COMMITTED TO IMPROVING THE STATE OF THE WORLD

World Scenario Series

The Future Availability of Natural Resources

A New Paradigm for Global Resource Availability

November 2014

REF 231014

Contents

3 Preface

5 Executive Summary

7 **Section I.** Resource Availability – in the Eye of the Beholder

8 The contested nature of resource availability

10 Paradigms of resource availability

12 Rising costs

13 Long-term abundance

14 Social injustice

15 The perils of incomplete paradigms

16 **Section II.** Reappraising the Drivers of Resource Availability: A More Integrated Natural Resource Paradigm

18 Underestimated drivers of supply and demand

21 Nuanced drivers of growth

22 Resource interconnections

24 Distributional issues

25 Environmental externalities

25 Towards an integrated paradigm: glocal crises, contagion and environmental imperatives

28 **Section III.** Challenging Scenarios

31 Clash of interests

35 Alarming abundance

39 Challenges of transition

42 **Section IV.** Response Strategies

46 Conclusion

48 Annex: Process and Stakeholder Engagement

49 Bibliography

51 Acknowledgements and Project Team

Preface

Kristel Van der Elst
Senior Director, Head of Strategic Foresight, World Economic Forum

Nicholas Davis
Director, Head of Europe, World Economic Forum

The availability of natural resources, particularly food, water, energy and minerals, is an important issue but also a highly contested one, mostly because of the many different perspectives and opinions held by both experts and the general public.

This report takes a novel approach to enhance the understanding of natural resource availability over a 20-year time frame. It combines an analysis of the important factors of supply and demand at a global level, with an investigation into the different dominant "paradigms" that stakeholders use in discussing or assessing natural resources, with paradigms in this context being a combination of different, often deeply held assumptions. The report presents three scenarios that challenge these paradigms under different future conditions, and also reveals a number of important insights that come from a deeper understanding of the complex interactions inherent in resource flows. These aspects are summarized in the report's key messages (Box 1).

The World Economic Forum's approach was developed at the request of stakeholders across several of the Forum's communities. While desiring to collaborate on the long-term availability of food, they rapidly discovered that they held conflicting views on this issue's outlook and its drivers. The Forum's multistakeholder community contributed to the creation of a more holistic and constructive view of the future availability of natural resources by providing data and perspectives from interviews and workshops, which involved more than 300 global experts and relevant stakeholders over two years.

It is hoped the frameworks and data presented herein will not only continue to help clarify discussions and enhance mutual understanding between stakeholders on the challenges of resource availability, but also to assist with policy choices at the global, national and local levels – increasing the potential for collaborative action where it is most urgently needed.

Box 1. Key messages

Fragmented paradigms

Stakeholders tend to view the future availability of natural resources through the lens of one of four divergent paradigms:

- **#1** Focus on threats of material exhaustion
- **#2** Focus on rising costs
- **#3** Focus on abundance
- **#4** Focus on social justice

Insights

A lack of recognition of the assumptions behind each of these paradigms leads to polarization amongst decision-makers and, in so doing, impedes effective resource management. Analysis of these assumptions surfaces five key insights supported by most stakeholders that are useful in resolving disputes:

- **#1** Supply does not depend merely on biophysical availability
- **#2** Demand depends more on economic growth than population growth
- **#3** Political, economic, and social interconnections are critical but often underestimated
- **#4** Distributional issues are underap - preciated and can lead to systemic risks
- **#5** Tight feedback loops connect resource availability to climate and environmental change

An integrated paradigm

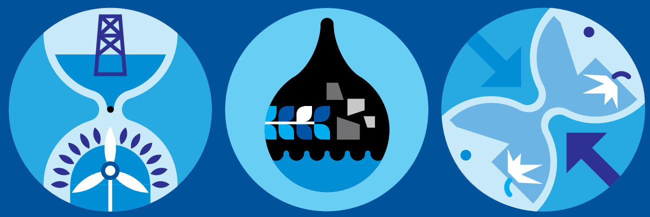
These insights allow us to construct a more integrated and holistic fifth paradigm:

- Geographic and temporal scales are critical variables for the availability of resources
- There are sufficient biophysical reserves or potential production of most natural resources at a global level to well past 2035
- “Market” or “user” availability is the primary concern, and this requires an understanding of how policies, prices, technology and preferences affect supply and demand
- The key risks to availability stem from rising production costs, the risks of local shortages and disruptions to global flows from “above ground” risks
- Multi-level connections amongst resources create tight feedback loops between local and global crises

