Committee (DAC) (2012), 'OECD DAC statistics on climate-related aid', www.oecd.org/dac/aidstatistics/FactsheetRio.pdf.

426 United Nations Conference on Sustainable Development (UNCSD) (2012), 'The Future We Want', www.un.org/en/sustainablefuture/.

427 Bleischwitz, R., Bahn-Walkowiak, B., Ekardt, F. Feldt and H. Fuhr, L. (2012), 'International Resource Politics: New Challenges Demanding New Governance Approaches for a Green Economy', Publication series on ecology, Vol. 26 (Berlin: Heinrich-Böll-Stiftung and Wuppertal Institute), www.boell.de/downloads/2012-06-International-Resource-Politics.pdf.

428 See Overseas Development Institute (ODI), German Development Institute (DIE), and European Centre for Development Policy Management (ECDPM) (2012), *Confronting Scarcity: Managing Water, Energy and Land for Inclusive and Sustainable Growth*, European Report on Development, http://erd-report.eu/erd/report_2011/documents/erd_report%202011_en_lowdef.pdf.

429 Ibid.

430 Dobbs et al., *Resource Revolution.*

431 See, for example, OECD (2011), *Tools for Delivering Green Growth,* Report prepared for the OECD Meeting of the Council at Ministerial Level, 25–26 May, Paris, www.oecd.org/greengrowth/48012326.pdf.

432 The 'Exemplary role' of the public sector is a concept embedded in the EC Directive on energy end-use efficiency and energy services (Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006).

433 Van Otterdijk, R. and Meybeck, A. (2011), *Global Food Losses and Food Waste* (Rome: FAO), www.fao.org/docrep/014/mb060e/mb060e00.pdf.

434 Brynjolfsson, E., Hitt, L.M. and Kim, H.H. (2011), 'Strength in Numbers: How Does Data-Driven Decisionmaking Affect Firm Performance?', *Social Science Electronic Publishing*, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1819486.

435 Botsman, R. and Rogers, R. (2010), *What's Mine is Yours: The Rise of Collaborative Consumption* (New York: Harper Collins).

436 Schmidhuber, S., Bruinsma, J., Boedeker, G. (2009), Capital Requirements for Agriculture in Developing Countries to 2050 (Rome: FAO); Motes, W.C. (2011), *Global Food and Agriculture Productivity Review: The Investment Challenge*, Global Harvest Initiative, www.globalharvestinitiative.org/wp-content/uploads/2012/08/Motes-The-Investment-Gap-Jan-31-2011.pdf.

437 BBC News (2010), 'China resumes exports to Japan', 24 November, www.bbc.co.uk/news/business-11826870.

438 The share of producers in supply can be calculated from USGS (2012), *Mineral Yearbook and USGS Commodity Summaries* (various editions), http://minerals.usgs.gov/minerals/pubs/commodity/myb/.

439 Global Trade Alert database and Evenett, S.J. (ed.) (2012), *Débâcle: The 11th GTA Report on Protectionism* (London: Centre for Economic Policy Research (CEPR)), www.globaltradealert.org/11th_GTA_report.

440 G20 (2008), *Declaration of the Summit on Financial Markets and the World Economy*, http://www.g20.utoronto.ca/2008/2008declaration1115.html.

441 Lamy, P. (2012), 'Speech of the Director-General of the World Trade Organization to the Thai Chamber of Commerce', 30 May, Bangkok, www.wto.org/english/news_e/sppl_e/sppl232_e.htm.

442 Global Trade Alert database and Evenett (ed.) (2012), *Débâcle*.

443 WTO (2010), *World Trade Report 2010*, www.wto.org/english/res_e/publications_e/wtr10_e.htm.

7. Conclusions

444 Booth, K. and Wheeler, N.J. (2008), *The Security Dilemma: Fear, Cooperation and Trust in World Politics* (Basingstoke: Palgrave Macmillan).

445 Klare, M.T. (2012), *The Race for What's Left: The Global Scramble for the World's Last Resources* (New York: Metropolitan Books), pp. 166–67.

446 Moran, D. and Russell, J.A. (2008), 'The Militarization of Energy Security', *Strategic Insights*, Vol. 7, No. 1.

447 Liskaa, A.J. and Perrin, R.K. (2010), 'Securing Foreign Oil: A Case for Including Military Operations in the Climate Change Impact of Fuels', *Environment: Science and Policy for Sustainable Development*, Vol. 52, No. 4, pp. 9–22.

448 Pelusoa, N.L. and Vandergeest, P. (2011), 'Political Ecologies of War and Forests: Counterinsurgencies and the Making of National Natures', *Annals of the Association of American Geographers*, Vol. 101, No. 3, pp. 587–608.

449 See, for example, LeVine, S. (2012), 'Meet the Winners and Losers of the Coming Age of Plenty', *Foreign Policy*, 18 July; Mackenzie, A. (2011), 'Mineral Deposits and their Global Strategic Supply', presentation on behalf of BHP Billiton to The Geological Society Shell London Lecture Series, 14 December, http://www.bhpbilliton.com/home/investors/reports/Documents/2011/111214_A%20Mackenzie%20Geological%20Society%20of%20London%20Presentation.pdf.

450 Bailey, R. (2012), 'Are We Facing Another Global Food Price Crisis?', Chatham House Expert Comment, 26 July 2012, www.chathamhouse.org/media/comment/view/185017.

Annex 1: The Chatham House Resource Trade Database

451 This is compiled by the United Nations Statistics Division (UNSD). See http://comtrade.un.org/.

452 See www.cepii.fr/anglaisgraph/bdd/baci.htm.

453 UN (2010), 'Harmonized Commodity Description and Coding Systems (HS)'. UN statistics website, available: http://unstats.un.org/unsd/tradekb/Knowledgebase/Harmonized-Commodity-Description-and-Coding-Systems-HS.

454 The HS nomenclature is revised at regular intervals to account for the changing nature of global trade. The database relies on the 1996 version of HS codes, which is the revision used by the BACI database.

455 The full classification of HS codes developed for the database is available from the authors on request.

456 See UN Comtrade (no date), 'Read Me First (Disclaimer): Every User of UN Comtrade should know the coverage and limitations of the data'. Available: http://comtrade.un.org/db/help/uReadMeFirst.aspx.

Annex 6: Emerging Consumer and Producer Countries

457 United States Department of Agriculture (USDA), Foreign Agricultural Service (FAS) (2010), *Cambodia: Future Growth Rate of Rice Production Uncertain*, Commodity Intelligence Report, 26 January, http://www.pecad.fas.usda.gov/highlights/2010/01/cambodia/.

458 Redo, D., T. Aide, M. Clark, and Andrade-Núñez, M. (2012), 'The Impact of Internal and External Policies on Land Change in Uruguay, 2001 to 2009', *Environmental Conservation*, Vol. 39, pp. 122–31.

459 Government of India Planning Commission (2011), *Report of Sub-Group-II on Metals and Minerals – Strategy Based upon the Demand and Supply for Mineral Sector*, p. 8, http://mines.gov.in/new/subgroup2.pdf.

460 Reuters (2012), 'Guinea launches production at its first iron mine', 11 June, www.reuters.com/article/2012/06/11/iron-guinea-idUSL5E8HB8CK20120611.

461 Iron Ore Team (2011), 'Brazilian iron ore output to double by 2015', 23 August, http://www.ironoreteam.com/brazilian-iron-ore-output-double-2015.

462 Payvand Iran News (2011), 'Iran's copper output will increase 3.5-fold: official', 20 November, http://www.payvand.com/news/11/nov/1204.html.

463 Hill, M. (2012), 'Colombia coal production to reach 120Mt in 2014, says Minister', *Mining Weekly,* 5 March, www.miningweekly.com/article/colombia-coal-production-to-reach-120mt-in-2014-says-minister-2012-03-05.

464 Thanhniennews (2012), 'Vietnam 2015 coal output to rise to 55–58 mln tons: gov't', Talkvietnam, 18 August, http://talkvietnam.com/2012/08/vietnam-2015-coal-output-to-rise-to-55-58-mln-tons-govt/.

465 AllAfrica (2011), 'Mozambique: coal production to reach 100 million tonnes by 2020', 15 December, http://allafrica.com/stories/201112160171.html; *African Economic Outlook* (2012), 'Mozambique', 22 June, www.africaneconomicoutlook.org/en/countries/southern-africa/mozambique/.

Annex 8: Selection of the Proposed R30 Countries

466 The latest FAO statistics on the consumption of agricultural commodities are from 2009, and consumption shares are calculated on the basis of these numbers.

Annex 10: Measuring Price Volatility in Commodity Prices

467 A good review of the recent literature on the subject can be found in Calvo-Gonzales, O., Shankar, R. and Trezzi, R. (2010), 'Are Commodity Prices More Volatile Now? A Long-run Perspective', Policy Research Working Paper Series 5460, The World Bank, http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-5460/.

468 See e.g. Arezki, R., Lederman, D., Zhao, H. (2011), 'The relative volatility of commodity prices: A reappraisal', IMF Working Paper WP/11/279, http://www.imf.org/external/pubs/ft/wp/2011/wp11279.pdf; Gilbert, C. (2006) 'Trends and Volatility in Agricultural Commodity Prices', in Sarris, A. and Hallam, D. (eds.), *Agricultural Commodity Markets and Trade: New Approaches to Analyzing Market Structure and Instability* (Cheltenham: FAO and Edward Elgar); Jacks, D., O'Rourke, K., Williamson J. (2009), 'Commodity Price Volatility and World Market Integration since 1700', *The Review of Economics and Statistics*, Vol. 93, No. 3, pp. 800–13, http://www.sfu.ca/~djacks/papers/publications/JOW.pdf.

469 It is important to note that focusing on aggregate indices is likely to understate actual commodity price volatility because daily price movements are summarized in monthly averages. Also these indices conceal differences in the underlying volatility between different types of resources and in different regional markets. The IMF's fossil fuel price index, for example, contains both (much more volatile) crude prices on international exchanges and (considerably less volatile) coal prices that are mostly determined through benchmark pricing systems.

470 Cashin, P., Dermott, C. (2002), 'The Long-Run Behavior of Commodity Prices: Small Trends and Big Variability', IMF Staff Papers, Vol. 49, No. 2, pp. 175–99, http://www.imf.org/External/Pubs/FT/staffp/2002/02/pdf/cashin.pdf; For a critical view on relying on standard deviations, see Moledina, A., Roe, T., Shane, M. (2004), 'Measuring Commodity Price Volatility and the Welfare Consequences of Eliminating Volatility', American Agricultural Economics Association, Annual meeting, 1–4 August, Denver, http://EconPapers.repec.org/RePEc:ags:aaea04:19963.

471 We also measure standard deviations of the percentage growth rates ($\ln(p_t/p_{t-1})$, where pt is equal to the value of the price index in period t), a measure that is frequently used in the literature. The results do not differ materially from the results of the analysis using relative standard deviations and are therefore not discussed in further detail here.

Bibliography

2030 Water Resources Group (2009), 'Charting Our Water Future: Economic Frameworks to Inform Decision-making', The Barilla Group, The Coca-Cola Company, The International Finance Corporation, McKinsey & Company, Nestlé S.A., New Holland Agriculture, SABMiller plc, Standard Chartered Bank, and Syngenta AG, http://www.mckinsey.com/Client_Service/Sustainability/Latest_thinking/Charting_our_water_future.

Advisory Group on Climate Change Financing (2010), *Report of the Secretary-General's High-Level Advisory Group on Climate Change Financing* (New York: UN), http://www.un.org/wcm/webdav/site/climatechange/shared/Documents/AGF_reports/AGF%20Report.pdf.

Afghanistan Research and Evaluation Unit (2012), *The A to Z Guide to Afghan Assistance* (Kabul: Afghanistan Research and Evaluation Unit).

African Development Bank Group (2009), *Soaring Food Prices and Africa's Vulnerability and Responses: an Update*, African Development Bank Working Series, http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/WORKING%2097.pdf.

African Economic Outlook (2012), 'Mozambique', 22 June, www.africaneconomicoutlook.org/en/countries/southern-africa/mozambique/.

Ahmed, M., Salayo, N.D., Viswanathan, K.K., Garces, L.R. and Pido, M.D. (2006), *Management of Fishing Capacity and Resource Use Conflicts in Southeast Asia: A Policy Brief* (Penang: WorldFish Center Malaysia).