Challenging scenarios

As a means of challenging stakeholders’ four fragmented paradigms and highlighting the above insights, the report presents three challenging scenarios for the future of resource availability:

- **Clash of Interests:** About evitable resource scarcity that is triggered by pre-emptive geopolitical escalations
- **Alarming Abundance:** About the limits of the desirability of resource abundance
- **Challenge of Transition:** About the difficulties and unintended consequences involved in shifting to a low-carbon world



Social and political innovations

Out of the scenarios and analysis emerge the need for social and political innovation in four specific areas

- Understanding and acknowledging different paradigms and underlying assumptions
- Moving decision makers further towards integrated specialisation – engaging multiple disciplines in resource management
- Managing and capitalising on existing and potential resource efficiencies using social and political levers
- Driving more focus on two sets of risks stemming from resource use: impact on the environment, and social disruption from distributional issues

Executive Summary

The future availability of natural resources – defined here as food, water, energy, and minerals – is critically important. All individuals and nations require them to sustain current standards of living, as well as to increase economic activity. Current and future resource availability is therefore a political, economic, social and environmental issue that can impact all stakeholder groups, often with disproportionate and indirect consequences. Given that resource-related supply chains are often global in nature, these consequences may easily be underestimated in both scale and scope.

Perspectives on future resource availability are, however, highly contested, mostly because natural resource supply and demand are hard to predict and complex in nature (Box 2). Stakeholders across different sectors, industries, countries and disciplines often disagree on the relative urgency to act on different perceived resource risks, and the appropriate responses in mitigation.

This work, which was conducted over two years in consultation with over 300 experts and decision-makers, aims to contribute to the debate by proposing a new paradigm for global resource availability. **The hope is that a more integrated, future-oriented view can shift the debate beyond a simplistic and polarized scarcity-abundance debate, and allow experts and decision-makers to find dispassionate common ground** to effectively tackle the challenge of resource availability.

Section I reveals that experts and decision-makers from both the public and private sectors tend to have **four distinct sets of perceptions (paradigms) of natural resource availability**:

- Threats of material exhaustion
- Concern about rising costs
- Long-term abundance
- Social injustice focused on distributional challenges

The data from interviews indicate a tendency for policy-makers and other decision-makers to define their resource management strategies and policies based primarily on one of these four conflicting paradigms – and, without clearly defining the deeply held assumptions that support them. In reality, while all four paradigms are valid, they are only true at specific scales or for specific resources, creating the potential for miscommunication. Moreover, the same underlying data can be framed at times to support multiple, conflicting conclusions. **Decision-makers are severely hampered, both individually and collectively, when having neither an appreciation of the overall system of resource availability, nor the ability to discuss the issue constructively across sectors and disciplines**.

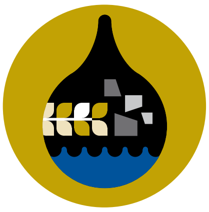
Section II uses these assumptions and an analysis of global data to present **five cross-cutting and important insights:**

1. The role of technology, preferences, policies and prices is underestimated when forecasting supply and demand for natural resources.
2. Contrary to popular perceptions, population growth is and will be far less significant in spurring resource demand than economic growth and development in the period to 2035.
3. Physical, economic, political and social interconnections between resources are growing, and will increasingly influence resource availability, in both positive and negative ways.
4. Defining natural resource availability often fails to consider how they are distributed, both between countries and between individuals within countries.
5. Environmental factors create local and global risks to resource availability, while resource production and use are the primary factors in environmental risks.

From these insights, the report constructs a holistic paradigm aimed at overcoming the fragmented views typically held by stakeholders. This paradigm shows that while the world has sufficient global stocks of natural resources to meet most of society's demands, the flow of resource distribution is increasingly threatened by highly uncertain "above ground" factors. Similarly, local crises risk having disproportionate global effects on resources because of the high level of interconnections among resources and the factors influencing their availability. This, in turn, indicates a need for heightened care in addressing social and environmental considerations.

Section III provides three relevant and demanding narratives for the times ahead, to illustrate the challenges and opportunities associated with future resource availability, and to sensitize decision-makers about potential scenarios at odds with their assumptions. These narratives are:

Clash of interests: A world where resource scarcity plays out because of pre-emptive geopolitical measures taken by countries acting on psychological fears. Market deficiencies appear as the world's geo-economic commons are divided into myriad competing channels of exchange.