Aissaoui, A. (2012), 'Fiscal Breakeven Prices Revisited: What More Could They Tell Us About OPEC Policy Intent?', *APICORP Research: Economic Commentary*, Vol. 7, No. 8–9, http://www.mees.com/en/articles/5660-fiscal-break-even-prices-revisited-what-more-could-they-tel-us-about-opec-policy-intent.

Akhmouch, A. (2012), *Synthesis Report for the Condition for Success 1: Good Governance*, OECD Water Governance Programme, http://www.oecd.org/gov/regionaldevelopment/49827425.pdf.

AllAfrica (2011), 'Mozambique: Coal Production to Reach 100 Million Tonnes By 2020', 15 December, http://allafrica.com/stories/201112160171.html.

Alyousef, Y. and Stevens, P. (2011), 'The cost of domestic energy prices to Saudi Arabia', *Energy Policy*, Vol. 31, No. 11, pp. 6900–6905.

Andrews-Speed, P., Bleischwitz, R., Boersma, T., Johnson, C., Kemp, G. and VanDeveer, S. (2012), *The Global Resource Nexus: The Struggles for Land, Energy, Food, Water, and Minerals* (Washington, DC: German Marshall Fund).

Anseeuw, W., Alden Wily, L., Cotula, L. and Taylor, M. (2012), *Land Right and the Rush for Land: Findings of the Global Commercial Pressures on Land Research Project*, International Land Coalition, http://www.landcoalition.org/sites/default/files/publication/1205/ILC%20GSR%20report_ENG.pdf.

Antofagasta Plc (2012), 'Copper Industry', presentation at the Santander 16th Annual Latin American Conference, January, Cancún, www.antofagasta.co.uk/pdf/presentations/Aplc201101_Santander%20Conference_Final.pdf.

Arezki, R., Lederman, D., Zhao, H. (2011), 'The relative volatility of commodity prices: A reappraisal', IMF Working Paper WP/11/279, http://www.imf.org/external/pubs/ft/wp/2011/wp11279.pdf.

Association of Southeast Asian Nations (ASEAN) (2011), *Joint Press Statement of the Eleventh Meeting of the ASEAN Ministers on Agriculture and Forestry and the Ministers of Agriculture of the People's Republic of China, Japan and the Republic of Korea* (11th AMAF Plus Three), http://www.asean.org/news/asean-statement-communiques/item/joint-press-statement-of-the-eleventh-meeting-of-the-asean-ministers-on-agriculture-and-forestry-and-the-ministers-of-agriculture-of-the-people-s-republic-of-china-japan-and-the-republic-of-korea-11th-amaf-plus-three.

Audretsch, D. B., Keilbach, M., and Lehmann, E. (2006), *Entrepreneurship and Economic Growth* (New York: Oxford University Press).

Azam, S. and Q. Li (2010), 'Tailings Dam Failures: A Review of the Last One Hundred Years', *Geotechnical News*, Vol. 28, No. 4, pp. 50–53.

Bacchus, J. (2012), 'World Trade Rules Need an Exemption For Green Energy', *International Business Times*, 2 November, http://www.ibtimes.com/world-trade-rules-need-exemption-green-energy-858228.

Bailey, R. (2012), 'Are We Facing Another Global Food Price Crisis?', Chatham House Expert Comment, 26 July 2012, http://www.chathamhouse.org/media/comment/view/185017.

Bailey, R. (2012), *Famine Early Warning and Early Action: The Cost of Delay* (London: Chatham House).

Bailey, R. (forthcoming), 'The Food Versus Fuel Nexus', in Andreas Goldthau (ed.), *The Handbook of Global Energy Policy* (London: Wiley-Blackwell).

Bailis, R., Chatellier, J.L. and Ghilardi, A. (2012), 'Ecological Sustainability of Woodfuel as an Energy Source in Rural Communities', Chapter 18 of Ingram J.C, DeClerck., F and Rumbaitis del Rio, C. (2012), *Integrating Ecology and Poverty Reduction: Ecological Dimensions* (New York: Springer Publishing).

Barboza, D. (2010), 'Rio Tinto Executive Admits to Taking Two Bribes', *New York Times*, 26 March, http://www.nytimes.com/2010/03/27/world/asia/27riotinto.html.

Bazilian, M. and Onyeji, I. (2012), 'Fossil fuel subsidy removal and inadequate public power supply: Implications for Businesses', *Energy Policy*, Vol. 45, pp. 1–5.

Bazilian, M., Onyeji, I. et al. (2012), *Re-considering the Economics of Photovoltaic Power*¸ Bloomberg New Energy Finance White Paper, www.bnef.com/WhitePapers/download/82.

BBC News (2010), 'China resumes exports to Japan', 24 November, http://www.bbc.co.uk/news/business-11826870.

BBC News (2012), 'U.S., EU and Japan challenge China on rare earths at WTO', 20 March, http://www.bbc.co.uk/news/business-17348648.

BBC News (2012), 'South Africa's Lonmin Marikana mine clashes killed 34', 17 August, www.bbc.co.uk/news/world-africa-19292909.

BBC News (2012), 'Food prices jump will hit poor, World Bank warns', 30 August, http://www.bbc.co.uk/news/world-19431890.

Beeson, M., Soko, M. and Yong, W. (2011), 'The new resource politics: can Australia and South Africa accommodate China?', *International Affairs*, Vol. 87, No. 6, pp. 1365–1384.

Bellarby, J., Foereid, B., Hastings, A. and Smith, P. (2008), 'Cool Farming: Climate impacts of agriculture and mitigation potential', http://www.greenpeace.org/international/en/publications/reports/cool-farming-full-report/.

Beltran, J.M. and Koo-Oshima S. (eds) (2006), 'Water Desalination for Agricultural Applications', Proceedings of the Food and Agriculture Organization Expert Consultation on Water Desalination for Agricultural Applications on 26–27 April 2004, Rome, ftp://ftp.fao.org/agl/aglw/docs/lwdp5_e.pdf.

BHP Billiton (2011), 'Steelmaking materials briefing', presentation by Marcus Randolph, 30 September, http://www.bhpbilliton.com/home/investors/reports/documents/110930%20steelmaking%20materials%20briefing_combined.pdf.

Biswas, S., Mittal, A. and Srikanth, G. (2009), *Composites – The Future Building Material*, Technology Information, Forecasting and Assessment Council of India, http://www.tifac.org.in/index.php?option=com_content&view=article&id=542:composites-the-future-building-material&catid=85:publications&Itemid=952.

Blas, J. (2012) 'China buyers defer raw material cargos', *Financial Times*, 20 May, http://www.ft.com/cms/s/0/a1f5ddda-a26b-11e1-a605-00144feabdc0.html#axzz24wdVnrhu.

Blas, J. (2012), 'Chinese defaults prompt mystery', *Financial Times*, 28 May, http://www.ft.com/cms/s/0/c7a61f2c-a8a1-11e1-be59-00144feabdc0.html#axzz251V2jFKD.

Bleischwitz, R., Bahn-Walkowiak, B., Ekardt, F. Feldt and H. Fuhr, L. (2012), 'International Resource Politics: New challenges demanding new governance approaches for a green economy', Publication series on ecology, Vol. 26 (Berlin: Heinrich-Böll-Stiftung and Wuppertal Institute), www.boell.de/downloads/2012-06-International-Resource-Politics.pdf.

Bloomberg (2011), 'Amazon Deforestation Jumped Sixfold on Expanded Soy Planting, Brazil Says', 18 May, http://www.bloomberg.com/news/2011-05-18/amazon-deforestation-jumped-sixfold-on-expanded-soy-planting-brazil-says.html.

Bloomberg (2012), 'Baltic Dry Index', http://www.bloomberg.com/quote/BDIY:IND/chart/.

Bloomberg New Energy Finance (2011), 'Onshore wind energy to reach parity with fossil-fuel electricity by 2016', http://bnef.com/PressReleases/view/172.

Bloomberg New Energy Finance (2012), 'Investment, infrastructure & innovation for green growth', presentation at the OECD by Michael Liebreich, Chief Executive Officer, www.bnef.com/free-publications/presentations/.

Bloomberg New Energy Finance (2012), *Water Research Note: Thirsty coal dries up China's water supplies*, https://www.dropbox.com/s/464jwiabfvn7w6e/bnef_rn_water_and_coal_china_2012_02_08.pdf.

Blore, S. and Smillie, I. (2011), *Taming the Resource Curse: Implementing the ICGLR Certification Mechanism for*

Conflict-prone Minerals (Ottawa: Partnership Africa Canada), http://www.pacweb.org/Documents/icglr/PAC_Report_on_ICGLR_RCM-03-2011-eng.pdf.

Booth, K. and Wheeler, N.J. (2008), *The Security Dilemma: Fear, Cooperation and Trust in World Politics* (Basingstoke: Palgrave Macmillan).

Botsman, R. and Rogers, R. (2010), *What's Mine is Yours: The Rise of Collaborative Consumption* (New York: Harper Collins).

Bowen, B. and Gooday, P. (1993), *The Economics of Coal Export Controls*, Australian Bureau of Agricultural and Resource Economics Research Report 93.8, http://adl.brs.gov.au/data/warehouse/pe_abarebrs99000264/rr93.8_coal_exports.pdf.

Bowlus, J. (2012), *How Verbal Threats to Close Oil Transit Chokepoints Lead to Military Conflict*, Policy Brief No. 29, Global Political Trends Center, Istanbul Kültür University, http://www.isn.ch/isn/Digital-Library/Publications/Detail/?ots591=0c54e3b3-1e9c-be1e-2c24-a6a8c7060233&lng=en&ord582=grp1&id=136459.

Bremmer, I. and Johnston, R. (2008), 'The Rise and Fall of Resource Nationalism', *Survival: Global Politics and Strategy*, Vol. 51, No. 2, pp. 149–158.

British Petroleum (BP) (2011), *Statistical Review of World Energy*, June, http://www.bp.com/assets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2011/STAGING/local_assets/pdf/statistical_review_of_world_energy_full_report_2011.pdf.

British Petroleum (BP) (2012), *BP Energy Outlook 2030*, January, http://www.bp.com/liveassets/bp_internet/globalbp/STAGING/global_assets/downloads/O/2012_2030_energy_outlook_booklet.pdf.

Broderick, M. and Hendel-Blackford, S. (2007), 'All change: Adapting to consequences of climate change', *Mining Environmental Management*, pp. 28–29.

Brynjolfsson, E., Hitt, L.M. and Kim, H.H. (2011), 'Strength in Numbers: How Does Data-Driven Decisionmaking Affect Firm Performance?', *Social Science Electronic Publishing*, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1819486.

Buijs, B. and Sievers, H. (2011), 'Critical Thinking about Critical Minerals: Assessing risks related to resource security', CIEP Briefing Paper, November, http://www.clingendael.nl/publications/2011/20111111_ciep_bgr_briefingpaper_buijs_sievers_critical_thinking_about_critical_minerals.pdf.

Cabitza, M. (2012), 'Peru mine disputes mar President Humala's first year', *BBC News*, 28 July, http://www.bbc.co.uk/news/world-latin-america-18980109.

Cai, P. (2012), 'China business fights political backlash', *Sydney Morning Herald*, 13 August, http://www.smh.com.au/business/china-business-fights-political-backlash-20120812-242ry.html.

Call, C.T. (2010), 'Liberia's War Recurrence: Grievance over Greed', *Civil Wars*, Vol. 12, No. 4, pp. 347–369.

Calvo-Gonzales, O., R. Shankar and R. Trezzi (2010), 'Are commodity prices more volatile now? A long-run perspective', Policy Research Working Paper Series 5460, The World Bank, http://elibrary.worldbank.org/content/workingpaper/10.1596/1813-9450-5460/.

Campbell, K.M. et al. (2007), *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change* (Washington, DC: CSIS and CNAS).

Cashin, P., Dermott, C. (2002), 'The Long-Run Behavior of Commodity Prices: Small Trends and Big Variability', IMF Staff Papers, Vol. 49, No. 2, pp. 175–199, http://www.imf.org/External/Pubs/FT/staffp/2002/02/pdf/cashin.pdf.

Chatham House and Grantham Institute (forthcoming), *The Reform of Global Energy Governance* (London: Chatham House).