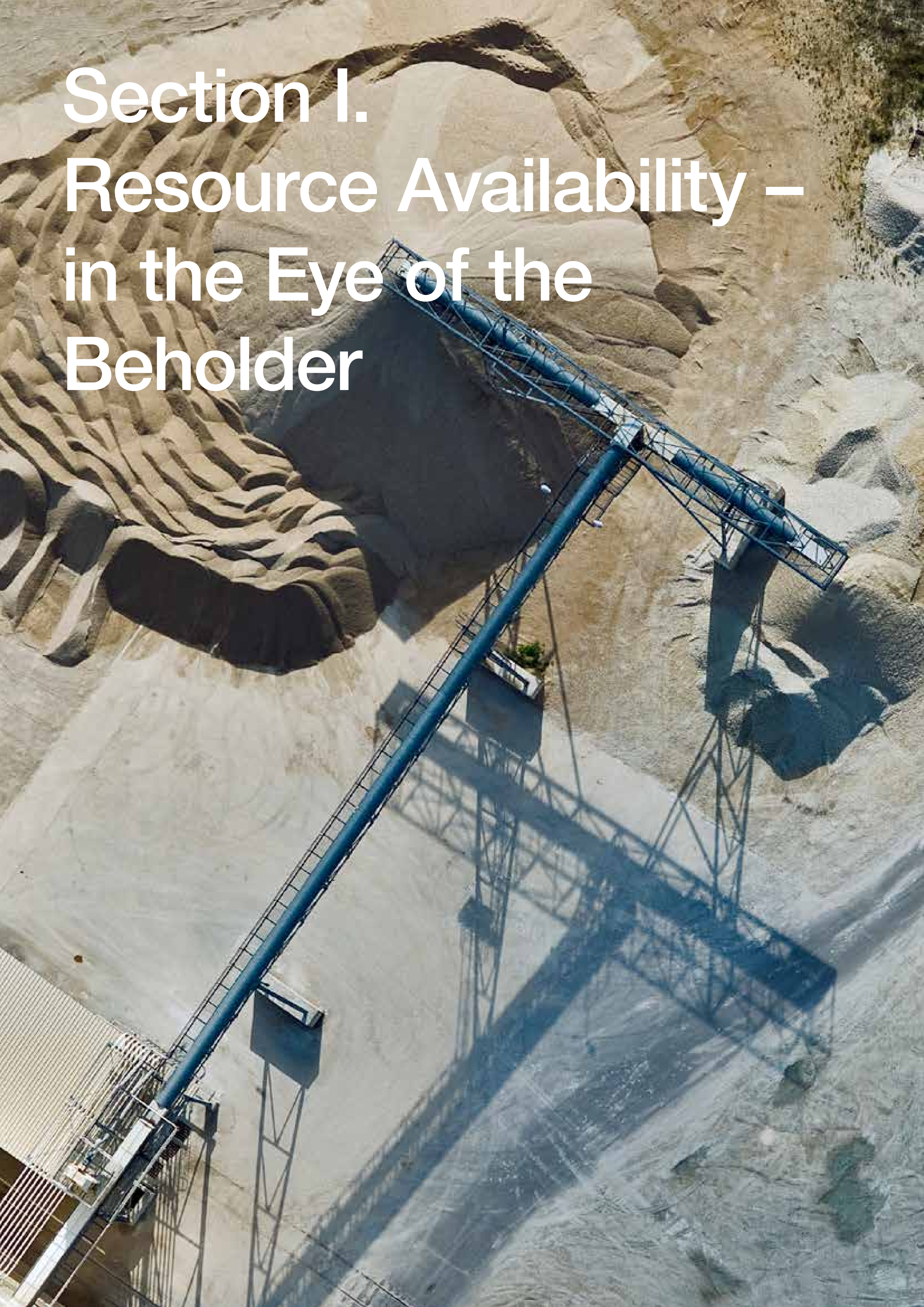


Alarming abundance: The apparent benefits of plentiful fossil and renewable energy risk being overshadowed in this world by their impact on associated resources such as water, and by their social and environmental consequences.

Challenge of transition: In this world, governments, consumers and companies realize and accept the full costs of their transition to a low-carbon, durable and sustainably sourced economy. They suffer through what they perceive as a change in their use of natural resources – one that is essential for social and environmental sustainability.

Responding effectively to concerns about resource availability requires global, national and local decision-makers to have a more complete, nuanced and common understanding of resource availability, as well as its implications for economies and political systems at multiple levels. Consequently, this report concludes by highlighting the need for people to better understand their own natural resource paradigm and that of others; better appreciate the real drivers of resource availability; make an effort to increase resource efficiency practices; invest in "integrated specialization" to cut across isolated resource management; be more devoted to social and political considerations; and provide support for greater expertise in environmental mitigation and adaptation.