Chazan, G. (2012), 'Opec's price hawks press Saudi on output', *Financial Times*, 12 June, http://www.ft.com/cms/s/0/c2d19494-b496-11e1-bb2e-00144feabdc0.html#axzz20Of1dcs0.

Chazan, G. (2012), 'Saudi Arabia: Kingdom's power broker role at risk', *Financial Times*, 28 March, http://www.ft.com/cms/s/0/d50b7efa-6e9a-11e1-a82d-00144feab49a.html#axzz2B3rJSQ00.

Chen, G.Y., Lee, M.W. and Wang, G.J. (2010), 'Fabrication of Dye-Sensitized Solar Cells with a 3D Nanostructured Electrode', *International Journal of Photoenergy*, Vol. 2010.

Cheung, W.W.L., Lam, V.W.Y., Sarmiento, J. L., et al. (2010), 'Large-scale redistribution of maximum fisheries catch potential in the global ocean under climate change', *Global Change Biology*, Vol. 16, No. 1, pp. 24–35.

Cheung, Y.-W., de Haan, J., Qian, X. and Yu, S. (2012), 'China's Outward Direct Investment in Africa', *Review of International Economics*, Vol. 20, No. 2, pp. 201–220.

China Council for International Cooperation on Environment and Development (CCICED) Task Force (2011), *China's Low Carbon Industrialisation Strategy: CCICED Task Force Report*, http://content.lib.sfu.ca/cdm/singleitem/collection/cciced/id/1306.

Ching-Yan W., Mathews, J.A. (2012), 'Knowledge flows in the solar photovoltaic industry: Insights from patenting by Taiwan, Korea, and China', *Research Policy*, Vol. 41, No. 3, pp. 524–540.

Circle of Blue (2012), 'Protests Break Out After India's Supreme Court Rules in Favor of Downstream State in Cauvery River Dispute', www.circleofblue.org/waternews/2012/world/protests-break-out-after-indias-supreme-court-rules-in-favor-of-downstream-state-in-cauvery-river-dispute/.

Citi (2011), Sainsbury, C., Wilkins, C., Haddad, D., Seeney, D. et al., *Generation Next: A Look at Future Greenfield Growth Projects*.

Clay, J. (2004), *World Agriculture and the Environment: A Commodity-by-Commodity Guide to Impacts And Practices* (Washington, DC: Island Press), http://wwf.panda.org/what_we_do/footprint/agriculture/beef/environmental_impacts/habitat_conversion/.

Cline, W.R. (2007), *Global Warming and Agriculture: Impact Estimates by Country*, Center for Global Development (Washington, DC: Center for Global Development).

CNA (2007), National Security and the Threat of Climate Change, www.cna.org/sites/default/files/National%20Security%20and%20the%20Threat%20of%20Climate%20Change%20-%20Print.pdf.

Cochrane, K., De Young, C., Soto, D. and Bahri, T. (2009), *Climate change implications for fisheries and aquaculture: Overview of current scientific knowledge* (Rome: FAO).

ConceptBank (2012), 'Indonesia, Vietnam curb raw minerals exports', 19 June, http://concept-bank.com/?p=902.

Conway, D. and Schipper, E.L. (2011), 'Adaptation to climate change in Africa: Challenges and opportunities identified from Ethiopia', *Global Environmental Change*, Vol. 21, No. 1, pp. 227–237.

Conway, G. (2012), *One Billion Hungry: Can we feed the world?* (Ithaca: Cornell University Press).

Cottier, T., Malumfashi, G., Matteotti-Berkutova, S., Nartova, O., de Sépibus, J. and Bigdeli, S.Z. (2010), 'Energy in WTO law and policy', *World Trade Report 2010*, World Trade Organisation (WTO), http://www.wto.org/english/res_e/publications_e/wtr10_forum_e/wtr10_7may10_e.htm.

Davison, W. (2012), 'SouthWest Energy of Ethiopia Optimistic on Oil Search in Ogaden', *Bloomberg*, 9 May, http://www.bloomberg.com/news/2012-05-09/southwest-energy-of-ethiopia-optimistic-on-oil-search-in-ogaden.html.

Deininger, K. and Byerlee, D. (2010), *Rising Global Interest in Farmland: Can it Yield Sustainable and Equitable Benefits?* (Washington, DC: The World Bank), http://siteresources.worldbank.org/INTARD/Resources/ESW_Sept7_final_final.pdf.

De la Tour, A., Glachant, M., Meniere, Y. (2010), 'Innovation and international technology transfer: The case of the Chinese photovoltaic industry', *Energy Policy*, Vol. 39, No. 2, pp. 761–770.

Delgado, C.L., Wada, N., Rosegrant, M.W., Meijer, S. and Ahmed, M. (2003), *Fish to 2020: Supply and Demand in Changing Global Markets* (Washington, DC and Penang: International Food Policy Research Institute and Worldfish Center), http://www.ifpri.org/sites/default/files/pubs/pubs/books/fish2020/oc44.pdf.

Deloitte and U.S. Council on Competitiveness (2010), *Global Manufacturing Competitiveness Index*, http://www.deloitte.com/assets/Dcom-Global/Local%20Assets/Documents/Manufacturing/DTT_Global_Manufacturing_Competiveness_Index_6_23_2010.pdf.

De Stefano, L. et al. (2010), *Mapping the Resilience of International River Basins to Future Climate Change-Induced Water Variability*, The World Bank Water Sector Board Discussion Paper Series, http://www.transboundarywaters.orst.edu/publications/publications/De%20Stefano%20et%20al%202010.pdf.

Development, Concepts and Doctrine Centre (DCDC) (2010), *Strategic Trends Programme: Global Strategic Trends – Out to 2040* (4th edition) (Shrivenham: UK Ministry of Defence), http://www.mod.uk/NR/rdonlyres/6AAFA4FA-C1D3-4343-B46F-05EE80314382/0/GST4_v9_Feb10.pdf.

Dittrich, M., Giljum, S., Lutter, S. and Polzin, C. (2012), *Green Economies Around the World? Implications of Resource Use for Development and the Environment* (Vienna: Sustainable Europe Research Institute (SERI)).

Dobbs, R., Oppenheim, J., Thompson, F., Brinkman, M., and Zornes, M. (2011), *Resource Revolution: Meeting the World's Energy, Materials, Food and Water Needs*, McKinsey Global Institute, http://www.mckinsey.com/insights/mgi/research/natural_resources/resource_revolution.

Dupont, A. (2008), 'The Strategic Implications of Climate Change', *Survival*, Vol. 50, No. 3, pp. 29–54.

Dyer, G., Anderlini, J. and Sender, H. (2011), 'China's lending hits new heights', *Financial Times*, 17 January, http://www.ft.com/cms/s/0/488c60f4-2281-11e0-b6a2-00144feab49a.html#axzz1xUXVk3hF.

E3G (2011), Mabey, N. et al., *Degrees of Risk: Defining a Risk Management Framework for Climate Security* (London and Washington, DC: E3G), http://

www.e3g.org/images/uploads/Degrees%20of%20Risk_Defining%20a%20Risk%20Management%20Framework%20for%20Climate%20Security_Full%20Report.pdf.

Earth Policy Institute. 'Annual Solar Photovoltaics Production by Country, 1995–2010'. Available: http://www.earth-policy.org/data_center/C23.

Economic Times (2012), 'India's steel import may touch 50 mn tonnes by 2020', 13 April, http://articles.economictimes.indiatimes.com/2012-04-13/news/31337560_1_steel-production-steel-imports-million-tonnes.

Economic Times (2012), 'India's coal imports projected at 185 MT by 2017', 16 July, http://articles.economictimes.indiatimes.com/2012-07-16/news/32698225_1_production-target-coal-imports-coal-india.

Economist (2011), 'South Asia's Water: Unquenchable Thirst', 19 November, http://www.economist.com/node/21538687.

Economist (2012), 'Natural disasters', 31 May, http://www.economist.com/node/21551513.

Ehrlich, P. (1968), *The Population Bomb* (New York: Ballantine Books).

Ellen MacArthur Foundation (2011), *Towards the Circular Economy: Economic and business rationale for an accelerated transition*, http://www.thecirculareconomy.org/.

Elliot, L. (2011), 'Rising food and oil prices are biggest threat to recovery, says World Bank', *The Guardian*, 8 June, http://www.guardian.co.uk/business/2011/jun/08/food-oil-prices-biggest-threat-recovery.

Ember, C.R., Adem, T.A., Skoggard, I. and Jones, E.C. (2012), 'Livestock Raiding and Rainfall Variability in Northwestern Kenya', *Civil Wars*, Vol. 14, No. 2, pp. 159–181.

Emmerson, C. and Lahn, G. (2012), *Arctic Opening: Opportunity and Risk in the High North*, Lloyd's-Chatham House Report, http://www.lloyds.com/~/media/Files/News%20and%20Insight/360%20Risk%20Insight/Arctic_Risk_Report_20120412.pdf.

Emmerson, C. and Stevens, P. (2012), 'Maritime Choke Points and the Global Energy System: Charting a Way Forward' (London: Chatham House), http://www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/bp0112_emmerson_stevens.pdf.

England, A. and Blas, J. (2008), 'Water fears lead Saudis to end grain output', *Financial Times*, 27 February, http://www.ft.com/cms/s/0/f02c1e94-e4d6-11dc-a495-0000779fd2ac.html#axzz24wdVnrhu.

Ericsson, M. (2010), *Global mining towards 2030: Food for thought for the Finnish mineral policy process 2010*, Geological Survey of Finland, Report of Investigation 187.

Ericsson, M. (2012), 'EU & critical raw materials – implications for the industry', presentation at the From Sustainable Mining to Ecodesign Conference in Helsinki, 29 August, www.vtt.fi/files/events/GWW2012/FromSustainableMiningToEcodesign_Ericsson.pdf.

Ernst and Young (2011), *Business risks facing mining and metals 2011–2012*, http://www.ey.com/Publication/vwLUAssets/Business_risks_facing_mining_and_metals_2011-2012/$File/Metal_Mining_paper_02Aug11_lowres.pdf.

European Commission (2011), *Japan-EU Workshop on Substitution of Critical Raw Materials*, Final Report on Workshop held in Tokyo on 21–22 November, http://ec.europa.eu/research/industrial_technologies/pdf/japan-eu-workshop_en.pdf.

European Commission (2011), *Tackling the Challenges in Commodity Markets and on Raw Materials*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on 2 February, http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/communication_en.pdf.

European Report on Development (2012), *Confronting Scarcity: Managing water, energy and land for inclusive and sustainable growth* (Brussels: European Union).

Evans, A. (2012), *Resources, Risk and Resilience: Scarcity and Climate Change in Ethiopia* (New York: New York University Center on International Cooperation).

Export-Import Bank of India (2011), 'Indian Lines of Credit: An instrument to enhance India-Africa partnership', presentation, www.indiainbusiness.nic.in/trade/presentation_loc/exim.pdf.

FAO (Food and Agriculture Organization of the United Nations) (2006), *World Agriculture: towards 2030/2050* (Rome: FAO), http://www.fao.org/fileadmin/user_upload/esag/docs/Interim_report_AT2050web.pdf.

FAO (2009), *How to Feed the World in 2050* (Rome: FAO), http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf.

FAO (2009), *State of the World's Forests 2009* (Rome: FAO), ftp://ftp.fao.org/docrep/fao/011/i0350e/i0350e.pdf.

FAO (2010), *Global Forest Resources Assessment 2010: Main report* (Rome: FAO), http://www.fao.org/docrep/013/i1757e/i1757e.pdf.

FAO and United Nations Economic Commission for Europe (UNECE) (2010), *Forest Products Annual*

Market Review 2009–2010, http://timber.unece.org/fileadmin/DAM/publications/sp-25.pdf.

FAO (2011), *Aquastat Water withdrawal by region*, http://www.fao.org/nr/water/aquastat/dbase/AquastatWorldDataEng_20101129.pdf.

FAO (2011), *Current world fertilizer trends and outlook to 2015* (Rome: FAO).

FAO, International Fund for Agricultural Development (IFAD) and World Food Programme (WFP) (2011), *The State of Food Insecurity in the World: How does international price volatility affect domestic economies and food security?* (Rome: FAO), http://www.fao.org/docrep/014/i2330e/i2330e00.htm.

FAO, International Fund for Agriculture Development (IFAD), International Monetary Fund (IMF), Organisation for Economic Co-operation and Development (OECD), United Nations Conference on Trade and Development (UNCTAD), World Food Programme (WFP), the World Bank, the World Trade Organisation (WTO), International Food Policy Research Institute (IFPRI) and the United Nations High-Level Task Force on Global Food Security Crisis (UN HLTF) (2011), *Price Volatility in Food and Agricultural Markets: Policy Responses*, Report to the G20, 2 June, http://www.worldbank.org/foodcrisis/pdf/Interagency_Report_to_the_G20_on_Food_Price_Volatility.pdf.

FAO (2011), *The State of the World's Land and Water Resources for Food and Agriculture (SOLAW): Global distribution of physical water scarcity by major river basin* (Rome: FAO; London: Earthscan).

FAO (2012), *Aquastat: FAO's Information System on Water and Agriculture*, http://www.fao.org/nr/water/aquastat/main/index.stm.

FAO (2012), *Asia Pacific Food Situation Update*, http://www.fao.org/docrep/015/an022e/an022e00.pdf.

FAO (2012), *The State of World Fisheries and Aquaculture 2012* (Rome: FAO).

FAO (2012), *FishStat Plus*, Fisheries and Aquaculture Department, http://www.fao.org/fishery/statistics/software/fishstat/en.

FAOSTATS (Food and Agriculture Organization of the United Nations Statistics Division), http://faostat3.fao.org/home/index.html.

Fattouh, B. and Stern, J. (eds) (2011), *Natural Gas Markets in the Middle East* (Oxford University Press).

Fetzek, S. (2009), *Climate-Related Impacts on National Security in Mexico and Central America*, Royal United Services Institute Interim Report, http://www.rusi.org/downloads/assets/Mexico_CC_Text_-_English.pdf.

Fischendler, I., Dinar, S. and Katz, D. (2011), 'The Politics of Unilateral Environmentalism: Cooperation and Conflict over Water Management along the Israeli-Palestinian Border', *Global Environmental Politics*, Vol. 11, No. 1, pp. 36–61.

Fontanella-Khan, J. (2011), 'India lifts Karnataka iron ore export ban', *Financial Times*, 5 April, http://www.ft.com/cms/s/0/fd1b30f6-5f74-11e0-bd1b-00144feab49a.html#axzz251V2jFKD.

Ford, J.D., Pearce, T., Prno, J., Duerden, F. et al. (2011), 'Canary in a coalmine: Perceptions of climate change risks and response options among Canadian mine operations', *Climatic Change*, Vol. 109, No. 3, pp. 399–415.

Foresight (2011), *International Dimensions of Climate Change* (London: Government Office for Science), http://www.bis.gov.uk/assets/foresight/docs/international-dimensions/11-1042-international-dimensions-of-climate-change.pdf.

Foresight (2011), *The Future of Food and Farming* (London: The Government Office for Science), www.bis.gov.uk/foresight/our-work/projects/current-projects/global-food-and-farming-futures/reports-and-publications.

Foster, V. and Briceño-Garmendia, C. (2009), *Africa's Infrastructure: A Time for Transformation*, (Washington, DC: The World Bank), http://siteresources.worldbank.org/INTAFRICA/Resources/aicd_overview_english_no-embargo.pdf.

Froggatt, A. and Lahn, G. (2010), *Sustainable Energy Security: Strategic Risks and Opportunities for Business*, Lloyd's-Chatham House 360° Risk Insight White Paper, http://www.lloyds.com/~/media/Lloyds/Reports/360%20Energy%20Security/7238_Lloyds_360_Energy_Pages.pdf.

Frost and Sullivan (2012), 'Automotive Carbon Fiber Composites to Grow at a Staggering Growth Rate until 2017', http://www.frost.com/prod/servlet/press-release.pag?Src=RSS&docid=263051000.

G20 (2008), *Declaration of the Summit on Financial Markets and the World Economy*, http://www.g20.utoronto.ca/2008/2008declaration1115.html.

G20 (2009), *G20 Leaders' Statement: The Pittsburgh Summit, September 24-25*, http://www.g20.utoronto.ca/2009/2009communique0925.html.

Gately, D., Al-Yousef, N. and Al-Sheikh, H.M.H. (2012), *The Rapid Growth of OPEC's Domestic Oil Consumption* (New York University), http://www.econ.nyu.edu/dept/courses/gately/OPEC_Consumption_Gately_AlYousef_AlSheikh_April2012.pdf.

German Advisory Council on Global Change (WBGU) (2007), *Climate Change as a Security Risk* (London: Earthscan).

Gilbert, C. (2006), 'Trends and Volatility in Agricultural Commodity Prices', in Sarris, A. and D. Hallam (eds.), *Agricultural Commodity Markets and Trade: New Approaches to Analysing Market Structure and Instability* (Cheltenham: FAO and Edward Elgar).

Gilbert, C. (2011), *International Agreements for Commodity Price Stabilisation: An Assessment* (Paris: OECD), http://www.oecd-ilibrary.org/docserver/download/5kg0ps7ds0jl.pdf?expires=1355314445&id=id&accname=guest&checksum=F577824D7D52317 2E96F96A474401B25.

Gleick, P. (2010), 'China and Water ', Chapter 5 in *The World's Water: 2008–2009* (6th edition) (Washington, DC: Island Press).

Global Environmental Facility and International Fund for Agricultural Development (2002), *Tackling Land Degradation and Desertification,* http://www.ifad.org/events/wssd/gef/GEF_eng.pdf.

Global Humanitarian Assistance (GHA) (2012), *GHA Report 2012,* Global Humanitarian Assistance, www.globalhumanitarianassistance.org/wp-content/uploads/2012/07/GHA_Report_2012-Websingle.pdf.

Global Subsidies Initiative (2010), *Strategies for Reforming Fossil-Fuel Subsidies: Practical lessons from Ghana, France and Senegal,* International Institute for Sustainable Development, http://www.iisd.org/gsi/sites/default/files/strategies_ffs.pdf.

Global Trade Alert database and Evenett, S.J. (ed.) (2012), *Débâcle: The 11th GTA report on protectionism* (London: Centre for Economic Policy Research (CEPR)), www.globaltradealert.org/11th_GTA_report.

Global Water Intelligence (2009), 'A new dawn for desalination in Chile', *Global Water Intelligence*, Vol. 10, No. 12.

Global Witness (2012), *Getting to Gold: how Afghanistan's first mining contracts can support transparency and accountability in the sector* (London: Global Witness).

Gomez, F., Guzman, J.I. and Tilton, J.E. (2007), 'Copper recycling and scrap availability', *Resources Policy*, Vol. 32, No. 4, pp. 183–190.

Government of India Planning Commission (2011), *Report of Sub-Group-II on Metals and Minerals – Strategy based upon the demand and supply for mineral sector*, http://mines.gov.in/new/subgroup2.pdf.

Government of the United Arab Emirates (2011), *Food Security and Water G20 White Paper*, http://www.uaeg20.ae/usr/pages/en/Food%20and%20Water%20 Security%20policy.pdf.

Grimes, S., Donaldson, J. and Gomez, G.C. (2008), *Report on the Environmental Benefits of Recycling* (Brussels: Bureau of International Recycling (BIR)), http://www.bir.org/assets/Documents/publications/brochures/BIR_CO2_report.pdf.

Guardian (2012), 'Nigeria restores fuel subsidy to quell nationwide protests', 16 January, www.guardian.co.uk/world/2012/jan/16/nigeria-restores-fuel-subsidy-protests.

Gustavsson, J., Cederberg, C. and Sonesson, U. (2011), *Global Food Losses and Food Waste: Extent, Causes and Prevention* (Rome: FAO), http://www.fao.org/docrep/014/mb060e/mb060e00.pdf.

Gutowski, T.G., Sahni, S., Boustani, A. and Graves, S.C. (2011), 'Remanufacturing and Energy Savings', *Environmental Science and Technology*, Vol. 45, No. 10, pp. 4540–4547.

Halden, P. (2007), *The Geopolitics of Climate Change: Challenges to the International System* (Stockholm: Swedish Defence Research Agency, FOI), http://www2.foi.se/rapp/foir2377.pdf.

Hammond, J. (2012), 'Kirchner Joins the Resource Wars', *The European*, 18 May, http://theeuropean-magazine.com/381-hammond-joseph/682-global-resource-nationalism.

Heffer, P. and Prud'homme, M. (2011), *Fertilizer Outlook 2011–2015*, International Fertilizer Industry Association (IFA).

Helm, D. (2012) 'EU Energy Policy and the Role of Gas in Decarbonisation', presentation to the Flame Conference in Amsterdam on 17 April, www.dieterhelm.co.uk/sites/default/files/FLAME%20 D%20Helm.pdf.

Hendrix, C.S. and Salehyan, I. (2012), 'Climate Change, Rainfall, and Social Conflict in Africa', *Journal of Peace Research*, Vol. 49, No. 1, pp. 35–50.

Henry, M. (2011), 'Growth and Evolution of Commodities Demand', presentation on behalf of BHP Billiton, 4 May, http://www.bhpbilliton.com/home/investors/reports/Documents/110504MhMacquarieConference.pdf.

Hernandez, V. (2012), 'YPF nationalism: Is Argentina playing with fire?', *BBC News*, 17 April, http://www.bbc.co.uk/news/world-europe-17740393.

Herring, H. and Sorell, S. (eds) (2009), *Energy Efficiency and Sustainable Consumption: The Rebound Effect* (Basingstoke: Palgrave Macmillan).

High Representative and European Commission (2008), *Climate Change and International Security*, Joint Paper to the European Council, http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/reports/99387.pdf.

Hill, M. (2012), 'Colombia coal production to reach 120Mt in 2014, says Minister', *Mining Weekly*, 5 March, www.miningweekly.com/article/colombia-coal-production-to-reach-120mt-in-2014-says-minister-2012-03-05.

Hitachi (2012), 'Highly efficient industrial 11kW permanent magnet synchronous motor without rare-earth metals', http://www.hitachi.com/New/cnews/120411.html.

Hodgkinson, J.H., Littleboy, A. Howden, M., Moffat, K. and Loechel, B. (2010), *Climate adaptation in the Australian mining and exploration industries*, CSIRO Climate Adaptation Flagship Working paper No. 5, http://www.csiro.au/resources/CAF-working-papers.html.

Hoekman, B., Mattoo, A. and English, P. (eds) (2002), *Trade, and the WTO: A Handbook* (Washington, DC: The World Bank).

Hoelscher, K., Miklian, J. and Vadlamannati, K.C. (2012), 'Hearts and Mines: A District-level Analysis of the Maoist Conflict in India', *International Area Studies Review*, Vol. 15, No. 2, pp. 141–160.

Hoff, H. (2011), *Understanding the Nexus: Background Paper for the Bonn 2011 Conference: The Water, Energy and Food Security Nexus* (Stockholm: Stockholm Environment Institute).

Howard, R. (2009), *The Arctic Gold Rush: The New Race for Tomorrow's Natural Resources* (London and New York: Continuum).

Howarth, R. W., Santoro, R. and Ingraffea, A. (2011), 'Methane and the greenhouse-gas footprint of natural gas from shale formations', *Climatic Change*, Vol. 106, No. 4.

Hubbert, M.K. (1956), 'Nuclear Energy and the Fossil Fuels', presentation given at the Spring Meeting of the Southern District Division of Production, American Petroleum Institute, San Antonio, Texas, 7–9 March, http://energycrisis.biz/hubbert/1956/1956.pdf.

Human Rights Watch (2011), *You'll Be Fired if You Refuse: Labor Abuses in Zambia's Chinese State-owned Copper Mines*, http://www.hrw.org/sites/default/files/reports/zambia1111ForWebUpload.pdf.

IEA (International Energy Agency) (2007), *Oil Supply Security: Emergency Response of IEA Countries*, http://books.google.co.uk/books?id=COdAuw4GVewC&pg=PA11&lpg=PA11&dq=Oil+Supply+Security:+Emergency+Response+of+IEA+countries+2007&source=bl&ots=VR47nZvZYN&sig=mLRR98f2pvlZUnT8ftz0UhZiQVE&hl=en#v=onepage&q&f=false.

IEA (2007), *Tracking Industrial Energy Efficiency and CO2 Emissions* (Paris: IEA).

IEA (2008), *World Energy Outlook 2008* (Paris: IEA).

IEA (2011), *World Energy Outlook 2011* (Paris: IEA).