Section I. Resource Availability – in the Eye of the Beholder



The contested nature of resource availability

Concern over the potential for resource scarcity has grown in the past decade among all stakeholder groups – from experts and civil society actors to government and business players. A recent survey by the World Economic Forum's Network of Global Agenda Councils showed that resource scarcity was the second most underestimated global issue for its 800 experts, surpassed only by the related issue of income disparity. Similar results were obtained in the Forum's issue mapping by 500 chief executive officers and other leaders; and, food and water scarcity ranked the highest of 30 risks in the Forum's Global Risks 2013 and Global Risks 2014 reports. However despite agreeing on the importance of this issue, decision-makers still seem confused about its true implications.

For the last two years, the World Economic Forum has interviewed and held seven workshops for experts and decision-makers, engaging more than 300 of them to explore their understanding of resource availability over a 20-year time horizon. The research indicates that **opinions are starkly divided on the risks to resource availability, which resources are most affected, and how the dynamics are likely to play out in the coming decades**. These opinions differ by group of stakeholders, by which resources are being considered and whether the assessment is global, regional or local.

Box 2. The Future of Natural Resources: Important, Contested, Uncertain and Complex

Concerns over the future availability of natural resources – defined here as food, water, energy and minerals – has grown particularly acute in the early 21st century. At a material level, this was largely because of rapid growth in demand, especially in Asia, and resulting price increases that wiped out reductions in average commodity prices from the past 100 years (Figure 1). These concerns have been compounded by scarcity issues, once viewed as geographically contained or as temporary phenomena, that have become global in scope and impact long-term views. In parallel, the risk of reaching a point of no return in environmental degradation has not only created concern that a depleted ecosystem could threaten the availability of natural resources, but also given rise to worries that newfound abundance in certain stocks (e.g. shale gas) could further damage the environment's long-term sustainability.

The resulting picture of the future availability of natural resources is:

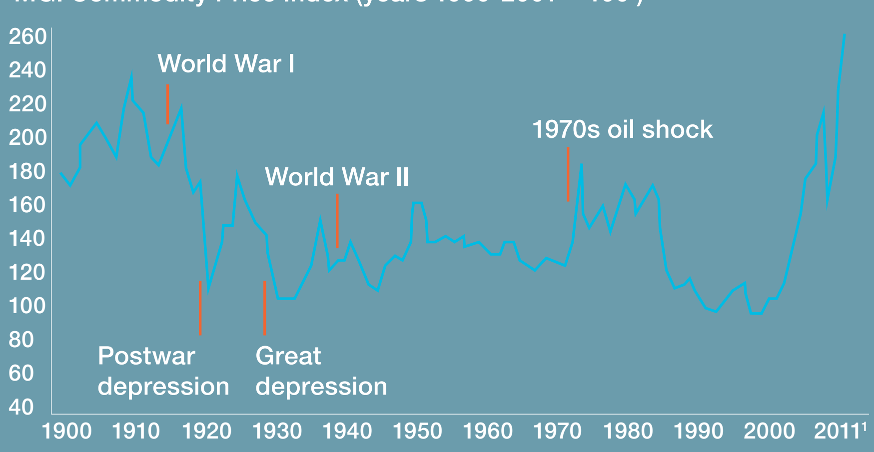
Critically important to stakeholders: Despite exhortations by some to decouple economic growth from the increasing use of resources, the world's current economic systems require reliable access to natural resources to deliver populations with even a minimal quality of life. Shortages in critical inputs could cause significant damage to economic and social systems, leading to geopolitical conflict, political instability and social unrest. Such effects are unevenly distributed; as with global food markets in recent years, high and volatile commodity prices can create existential concerns for low-income families, contribute to political instability and influence trends such as global migration.

Contested due to polarization: Over this century's first decade, a flurry of academic papers, statements from civil society, advice from investors and alarming media reports have resulted in an increasing polarization of viewpoints on the matter, with stakeholders' perspectives sharply divided as either bearish or bullish on future resource availability. The result has been a muddled picture favouring antagonism and reasons linked to personal opinion, rather than a common understanding and collaborative solutions to the world's resource challenge.

Complex to understand: Natural resource availability is the function of the supply and demand of resources that are discovered, developed, processed, distributed and consumed in intricate value chains, a significant portion of which are global. Though these value chains seem to operate as markets for most end consumers, they all suffer from distortions at different points, thanks to monopolistic structures, constrained supply routes and government intervention (subsidies, taxation). Further, while nearly all natural-resource value chains are subject to physical interference from weather, climate and political instability, pricing on global markets is sensitive to the actions of traders and investors uninterested in physical delivery, and is thus exposed to the prevailing views on global economic growth.