IEA (2011), *Oil Market Report: 15 March 2011*, http://omrpublic.iea.org/omrarchive/15mar11full.pdf.

IEA (2012), *World Energy Outlook 2012* (Paris: IEA).

IFAD (International Fund for Agricultural Development) (2010), *Desertification*, http://www.ifad.org/pub/factsheet/desert/e.pdf.

IFAD (2012), *Tackling Land Degradation and Desertification*, http://www.ifad.org/events/wssd/gef/gef_ifad.htm.

IHS Global Insight (2011), *The Economic and Employment Contributions of Shale Gas in the United States*, http://anga.us/media/235626/shale-gas-economic-impact-dec-2011.pdf.

IMF (International Monetary Fund) (2006), *World Economic Outlook*, http://www.imf.org/external/pubs/ft/weo/2006/02/pdf/weo0906.pdf.

IMF (2011), *Managing Global Growth Risks and Commodity Price Shocks: Vulnerabilities and Policy Challenges for Low-Income Countries*, http://www.imf.org/external/np/pp/eng/2011/092111.pdf.

IMF (2012), *Primary Commodity Prices database*, http://www.imf.org/external/np/res/commod/index.aspx.

International Crisis Group (2010), *Northern Nigeria: Background to Conflict*, Africa Report No. 168, Brussels.

IPCC (Intergovernmental Panel on Climate Change) (2007), *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf.

IPCC (2011), Kumar, A., Schei, T., Ahenkorah, A. et al. 'Hydropower', Chapter 5 in Edenhofer, O., Pichs-Madruga, R., Sokona, Y. et al. (eds.), *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge University Press), http://srren.ipcc-wg3.de/report/IPCC_SRREN_Ch05.pdf.

IPCC (2012), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (Cambridge University Press), http://www.ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf.

IPCC (2012), 'Summary for Policymakers' in Field, C.B., Barros, V., Stocker, T.F., Qin, D. et al. (eds), *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* (Cambridge University Press), http://www.ipcc-wg2.gov/SREX/images/uploads/SREX-All_FINAL.pdf.

Iron Ore Team (2011), 'Brazilian iron ore output to double by 2015', 23 August, http://www.ironoreteam.com/brazilian-iron-ore-output-double-2015.

Jacks, D., O'Rourke, K. and Williamson, J. (2009), 'Commodity price volatility and world market integration since 1700', *The Review of Economics and*

Statistics, Vol. 93, No. 3, pp. 800–813, http://www.sfu.ca/~djacks/papers/publications/JOW.pdf.

James, C. (2011), *Global Status of Commercialized Biotech/GM Crops: 2011* (Ithaca, New York: International Service for the Acquisition of Agri-Biotech Applications).

Japan Today (2010), 'Gov't to study stockpiling rare earth minerals', 2 October.

Jermy, S. (2011), *Strategy for Action: Using Force Wisely in the 21st Century* (London: Knightstone Publishing)

Jiang, J. and Sinton, J. (2011), *Overseas Investments by Chinese National Oil Companies: Assessing the drivers and impacts*, International Energy Agency (IEA), http://www.iea.org/publications/freepublications/publication/overseas_china.pdf.

Joffé, G., Stevens, P., George, T., Lux, J. and Searle, C. (2009), 'Expropriation of oil and gas investments: Historical, legal, and economic perspectives in a new age of resource nationalism', *World Energy Law & Business*, Vol. 2, No. 1, pp. 3–23.

Johnstone, S. and Mazo, J. (2011), 'Global Warming and the Arab Spring', *Survival*, Vol. 53, No. 2, pp. 11–17.

Kader, A.A. (2003), 'A perspective on postharvest horticulture (1978–2003)', *HortScience*, Vol. 38, No. 5, pp. 1004–1008.

Kasarda, J.D., Appold, S.J. and Mori, M. (2006), 'The Impact of the Air Cargo Industry on the Global Economy', presentation for the International Air Cargo Association Air Cargo Forum, Calgary, 13 September, www.tiaca.org/images/TIACA/PDF/The%20Impact%20of%20the%20Air%20Cargo%20Industry%20on%20the%20Global%20Economy.pdf.

Katz, D. (2011), 'Hydro-Political Hyperbole: Examining Incentives for Overemphasizing the Risks of Water Wars', *Global Environmental Politics*, Vol. 1, No. 1, pp. 12–35.

Kawamoto, H. (2008), 'Japan's Policies to be Adopted on Rare Metal Resources', *Science & Technology Trends Quarterly Review*, Vol. 27, pp. 57–76.

Keenan, R. (2011), 'Australia Blocked Rare Earth Deal on Supply Concerns', *Bloomberg*, 15 February, http://www.bloomberg.com/news/2011-02-14/australia-blocked-china-rare-earth-takeover-on-concern-of-threat-to-supply.html.

Kellet, J. and Sparks, D. (2012), *Disaster Risk Reduction: Spending where it should count*, Global Humanitarian Assistance Briefing Paper, http://www.globalhumanitarianassistance.org/wp-content/uploads/2012/03/GHA-Disaster-Risk-Report.pdf.

Kingsnorth, D.J. (2011), *Rare Earths: Reducing our dependence on China*, Table 3 and 8 (Mt Claremont, Western Australia: IMCOA).

Klare, M.T. (2012), *The Race for What's Left: The Global Scramble for the World's Last Resources* (New York: Metropolitan Books), pp. 166–167.

Kojima, M., Matthews, W. and Sexsmith, F. (2010), *Petroleum Markets in Sub-Saharan Africa*, World Bank Extractive Industries for Development Series #15, http://siteresources.worldbank.org/INTOGMC/Resources/336099-1158588096604/eifd15_ssa_oil_markets.pdf.

Kooroshy, J., Korteweg, R. and de Ridder, M. (2010), *Rare Earth Elements and Strategic Mineral Policy* (The Hague: The Hague Centre for Strategic Studies).

Lacey, S. (2012), 'U.S. Coal Generation Drops 19 Percent in One Year, Leaving Coal With 36 Percent Share of Electricity', US Department of Energy, http://thinkprogress.org/climate/2012/05/14/483432/us-coalgeneration-drops-19-percent-in-one-year-leaving-coal-with-36-percentshare-of-electricity/?mobile=nc.

Lahn, G. and Stevens, P. (2011), *Burning Oil to Keep Cool: The Hidden Energy Crisis in Saudi Arabia* (London: Chatham House).

Lamy, P. (2012), 'Speech of the Director-General of the World Trade Organization to the Thai Chamber of Commerce', 30 May, Bangkok, www.wto.org/english/news_e/sppl_e/sppl232_e.htm.

Landis, J. (2012), 'The Syrian Uprising of 2011: Why the Asad Regime Is Likely to Survive to 2013', Journal Essay, Middle East Policy Council, http://www.mepc.org/journal/middle-east-policy-archives/syrian-uprising-2011-why-asad-regime-likely-survive-2013?print.

Land Matrix, Beta version, International Land Coalition (ILC), Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), Centre for Development and Environment (CDE),German Institute for Global and Area Studies (GIGA) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), April 2012, http://landportal.info/landmatrix.

Lee, B. (2009), 'Managing the Interlocking Climate and Resource Challenges', *International Affairs*, Vol. 85, No. 6, p. 1113.

Lee, B., Iliev, I. and Preston, F. (2009), *Who Owns Our Low Carbon Future? Energy Technologies and Intellectual Property* (London: Chatham House).

Lee, B., Preston, F. and Green, G. (2012), *Preparing for High-impact, Low-probability Events: Lessons from Eyjafjallajökull* (London: Chatham House), http://www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/r0112_highimpact.pdf.

Lemaux, P. (2008), 'Genetically engineered plants and foods: a scientist's analysis of the issues (part I)', *Annual Review of Plant Biology*, Vol. 59, No. 1, pp. 771–812.

Lennon, J. (2012), 'Base metals outlook: Drivers on the supply and demand side', presentation, February 2012, Macquarie Commodities Research, http://www.macquarie.com/dafiles/Internet/mgl/msg/iConference/documents/18_JimLennon_Presentation.pdf.

LeVine, S. (2012), 'Meet the winners and losers of the coming age of plenty', *Foreign Policy,* 18 July.

Liskaa, A.J. and Perrin, R.K. (2010), 'Securing Foreign Oil: A Case for Including Military Operations in the Climate Change Impact of Fuels', *Environment: Science and Policy for Sustainable Development*, Vol. 52, No. 4, pp. 9–22.

Liss, C. (2007), *The Roots of Piracy in Southeast Asia* (Melbourne: The Nautilus Institute), http://nautilus.org/apsnet/the-roots-of-piracy-in-southeast-asia/.

Lobell, D.B., Burke, M.B., Tebaldi, C., Mastrandrea, M.D., Falcon, W.P. and Naylor, R.L. (2008), 'Prioritizing Climate Change Adaptation Needs for Food Security in 2030', *Science*, Vol. 319, No. 5863, pp. 607–610.

Lobell, D.B. et al. (2011), 'Climate Trends and Global Crop Production Since 1980', *Science*, Vol. 333, No. 6042, pp. 616–620.

Loechel, B., Hodgkinson, J.H., Moffat, K., Crimp, S., Littleboy, A., Howden, M. (2010), *Goldfields-Esperance Regional Mining*, Climate Vulnerability Workshop, CSIRO, http://www.csiro.au/en/Organisation-Structure/Flagships/Climate-Adaptation-Flagship/climate-vulnerability-goldfields-report.aspx.

Lohmar, B. (2004), *China's Wheat Economy: Current Trends and Prospects for Imports*, U.S. Department of Agriculture (USDA) Electronic Outlook Report from the Economic Research Service, WHS 04D-01, May.

Lujala, P. (2010), 'The Spoils of Nature: Armed Civil Conflict and Rebel Access to Natural Resources', *Journal of Peace Research*, Vol. 47, No. 1, pp. 15–28.

Mabey, N. and Mitchell, J.V. (2010), *Investing for an Uncertain Future: Priorities for UK Energy and Climate Security* (London: Chatham House).

Mackenzie, A. (2011), 'Mineral Deposits and their Global Strategic Supply', presentation on behalf of BHP Billiton to The Geological Society Shell London Lecture Series, 14 December, http://www.bhpbilliton.com/home/investors/reports/Documents/2011/111214_A%20Mackenzie%20Geological%20Society%20of%20London%20Presentation.pdf.

Malthus, T. (1798), *An Essay on the Principle of Population.*

Maribus (2011), *World Ocean Review 2011*, Chapter 8 (Transport), http://worldoceanreview.com/en/order/.

Masuda, T. and Goldsmith, P. D. (2009), 'World Soybean Production: Area Harvested, Yield, and Long-Term Projections', *International Food and Agribusiness Management Review*, Vol. 12, No. 4.

Mayer, G. (2012), 'U.S. predicts receding food price threat', *Financial Times*, 23 February, http://www.ft.com/cms/s/0/54cf1176-5e40-11e1-85f6-00144feabdc0.html#axzz24wdVnrhu.

McKay, H., Sheng, Y. and Song, L. (2010), 'China's metal intensity in comparative perspective', in Garnaut, R., Golley, J. and Song L. (eds), *China: The Next Twenty Years of Reform and Development* (Canberra: ANU E Press).

McKinsey (2012), *Meet the 2020 Chinese Consumer*, http://www.mckinseychina.com/wp-content/uploads/2012/03/mckinsey-meet-the-2020-consumer.pdf.

Meadows, D.H. et al. (1972), *Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: Universe Books).

Medlock, K.B., Jaffe, A.M. and Hartley, P.R. (2011), *Shale Gas and U.S. National Security* (Houston: James A. Baker III Institute for Public Policy), http://www.bakerinstitute.org/publications/EF-pub-DOEShaleGas-07192011.pdf.

Meinzen-Dick, R. and Appasamy, P.P. (2011), *Finding the Source: Urbanization and Intersectoral Competition for Water* (Washington, DC: The Woodrow Wilson Centre for Scholars), http://www.wilsoncenter.org/publication/finding-the-source-urbanization-and-intersectoral-competition-for-water.

Mekonnen, M.M. and Hoekstra, A.Y. (2010), 'The green, blue and grey water footprint of crops and derived crop products', *Value of Water Research Report Series*, No. 47 (Delft, the Netherlands: UNESCO-IHE).