Uncertain in its predictions. This complexity leads to significant uncertainty on future demand and supply of different resources, which are subject to consumer price sensitivity and myriad possible issues linked to supply. Surprises are also numerous on the upside, as abundant rainfall, technological breakthroughs and new discoveries can quickly cause a shift from scarcity to abundance. While almost all predictions of resource availability and prices use the recent past as a guide, both are highly volatile and have proved impossible to predict reliably over the medium and long term.

Figure 1. Sharp Increases in Commodity Prices Have Erased Price Declines



[1] 2011 prices are based on average of the eight months of 2011.

Source: Grilli and Yang; Stephan Pfaffenzeller; World Bank; International Monetary Fund (IMF); Organisation for Economic Co-operation and development (OECD); UN Food and Agriculture Organization (FAO); UN Comtrade; McKinsey analysis

Reproduced from: McKinsey & Company, 2011. *Resource Revolution: Meeting the world's energy, materials, food, and water needs*

Paradigms of resource availability

The interviews and workshops revealed that **four main perspectives or "paradigms"** of resource availability recur among experts, decision-makers and laypeople alike, and those from different backgrounds. These paradigms are:

Material exhaustion and crash – the threat of using up physical resources

Rising costs – the pressure caused by rising prices and costs of resources

Long-term abundance – the concerns about resource availability are irrational and overblown

Social injustice – distributional challenges and the risks that arise from uneven and unfair access to natural resources

Based on the interviews, a stakeholder's dominant paradigm related to resource availability seems to depend on the following factors, which often form part of an "unconscious framing" of the issue:

- **The physical and temporal boundaries of the resource system.** These include physical/geographical boundaries (particularly for natural systems such as water basins), economic boundaries that influence opportunities for trade, the time frame, and whether externalities are considered as relevant (e.g. impact on the environment).
- **The type of resource and its price.** Resource characteristics (e.g. renewable versus non-renewable) are clearly pertinent, while pricing affects assumptions about the incentives to conserve the resource, and the ability to transport and trade it to offset local physical scarcity through imports. Fresh water, for example, is often underpriced for consumers, leading to overconsumption. In addition, its high weight-to-price ratio makes transporting water uneconomic, leading to reliance on local supplies.
- **The relevant users.** A stakeholder analysing the availability of resources in the formal economy for a particular business sector may come to very different conclusions for the economic access and availability of resources for remote, marginalized populations in the same country.

Each paradigm can be linked with a particular set of assumptions that influence how an individual perceives and describes the likely dynamics of resource availability over the medium-term future. The paradigms, as well as their underlying assumptions and arguments, unconscious framing of issues, common supporters and examples, are described hereafter.

1

Paradigm

Material exhaustion and crash

Main argument

Society is facing hard limits, both physical and environmental, as decreasing supply of resources meets exponentially rising demand driven by population and economic growth. As these limits are reached, radical shifts in economies, infrastructure and daily lives are needed to avoid a catastrophic crash.

Illustrative quote

"Nature is the basis of our well-being and our prosperity – but we are using up way too much of the Earth's finite resources. WWF's *Living Planet Report* shows clearly that humanity's demands exceed our planet's capacity to sustain us – simply put, we are asking for more than we have available."
Jim Leape, Director-General, WWF International (2006-2014)

Assumptions and arguments

- The biosphere has a finite supply of material resources, but demand for them grows exponentially, leading inevitably to unprecedented shortages.
- Inherent physical and economic needs of life and development mean little room exists to substitute with new types of resources.
- Development and adoption of new technologies to increase resource supply will be too slow to close the gap between supply and demand.
- Society cannot simply ignore the exhaustion of resources, as many have an inherent value beyond their commodity price.

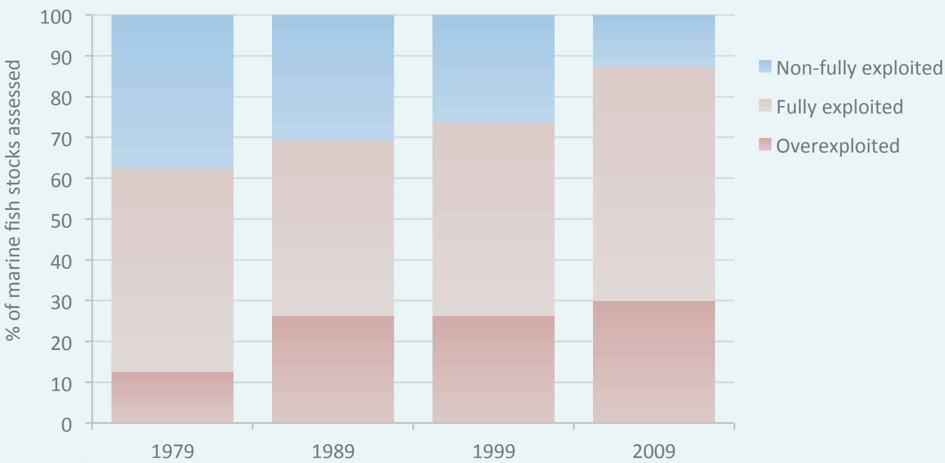
Unconscious framing

Stakeholders attached to this paradigm tend to think in the following ways:
- Long-term time frames: often more than 100 years in the future
- Locally bounded systems: local rather than global stocks
- Specific, clearly-defined resources as the dominant unit of analysis (e.g. particular freshwater basins, specific fisheries or stocks)
- Specific users linked to defined geographies

Common supporters

- Individuals working with non-governmental organizations focused on the environment, and other groups
- Individuals working with locally-constrained and threatened resources
- Media figures focused on extreme scenarios

Figure 2. Rapid Decline in Share of Marine Fish Stocks Not Fully Exploited

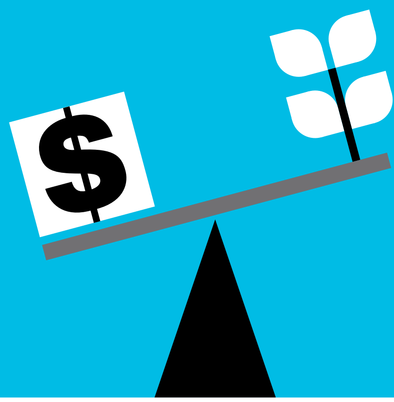


Source: Reproduced from FAO (2012)

2

Paradigm

Rising costs



Main argument

Resources are not about to physically run out, but many are likely to become significantly more expensive. This will result from increasing regulation, riskier development sites, higher input costs, technical and skills issues, supply chain fragility, low substitutability due to infrastructure lock-in, political challenges and lagging investment. Economic growth will be put increasingly at risk.

Illustrative quote

"We, and the rest of the mining sector, have seen unacceptable levels of cost increases over the past five years, particularly here in Australia. […] All of our management teams are focusing on aggressive cost compression to roll back these unsustainable cost pressures."
Tom Albanese, Chief Executive Officer, Rio Tinto (2007-2013)

Assumptions and arguments

– Even with technological progress, increasing complexity in the operating environment – whether technical (e.g. deep-water drilling) or political (e.g. operating in politically fragile economies) – constrains the exploitation of existing and future resources.
– Transactional barriers, such as shortages in scarce production inputs including machinery, rigs and skilled operators, can often impede technological progress and the desire to expand capacity.
– Pressures on companies' "licence to operate", in terms of evolving safety and environmental standards and resulting new regulations that lead to delays, are significantly increasing their costs.

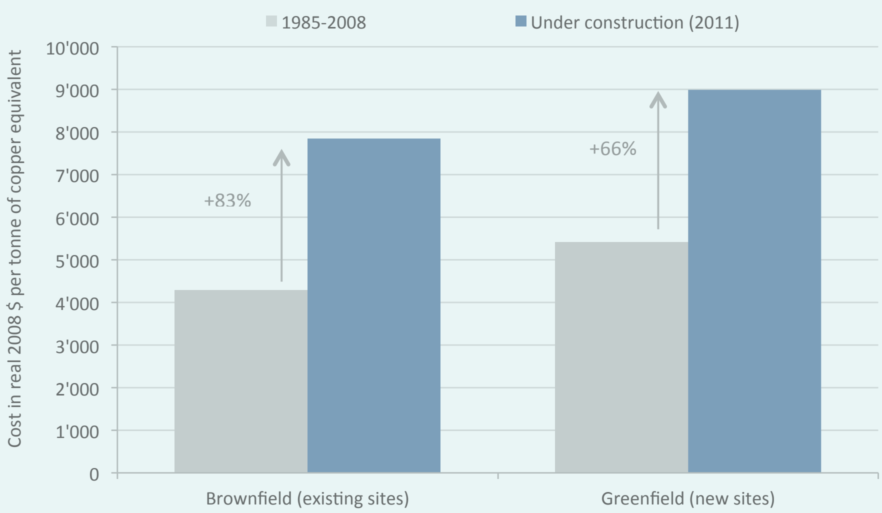
Unconscious framing

Stakeholders attached to this paradigm tend to think in the following ways:
– Short- to medium-term time frames: shorter than the human lifespan
– Global, traded resource markets linked to proven reserves
– Corporations or projects as the dominant unit of analysis, focusing on margins, markets and investment conditions
– Price-sensitive consumers