Menzie, W.D., Barry, J.J., Bleiwas, D.I., Bray, E.L., Goonan, T.G. and Matos, G. (2010), 'The Global Flow of Aluminum from 2006 through 2025', US Geological Survey Open-File Report 2010–1256, http://pubs.usgs.gov/of/2010/1256/pdf/ofr2010-1256..pdf.

Metals Economics Group (2012), *World Exploration Trends 2012: A Special Report from the Metals Economics Group for the PDAC International Convention.*

Middleton, R. (2008), *Piracy in Somalia: Threatening Global Trade, Feeding Local Wars* (London: Chatham House), http://www.chathamhouse.org/sites/default/files/public/Research/Africa/1008piracysomalia.pdf.

Minerals Council of Australia (2011), *The economic impact of the carbon pricing scheme assessing the costs in a world of fragmented policy action*, https://www.qrc.org.au/_dbase_upl/CIE_combined.pdf.

MinEx Consulting (2010), 'Global discovery trends 1950–2009: What, where and who found them', presentation by Richard Schodde, Managing Director, Toronto, 7 March, http://www.minexconsulting.com/publications/Global%20Discovery%20Trends%201950-2009%20PDAC%20March%202010.pdf.

Minot, N. (2010), *Transmission of World Food Price Changes to Markets in Sub-Saharan Africa*, International Food Policy Research Institute (IFPRI) Discussion Paper, http://www.ifpri.org/sites/default/files/Minot_2010.pdf.

Mitchell, J.V. (2002), *Renewing Energy Security* (London: Chatham House), http://www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/renewing_energy_security_mitchell_july_2002.pdf.

Mitchell, J.V. (2012), *What Next for the Oil and Gas Industry?* (London: Chatham House).

Mitchell, J.V. and Stevens, P. (2008), *Ending Dependence: Hard Choices for Oil-Exporting States* (London: Chatham House), http://www.chathamhouse.org/sites/default/files/public/Research/Energy,%20Environment%20and%20Development/0708oildependence.pdf.

Moledina, A., Roe, T., Shane, M. (2004), 'Measuring commodity price volatility and the welfare consequences of eliminating volatility', American Agricultural Economics Association, Annual meeting, 1–4 August, Denver, http://EconPapers.repec.org/RePEc:ags:aaea04:19963.

Moran, D. and Russell, J.A. (2008), 'The Militarization of Energy Security', *Strategic Insights*, Vol. 7, No. 1.

Morton, D.C. et al. (2006), 'Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon', *Proceedings of the National Academy of Sciences*, Vol. 103, No. 39, pp. 14637–14641.

Moss, R., Tzimas, E., Kara, H., Willis, P. and Kooroshy, J. (2011), *Critical Metals in Strategic Energy Technologies – Assessing Rare Metals as Supply-Chain Bottlenecks in Low-Carbon Energy Technologies* (Petten, The Netherlands: European Commission, Joint Research Centre (JRC)), http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/22726/1/reqno_jrc65592_critical%20metals%20in%20strategic%20energy%20technologies%20%28online%29.pdf.

Motes, W.C. (2011), *Global Food and Agriculture Productivity Review: the Investment Challenge*, Global Harvest Initiative, http://www.globalharvestinitiative.org/wp-content/uploads/2012/08/Motes-The-Investment-Gap-Jan-31-2011.pdf.

Mueller, N.D., Gerber, J.S., Johnston, M., Ray, D.K., Ramankutty, N. and Foley, J.A. (2012), 'Closing yield gaps through nutrient and water management', *Nature*, published online 29 August, http://www.nature.com/nature/journal/vaop/ncurrent/full/nature11420.html?WT.ec_id=NATURE-20120830.

Mulshaw, S. (2011), 'Here Comes the Flood! The Outlook for Nickel', presentation at the International Nickel Study Group, 12 April, www.insg.org/presents/Mr_Mulshaw_Apr11.pdf.

Mustafa, D. (2010), *Hydropolitics in Pakistan's Indus Basin* (Washington, DC: United States Institute of Peace).

Myers, N. (2002), 'Environmental refugees: a growing phenomenon of the 21st century', *Philosophical Transactions: Biological Sciences*, Vol. 357, No. 1420, pp. 609–613.

Nomikos, N. (2012), 'Managing Shipping Risk in the Global Supply Chain – The Case for Freight Options', http://www.bbk.ac.uk/cfc/papers/nomikos.pdf.

Nomura Global Economics (2010), *The Ascent of Asia*, www.nomura.com/europe/resources/pdf/nomura%20-%20the%20ascent%20of%20asia.pdf.

Noorani, J. (2011), *Hajigak – the jewel of Afghan mines* (Kabul: Integrity Watch Afghanistan).

Norgate, T.E. and Jahanshahi, S. (2011), 'Reducing the greenhouse gas footprint of primary metal production: Where should the focus be?', *Minerals Engineering*, Vol. 24, No. 14, pp. 1563–1570.

Odom, O. and Wolf, A.T. (2011), 'Institutional resilience and climate variability in international water treaties: the Jordan River Basin as "proof-of-concept"', *Hydrological Sciences Journal*, Vol. 56, No. 4, pp. 703–710.

OECD (Organisation for Economic Co-operation and Development) (2008), *Environmental Outlook to 2030*, http://www.oecd.org/environment/environmentalindicatorsmodellingandoutlooks/oecdenvironmentaloutlookto2030.htm.

OECD (2010), *Perspectives on Global Development 2010: Shifting Wealth* (Paris: OECD).

OECD (2011), *Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels* (Paris: OECD).

OECD (2011), *Overseas Investments by China's National Oil Companies*, http://www.oecd-ilibrary.org/docserver/download/5kgglrwdrvvd.pdf?expires=1355398133&id=id&accname=guest&checksum=7CE54CFB0661ED2E42D3BEA057FFD5AA.

OECD (2011), *Tools for Delivering Green Growth,* Report prepared for the OECD Meeting of the Council at Ministerial Level, 25–6 May, Paris, http://www.oecd.org/greengrowth/48012326.pdf.

OECD and Food and Agriculture Organisation of the United Nations (FAO)(2011), *OECD-FAO Agricultural Outlook 2011–2020*, http://dx.doi.org/10.1787/agr_outlook-2011-en.

OECD and Food and Agriculture Organisation of the United Nations (FAO)(2012), *OECD-FAO Agricultural Outlook 2012-2021*, http://www.oecd.org/site/oecd-faoagriculturaloutlook/#publication2012.

OECD (2012), *Sustainable Materials Management*, OECD Green Growth Policy Brief, http://www.oecd.org/env/resourceproductivityandwaste/SMM%20synthesis%20-%20policy%20brief_final%20GG.pdf.

OECD (2012), *World Environmental Outlook to 2050* (Paris: OECD).

OECD Development Assistance Committee (DAC) (2012), 'OECD DAC statistics on climate-related aid', http://www.oecd.org/dac/aidstatistics/FactsheetRio.pdf.

OECD and International Energy Agency (IEA) (2012), *Medium-Term Gas Market Report 2012* (Paris: OECD).

OKACOM (2010), *OKACOM protocol on hydrological data sharing for the Okavango River Basin*, The Permanent Okavango River Basin Water Commission.

Osborn, S.G., Vengosh, A., Warner, N. R. and Jackson, R.B. (2011), 'Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing', *Proceedings of the National Academy of Sciences*, Vol. 108, No. 20, http://www.pnas.org/content/108/20/8172.full.pdf.

Overseas Development Institute (ODI), German Development Institute (DIE), and European Centre for Development Policy Management (ECDPM) (2012), *Confronting Scarcity: Managing Water, Energy and Land for Inclusive and Sustainable Growth*, European Report on Development, http://erd-report.eu/erd/report_2011/documents/erd_report%202011_en_lowdef.pdf.

Oxley, M. (2009), 'Building Climate Resilience – Experiences from Disaster Risk Reduction', presentation, 3 December, http://community.eldis.org/?233@@.59cdc968/7!enclosure=.59cf7098&ad=1.

Parra-Bernal, G. and Simões, E. (2012), 'Vale wins injunction barring Brazil tax debt payment', Reuters, 9 May, http://www.reuters.com/article/2012/05/10/us-brazil-taxes-vale-idUSBRE84901W20120510.

Paskal, C. (2007), *How Climate Change is Pushing the Boundaries of Security and Foreign Policy* (London: Chatham House).

Paskal, C. (2010), *Global Warring: How Environmental, Economic, and Political Crises will Redraw the World Map* (New York: Palgrave Macmillan).

Payvand Iran News (2011), 'Iran's Copper Output Will Increase 3.5-Fold: Official', 20 November, http://www.payvand.com/news/11/nov/1204.html.

Pearce, T.D., Ford, J.D., Prno, J. Frank, D. et al. (2011), 'Climate change and mining in Canada', *Mitigation and Adaptation Strategies for Global Change*, Vol. 16, No. 3, pp. 347–368.

Pelusoa, N.L. and Vandergeest, P. (2011), 'Political Ecologies of War and Forests: Counterinsurgencies and the Making of National Natures', *Annals of the Association of American Geographers*, Vol. 101, No. 3, pp. 587–608.

People's Daily (2010), 'China plans strategic reserves for rare metals', 3 November, http://english.peopledaily.com.cn/90001/90778/90860/7186937.html.

Pepke, E. (2010), 'Growing trade of wood and paper products', presentation to UNECE/FAO workshop on 'Emerging Trade Measures in Timber Markets', March, http://timber.unece.org/fileadmin/DAM/meetings/01Pepke.pdf.

Pepke, E. (2012), 'Global Wood Markets: Consumption, Production and Trade', presentation at the International Forestry and Global Issues Conference, Nancy, 17 April.

Petroleum Economist (2012), 'Arctic investment competition heats up', 11 January, www.petroleum-economist.com/Article/2959654/Arctic-investment-competition-heats-up.html.

Piese, J. and Thirtle, C. (2010), 'Agricultural R&D, technology and productivity', *Philosophical Transactions of the Royal Society*, Vol. 365, No. 1554, pp. 3035–3047.

Platts (2012), 'Indonesia's nickel export restrictions to support prices: Citigroup', 31 May, http://www.platts.com/RSSFeedDetailedNews/RSSFeed/Metals/8347036.

Pomeroy, R., Parks, J., Pollnac, R. et al. (2007), 'Fish Wars: Conflict and Collaboration in Fisheries Management in Southeast Asia', *Marine Policy*, Vol. 31, No. 6, pp. 645–656.

Price, A., Brightbill, T., Weld, C., Capito, C. and Morgan, R. (2008), *Raw Deal: How Governmental Trade Barriers and Subsidies Are Distorting Global Trade in Raw Materials,* report prepared by Wiley Rein LLP for the American Scrap Coalition, http://legacy.steel.org/AM/Template.cfm?Section=Home&CONTENTID=26678&TEMPLATE=/CM/ContentDisplay.cfm.

Price, A. and Nance, S. (2010), 'Export Barriers and the Steel Industry', *The Economic Impact of Export Restrictions on Raw Materials* (Paris: OECD).

PricewaterhouseCoopers (2011), *You Can't Always Get What You Want: Global mining deals 2010*, http://www.pwc.com.au/industry/energy-utilities-mining/assets/Global-Mining-Deals-Mar11.pdf.

Probos (2010), 'Market share of certified wood more than doubles', www.probos.nl/home/bosbericht_bestanden/bosberichten2010-03E.pdf.

Radetski, M. (2006), 'The anatomy of the three commodity booms', *Resource Policy*, Vol. 31, pp. 56–64.

Raghavan, S. (2012), 'South Sudan civilians are trapped in conflict over oil', *Washington Post*, 1 May, www.washingtonpost.com/world/south-sudan-civilians-are-trapped-in-conflict-over-oil/2012/05/01/gIQAUX6buT_story.html.

Rakotoarisoa, M. A., Iafrate, M. and Paschali, M. (2011), *Why has Africa become a net food importer? Explaining Africa agricultural and food trade deficits* (Rome: FAO), http://www.fao.org/docrep/015/i2497e/i2497e00.pdf.

Redo, D., T. Aide, M. Clark, and Andrade-Núñez, M. (2012) 'The impact of internal and external policies on land change in Uruguay, 2001 to 2009', *Environmental Conservation*, Vol. 39, pp. 122–131.

Renner, M. (2011), *Water and Energy Dynamics in the Greater Himalayan Region: Opportunities for Environmental Peacebuilding* (Oslo: Norwegian Peacebuilding Resource Centre).

Reuters (2012), 'Guinea launches production at its first iron mine', 11 June, www.reuters.com/article/2012/06/11/iron-guinea-idUSL5E8HB8CK20120611.

Reuters (2012), 'Nigeria MEND Militants Claim Niger Delta Attack', Yenagoa, Nigeria, 2 March, http://www.reuters.com/article/2012/03/02/nigeria-militants-idUSL5E8E21GV20120302.

Revathy, L.N. (2011), 'Price volatility leading to more defaults in cotton contracts', *The Hindu Business Line*, 26 September, http://www.thehindubusinessline.com/industry-and-economy/agri-biz/article2487560.ece.

Rockström, J. et al. (2009), 'A Safe Operating Space for Humanity', *Nature*, Vol. 461, No. 282, pp. 472–475.

Rogers, P. (2012), 'Nigeria: The Generic Context of the Boko Haram Violence', Oxford Research Group, http://www.oxfordresearchgroup.org.uk/sites/default/files/AprEn12.pdf.

Ross, M.L. (2004), 'How Do Natural Resources Influence Civil War? Evidence from Thirteen Cases', *International Organization*, Vol. 58, No. 1, pp. 35–67.

Royal Academy of Engineering (2010), 'Global Water Security: An Engineering Perspective', http://www.raeng.org.uk/news/publications/list/reports/Global_Water_Security_report.pdf.

Royal Society (2009), *Reaping the benefits: Science and the sustainable intensification of global agriculture* (London: Royal Society), http://royalsociety.org/uploadedFiles/Royal_Society_Content/policy/publications/2009/4294967719.pdf.

Russell, D. (2010), *Who Rules the Waves? Piracy, Overfishing and Mining the Ocean* (London and New York: Pluto Press).

Rustad, S.A. and Binningsbø, H.M. (2012), 'A Price Worth Fighting For? Natural Resources and Conflict Recurrence', *Journal of Peace Research*, Vol. 49, No. 4, pp. 531–546.

Salidjanova, N. (2011), *Going Out: An Overview of China's Outward Foreign Direct Investment*, US-China Economic and Security Review Commission Staff Report, http://www.uscc.gov/researchpapers/2011/GoingOut.pdf.

Sauer, A., Klop, P. and Agrawal, S. (2010), *Over Heating: Financial Risks from Water Constraints on Power Generation in Asia – India, Malaysia, Philippines, Thailand, Vietnam* (Washington, DC: World Resources Institute and HSBC), http://pdf.wri.org/over_heating_asia.pdf.

Schmidhuber, S., Bruinsma, J., Boedeker, G. (2009), *Capital Requirements for Agriculture in Developing Countries to 2050* (Rome: FAO).

Schuemer-Cross, T. and Taylor, B.H. (2009), *The Right to Survive: The humanitarian challenge for the twenty-first century*, Oxfam International, http://www.oxfam.org/sites/www.oxfam.org/files/right-to-survive-report.pdf.

Selby, J. (2005), 'The Geopolitics of Water in the Middle East: Fantasies and Realities', *Third World Quarterly*, Vol. 26, No. 2, pp. 329–49.

Selivanova, Y. (2010), 'Trade in Energy: Challenges for International Trade Regulation', *World Trade Report 2010*, World Trade Organisation (WTO), www.wto.org/english/res_e/publications_e/wtr10_forum_e/wtr10_11june10_e.htm.

Sexton, R. (2012), *Natural resources and conflict in Afghanistan: Seven case studies, major trends and implications for the transition* (Kabul: Afghanistan Watch).

Sharma, R. (2011), *Food Export Restrictions: Review of the 2007–2010 Experience and Considerations for Disciplining Restrictive Measures*, FAO Commodity and

Trade Policy Research Working Paper No. 32, www.fao.org/fileadmin/templates/est/PUBLICATIONS/Comm_Working_Papers/EST-WP32.pdf.

Sida, L., Gray, B. and Asmare, E. (2012), *IASC Real-Time Evaluation of the Humanitarian Response to the Horn of Africa Drought Crisis: Ethiopia*, http://ochanet.unocha.org/p/Documents/IASC%20RTE%20Ethiopia%202012.pdf.

Silva, M. (2010), 'Somalia: State Failure, Piracy and the Challenge to International Law', *Virginia Journal of International Law*, Vol. 50, No. 3, pp. 553–578.

Sirin, C.V. (2011) 'Scarcity-Induced Domestic Conflict: Examining the Interactive Effects of Environmental Scarcity and "Ethnic" Population Pressures', *Civil Wars*, Vol. 13, No. 2, pp. 122–140.

Smith, D. and Vivekananda, J. (2007), *A Climate of Conflict: The links between climate change, peace and war* (London: International Alert), http://reliefweb.int/sites/reliefweb.int/files/resources/16A12BCAEAD0E411852573AE007570A3-International%20Alert_Climate%20of%20Conflict_07.pdf.

Solomon, M. (2012), *The Rise of Resource Nationalism: A Resurgence of State Control in an Era of Free Markets Or The Legitimate Search for a New Equilibrium?*, Southern African Institute of Mining and Metallurgy, http://www.saimm.co.za/Conferences/ResourceNationalism/ResourceNationalism-20120601.pdf.

Stevens, D. (1999), 'World War II Economic Warfare: The United States, Britain, and Portuguese Wolfram', *The Historian*, Vol. 61, No. 3, pp 539–56.

Stevens, P. (2008), 'National oil companies and international oil companies in the Middle East: Under the shadow of government and the resource nationalism cycle', *World Energy Law & Business*, Vol. 1, No. 1, pp. 5–30.

Stevens, P. (2008, 2009), *The Coming Oil Supply Crunch* (London: Chatham House).

Stevens, P. (2009), *Transit Troubles: Pipelines as a Source of Conflict* (London: Chatham House).

Stevens, P. (2010), *The Shale Gas Revolution: Hype and Reality* (London: Chatham House).

Stevens, P. (2012), *An Embargo on Iranian Crude Oil Exports: How Likely and with What Impact?* (London: Chatham House).

Stevens, P. (2012), *The 'Shale Gas Revolution': Developments and Changes* (London: Chatham House).

Streifel, S. (2006), *Impact of China and India on Global Commodity Markets*, World Bank working paper, http://siteresources.worldbank.org/INTCHIINDGLOECO/Resources/ChinaIndiaCommodityImpact.pdf.

Strzepek, K. and Boehlert, B. (2010), 'Competition for water for the food system', *Philosophical Transactions of the Royal Society*, Vol. 365, No. 1554, pp. 2927–2940.

Sumaila, U.R., Khan, A.S., Dyck, A.J. et al. (2010), 'A bottom-up re-estimation of global fisheries subsidies', *Journal of Bioeconomics*, Vol. 12, pp. 201–225.

Sustainable Europe Research Institute and Wuppertal Institute for Climate (2010), *Resource use and resource efficiency in Asia: A pilot study on trends over the past 25 years*, World Resources Forum, http://www.worldresourcesforum.org/files/Resource%20efficiency%20in%20Asia_final_0.pdf.

Thanhniennews (2012), 'Vietnam 2015 coal output to rise to 55–58 mln tons: gov't', Talkvietnam, 18 August, http://talkvietnam.com/2012/08/vietnam-2015-coal-output-to-rise-to-55-58-mln-tons-govt/.

Thomas, H. (2012), 'Difficult times for miners as costs rise', *Financial Times*, 29 May, http://www.ft.com/cms/s/0/b7e419ea-a996-11e1-9972-00144feabdc0.html#axzz24wdVnrhu.

Thurtell, D. (2011), 'Yuan Very Hungry Dragon: A Five-Year Outlook For Zinc', Citi presentation at the International Lead Zinc Study Group, 28 September.

Tir, J. and Stinnett, D.M. (2012), 'Weathering Climate Change: Can Institutions Mitigate International Water Conflict?', *Journal of Peace Research*, Vol. 49, No.1, pp. 211–225.

Tirado, R. and Allsopp, M. (2012), 'Phosphorus in agriculture: Problems and solutions', Greenpeace Research Laboratories Technical Report(Review) 02-2012, http://www.greenpeace.to/greenpeace/wp-content/uploads/2012/06/Tirado-and-Allsopp-2012-Phosphorus-in-Agriculture-Technical-Report-02-2012.pdf.

Trembath, A., Jenkins, J., Nordhaus, T., Shellenberger, M. (2012), *Where the Shale Gas Revolution Came From: Government's Role in Development of Hydraulic Fracturing in Shale,* Breakthrough Institute Energy & Climate Program, http://thebreakthrough.org/blog/Where_the_Shale_Gas_Revolution_Came_From.pdf.

Trench, A. (2010), 'The China Influence – Commodity Markets to 2012 and Beyond', Australian Resources Chinese Investment Conference, Adelaide, July, http://www.scribd.com/doc/81158181/1420-CRU.

Trikki, T. and Affes, Y. (2011), 'Managing Commodity Price Volatility in Africa', *Africa Economic Brief*, Vol. 2, No. 12.

Tu, J. (2011), *Industrial Organisation Of The Chinese Coal Industry,* Freeman Spogli Institute for International Studies, http://carnegieendowment.org/files/China_Coal_Value_Chain_Kevin_Tu3.pdf.

UK Timber Trade Federation (2010), *UK Timber Industry Certification*, http://www.cpet.org.uk/files/TimberTTFreport.pdf.

UNCSD (United Nations Conference on Sustainable Development) (2012), 'The Future We Want', www.un.org/en/sustainablefuture/.

UNCTAD (United Nations Conference on Trade and Development) (2002) *The Impact of High Energy Prices on Trade and Development*

UNCTAD (2011), *Recent Developments in Key Commodity Markets: Trends and Challenges*, http://unctad.org/en/docs/cimem2d19_en.pdf.

UNCTAD (2011), *Review of Maritime Transport 2011*, http://unctad.org/en/docs/rmt2011_en.pdf.

UNCTAD (2011), *World Investment Report 2011: Non-equity Modes of International Production and Development*, p. x, www.unctad-docs.org/files/UNCTAD-WIR2011-Full-en.pdf.

UNCTAD World Investment Forum (2012), *Sovereign Wealth Fund Round Table: Exploring the Potential of Sovereign Wealth Funds for Investment in Sustainable Development,* UNCTAD World Investment Forum 2012 Issues Note, http://unctad-worldinvestmentforum.org/assets/2012-forum-docs/WIF-SWF-Issues-Note-11-Apr.pdf.

UNCTADSTAT (United Nations Conference on Trade and Development Statistical Database) (2012), *International Trade in Goods and Services,* http://unctadstat.unctad.org/.

Under Secretary of Defense for Acquisition (2009), *Reconfiguration of the National Defense Stockpile Report to Congress*, U.S. Department of Defense.

UNEP (United Nations Environment Programme) (2010), *Metal Stocks in Society: Scientific synthesis*, http://www.unep.org/resourcepanel/Portals/24102/PDFs/Metalstocksinsociety.pdf.

UNEP (2011), Phosphorus and Food Production, UNEP Yearbook 2011, http://www.unep.org/yearbook/2011/pdfs/phosphorus_and_food_productioin.pdf.

UNEP (2012), *Global Environment Outlook 5: Summary for Policy Makers* (Rome: UNEP), http://www.unep.org/geo/pdfs/GEO5_SPM_English.pdf.

UNEP, International Trade Centre (ITC) and International Centre for Trade and Sustainable Development (ICTSD) (2012), *Trade and Environment Briefings: Export Restrictions*, International Centre for Trade and Sustainable Development Policy Brief No. 2, http://ictsd.org/downloads/2012/06/export-restrictions1.pdf.

UNISDR (United Nations International Strategy for Disaster Reduction) (2011), *Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disaster, Mid-Term Review* (Geneva: UNISDR), http://www.unisdr.org/we/inform/publications/18197.

UN (United Nations) (2009), *Climate Change and its Possible Security Implications*, Report of the Secretary General, http://daccess-dds-ny.un.org/doc/UNDOC/GEN/N09/509/46/PDF/N0950946.pdf?OpenElement.

UN (2010), 'Harmonized Commodity Description and Coding Systems (HS)', UN Statistics Division, http://unstats.un.org/unsd/tradekb/Knowledgebase/Harmonized-Commodity-Description-and-Coding-Systems-HS.