Common supporters

– Stakeholders linked to financial, extractive and agricultural sectors
– Risk and investment managers

Figure 3. Substantial Increase in Capital Cost of Copper Mine Projects

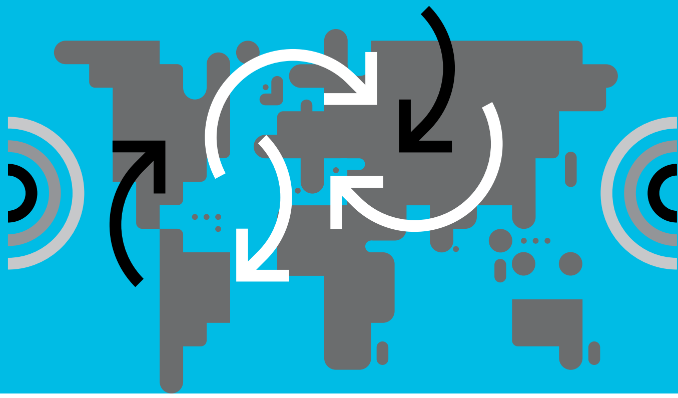


Source: World Economic Forum analysis, based on Xstrata (2011) and as reproduced in Stevens et al. (2013)

3

Paradigm

Long-term abundance



Main argument

Markets ensure that resource scarcity will not exist in the long term. Observed price rises result primarily from short-term imbalances and temporary shortages for certain inputs, and are the exception, not the norm. Competitive markets and technological innovation will bring supply and demand back into balance. Long-term, real resource prices will again trend downwards, while rare, local resource shortages can be solved by introducing market pricing mechanisms.

Illustrative quote

"Just about every important long-run measure of human material welfare shows improvement over the decades and centuries, in the United States and the rest of the world. Raw materials – all of them – have become less scarce rather than more."
Julian Simon (1932-1998), Professor of Business Administration, University of Maryland, USA

Assumptions and arguments

- Liberalized and globalized capitalist markets create sufficient incentive to innovate, and ensure the regular supply increases needed to keep long-term resource scarcity at bay. This has driven declines in prices over the last century.
- Technological innovations not only allow for expanded supply, but also complete substitution and open new sources (e.g. previous resource transitions, for example from wood to coal).
- Market failures and mispricing, which can lead to rare instances of localized resource shortages, can be solved with policy interventions.

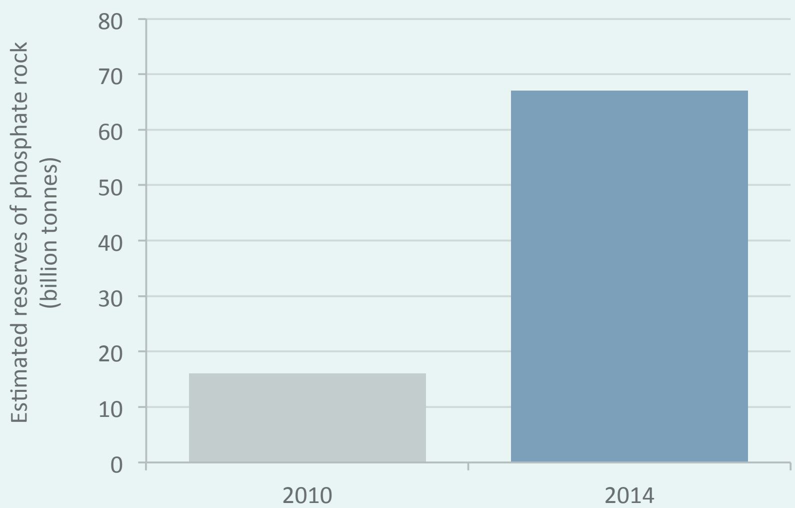
Unconscious framing

Stakeholders attached to this paradigm tend to think in the following ways:
- Long-term time frames: more than 20 years
- A global perspective going beyond segmentation between resources
- Market outcomes as the dominant unit of analysis: what matters is the end use for resources, not their origin