UN (2011), *World Population Prospects – 2010 Revision, medium variant*, http://esa.un.org/wpp/Documentation/pdf/WPP2010_Highlights.pdf.

United Nations Economic and Social Commission for Asia and the Pacific (2012), *Low Carbon Green Growth Roadmap for Asia and the Pacific, Turning Resource constraints and the climate crisis into economic growth opportunities*, http://www.unescap.org/esd/publications/environment/lcgg-roadmap/Roadmap_FINAL_15_6_12.pdf.

United Press International (2012), 'Sudans on Brink of All-out War over Oil', 3 May, http://www.upi.com/Business_News/Energy-Resources/2012/05/03/Sudans-on-brink-of-all-out-war-over-oil/UPI-16581336078729/#ixzz258ktJafr.

USDA (US Department of Agriculture) (2012), *USDA Agricultural Projections to 2021*, www.ers.usda.gov/media/273343/oce121_2_.pdf.

USDA, Foreign Agricultural Service (FAS) (2010), *Cambodia: Future Growth Rate of Rice Production Uncertain*, Commodity Intelligence Report, 26 January, http://www.pecad.fas.usda.gov/highlights/2010/01/cambodia/.

USDA Foreign Agricultural Service (FAS) Production, Supply & Distribution (PSD) statistics, http://www.fas.usda.gov/psdonline/psdQuery.aspx.

USGS (2012), *Mineral Yearbook and USGS Commodity Summaries* (various editions), http://minerals.usgs.gov/minerals/pubs/commodity/myb/.

US Department of Energy (DoE) (2010), *Critical Materials Strategy*, http://energy.gov/sites/prod/files/edg/news/documents/criticalmaterialsstrategy.pdf.

US EIA (US Energy Information Administration) (2012), 'Carbon Dioxide Emissions From Energy Consumption by Source', *Monthly Energy Review*, August, www.eia.gov/totalenergy/data/monthly/#environment.

US EIA (2012), *Country Report: Venezuela*, http://www.eia.gov/countries/analysisbriefs/Venezuela/venezuela.pdf.

US EIA (2012), 'What is the role of coal in the United States?', Energy in Brief article, http://www.eia.gov/energy_in_brief/role_coal_us.cfm.

US NIC (US National Intelligence Council) (2008), *Global Trends 2025: A Transformed World* (Washington, DC: U.S. Government Printing Office), http://www.aicpa.org/research/cpahorizons2025/globalforces/downloadabledocuments/globaltrends.pdf.

US NIC (2009), *China: The Impacts of Climate Change 2030*, U.S. National Intelligence Council Conference Report, http://www.dni.gov/files/documents/2009%20Conference%20Report_China_The%20Impact%20of%20Climate%20Change%20to%202030.pdf.

US NIC (2009), *India: The Impacts of Climate Change to 2030*, U.S. National Intelligence Council Conference Report, http://www.dni.gov/files/documents/2009%20Conference%20Report_India_The%20Impact%20of%20Climate%20Change%20to%202030.pdf.

US NIC (2009), *Russia: The Impacts of Climate Change 2030*, U.S. National Intelligence Council Conference Report, http://www.dni.gov/files/documents/2009%20Conference%20Report_Russia_The%20Impact%20of%20Climate%20Change%20to%202030.pdf.

US NIC (2011), *Impacts of Technology on Freshwater Availability to 2040*, U.S. National Intelligence Council Report NICR 2011-01.

US NIC (2012), *Global Water Security*, Office of the Director of National Intelligence, http://www.dni.gov/files/documents/Newsroom/Press%20Releases/ICA_Global%20Water%20Security.pdf.

US NIC (forthcoming 2013), *US National Security Impacts of Natural Resources by 2020, 2030 and 2040.*

Van Kauwenbergh, S. (2010), World Phosphate Rock Reserves and Resources, International Fertilizer Development Center (IFDC), http://pdf.usaid.gov/pdf_docs/PNADW835.pdf.

Van Otterdijk, R. and Meybeck, A. (2011), *Global Food Losses and Food Waste* (Rome: FAO), http://www.fao.org/docrep/014/mb060e/mb060e00.pdf.

Venton, C. (2007), 'Justifying the cost of disaster risk reduction: a summary of cost-benefit analysis', *Humanitarian Exchange Magazine*, No. 38, http://www.odihpn.org/humanitarian-exchange-magazine/issue-38/justifying-the-cost-of-disaster-risk-reduction-a-summary-of-cost%E2%80%93benefit-analysis.

Venton, C. (2012), 'The Economics of Resilience: Evidence from Kenya and Ethiopia', presentation, 28 May 2012, http://typo3.fao.org/fileadmin/user_upload/drought/docs/Economics%20of%20Resilience-Evidence%20from%20Kenya%20&%20Ethiopia%20%2819%20July%202012%29.pdf.

Von Braun, J. et al. (2009), *Implementing Physical and Virtual Food Reserves to Protect the Poor and Prevent Market Failure*, Policy Brief 10, International Food Policy Research Institute (IFPRI), http://www.ifpri.org/sites/default/files/publications/bp010.pdf.

Vörösmarty, C, McIntyre P., Gessner M., at al. (2010), 'Global threats to human water security and river biodiversity', *Nature,* Vol. 467, pp. 555–561.

Wada, Y., van Beek, L., van Kempen, C., Reckman, J., Vasak, S. and Bierkens, M. (2010), 'Global depletion of groundwater resources', *Geophysical Research Letters*, Vol. 37, No. L20402.

Wada, Y., van Beek, L. and Bierkens, M. (2012), 'Nonsustainable groundwater sustaining irrigation: A global assessment', Water Resources Research, Vol. 48, No. W00L06.

Wagner, J. (2012), '"Going out": Is China's skillful use of soft power in Sub-Saharan Africa a threat to U.S. Interests?', *Joint Force Quarterly*, Vol. 64, No. 1, pp. 99–106.

Waughray, D. and Workman, J.G. (eds) (2011), *Water Security: The Water-Food-Energy-Climate Nexus* (Washington, DC: Covelo Press).

Wiggins, S. and Keats, S. (2009), *Grain stocks and price spikes* (London: Overseas Development Institute), http://www.odi.org.uk/resources/docs/7631.pdf.

Willenbockel, D. (2011), 'Exploring Food Price Scenarios Towards 2030 with a Global Multi-Region Model', *Oxfam International Research Report* (Oxford: Oxfam International).

Winters, L.A. and Yusuf, S. (eds) (2007), *Dancing with Giants: China, India, and the Global Economy* (Washington, DC: The World Bank).

Wolf, A.T. (1999), 'Water Wars and Water Reality: Conflict and Cooperation Along International Waterways', pp. 251–65 in Lonergan, S. C. (ed), Environmental Change, Adaptation, and Human Security (Dordrecht: Kluwer Academic).

World Bank (2009), *Global Economic Prospects: Commodities at Crossroads*, http://siteresources.worldbank.org/INTGEP2009/Resources/10363_WebPDF-w47.pdf.

World Bank (2010), *Deep Wells and Prudence: Towards Pragmatic Action for Addressing Groundwater Overexploitation in India* (Washington, DC: The World Bank).

World Bank (2012), 'East Asia and Pacific Data Monitor: October 2012', www.worldbank.org/content/

dam/Worldbank/document/EAP-Data-Monitor-October-2012.pdf.

World Bank (2012), 'India Groundwater: a Valuable but Diminishing Resource', 6 March, www.worldbank.org/en/news/2012/03/06/india-groundwater-critical-diminishing.

World Bank and Development Research Center, State Council of the People's Republic of China (2012), *China 2030: Building a Modern, Harmonious, and Creative High-Income Society* (Washington, DC: The World Bank), www.worldbank.org/content/dam/Worldbank/document/China-2030-complete.pdf.

World Business Council for Sustainable Development (2009), *Transforming the market*, Energy Efficiency in Buildings Report, http://www.wbcsd.org/transformingthemarketeeb.aspx.

World Economic Forum (2012), *More with Less: Scaling Sustainable Consumption and Resource Efficiency*, http://www3.weforum.org/docs/IP/CO/WEF_CO_ScalingSustainableConsumptionResourceEfficiency_Report_2012.pdf.

World Energy Council (2010), *Water for Energy* (London: World Energy Council), http://www.worldenergy.org/documents/water_energy_1.pdf.

World Ocean Review (2010), 'World Ocean Review – Living with the Oceans', http://worldoceanreview.com/en/order/.

World Steel Association (2012), *Steel Statistical Yearbook* (various editions), http://www.worldsteel.org/statistics/statistics-archive/yearbook-archive.html.

World Water Assessment Programme (2009), *The United Nations World Water Development Report 3: Water in a Changing World* (Paris: UNESCO and London: Earthscan).

Worm, B. et al. (2006), 'Impacts of Biodiversity Loss on Ocean Ecosystem Services', *Science*, Vol. 314, No. 5800, pp. 787–790.

WTO (World Trade Organization) (2010), *World Trade Report 2010*, http://www.wto.org/english/res_e/booksp_e/anrep_e/world_trade_report10_e.pdf.

WTO, *Subsidies and Countervailing Measures: Overview*, http://www.wto.org/english/tratop_e/scm_e/subs_e.htm.

Wright, B. (2009), *International Grain Reserves: And Other Instruments to Address Volatility in Grain Markets*, Policy Research Working Paper 5028 (Washington, DC: The World Bank), http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/2009/08/25/000158349_20090825154655/Rendered/PDF/WPS5028.pdf.

Wright, B. (2011), 'Addressing the biofuels problem: food security options for agricultural feedstocks' in Prakash, A. (ed) *Safeguarding Food Security in Volatile Global Markets* (Rome: FAO), pp. 481–492.

Wright, B. (2011), 'The Economics of Grain Price Volatility', *Applied Economic Perspectives and Policy*, Vol. 33, No. 1, pp. 32–58.

Wright, B. and Cafiero, C. (2010), *Grain Reserves and Food Security in MENA Countries* (Washington, DC: The World Bank), http://siteresources.worldbank.org/DEC/.Resources/84797-1288208580656/7508096-1288208619603/Wright_Grain_Reserves_and_Food_Security_in_MENA_Countries_PAPER.pdf.

WWF (2011), *Soya and the Cerrado: Brazil's forgotten jewel*, http://assets.wwf.org.uk/downloads/soya_and_the_cerrado.pdf.

Zeitoun, M. (2008), *Power and Water in the Middle East: The Hidden Politics of the Palestinian-Israeli Water Conflict* (London and New York: I.B. Tauris).

Zeitoun, M. and Allan, J.A. (2008), 'Applying Hegemony and Power Theory to Transboundary Water Analysis', *Water Policy*, Vol. 10, No. 2, pp. 3–12, https://www.uea.ac.uk/polopoly_fs/1.147022!ZeitounAllan_Power_Hegemony_Theory_HH_Special_Issue.pdf.

Yao, S. (2006), *Chinese Agricultural Reform, the WTO and FTA Negotiations*, Asia-Pacific Research and Training Network on Trade Working Paper Series, No. 15, http://www.unescap.org/tid/artnet/pub/wp1506.pdf.

Yao, S., Sutherland, D. and Chen, J. (2010), 'China's Outward FDI and Resource-Seeking Strategy: A Case Study on Chinalco and Rio Tinto', *Asia-Pacific Journal of Accounting & Economics*, Vol. 17, pp. 313–326.

Zagema, B. (2011), *Land and Power: The growing scandal surrounding the new wave of investments in land*, (Oxford: Oxfam), http://www.oxfam.org/en/grow/policy/land-and-power.

Zala, B. (forthcoming), 'The Strategic Dimensions of Water: From National Security to Sustainable Security' in Lankford, B.A., Bakker, K., Zeitoun, M. and Conway, D. (eds), *Water Security: Principles, Perspectives and Practices* (London: Earthscan). No. 282y_HH_Special_Issue.pdf.

Zala, B. and Rogers, P. (2011), 'The "Other" Global Security Challenges: Socioeconomic and Environmental Realities after the War on Terror', *RUSI Journal*, Vol. 156, No. 4, pp. 26–33.

CHATHAM HOUSE

Chatham House, 10 St James's Square, London SW1Y 4LE
T: +44 (0)20 7957 5700 E: contact@chathamhouse.org
F: +44 (0)20 7957 5710 www.chathamhouse.org

Charity Registration Number: 208223