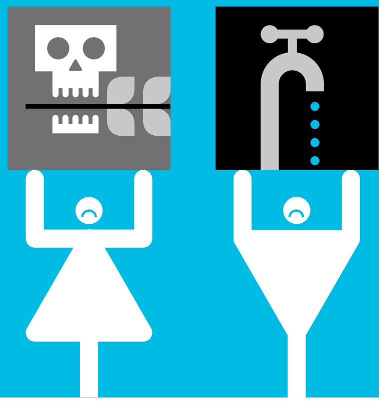
Common supporters

- Technologists
- Economists

Figure 4. Reserves of Key Resources Are Regularly Re-Evaluated for the Better



Source: USGS (2010; 2014)



4

Paradigm

Social injustice

Main argument

The absolute availability of resources is a distraction – the relative distribution of currently available resources is what really matters. Wealth and access to resources have been skewed to create critical social and humanitarian pressures, as well as those impacting development. Higher-income countries and groups must become more fair and equitable in distributing natural resources and their benefits. Part of the unfair distribution relates to who bears the costs of the negative externalities of resource production and consumption, as poorer nations and individuals are among the hardest hit.

Illustrative quote

"We are sleepwalking towards an avoidable age of crisis. One in seven people on the planet go hungry every day despite the fact that the world is capable of feeding everyone."
Dame Barbara Stocking, Chief Executive, Oxfam (2001-2013)

Assumptions and arguments

– Social justice and sustainable development are core ethical issues that markets are unable to address, given their proven inability to distribute goods fairly.
– The costs of negative environmental and social externalities are disproportionately borne by those least able to afford them, which is also deeply unfair.
– As a matter of ethics and values, those lucky enough to control access to resources should invest a significant portion of them to ensure that those deprived of resources are still able to experience their benefits.
– The trend towards a more educated, connected and aware global population will increase the visibility of unfair resource distribution and create pressures towards making it fairer.

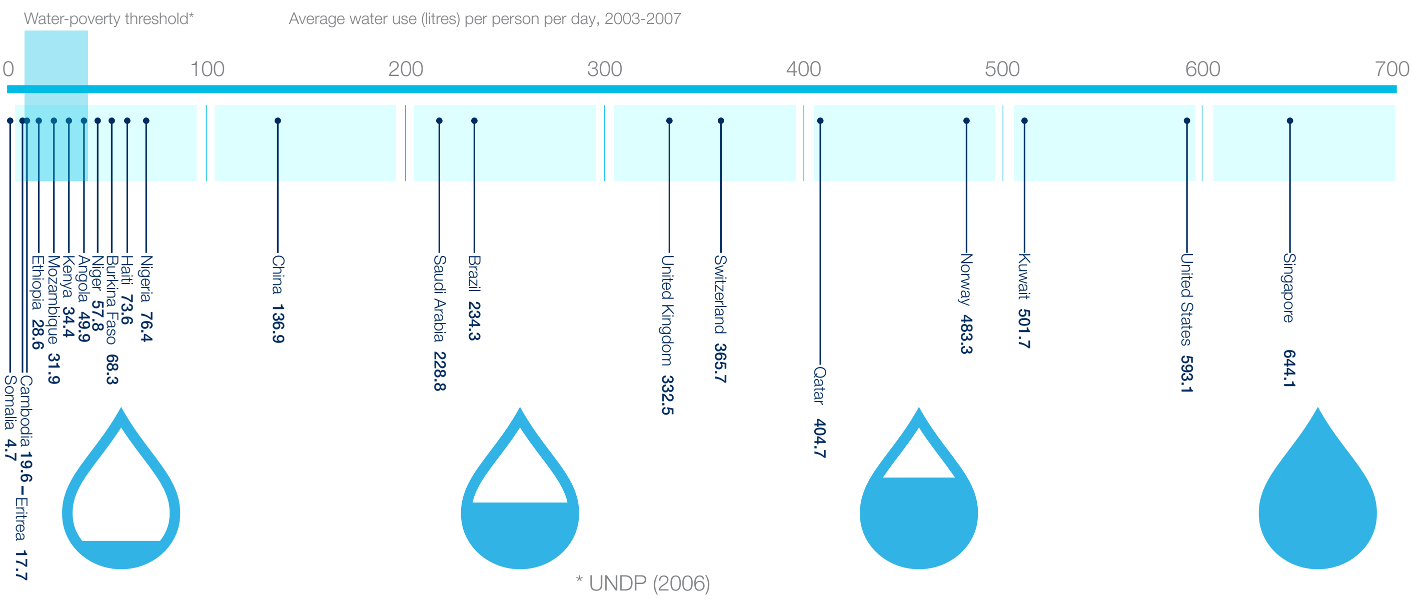
Unconscious framing

Stakeholders attached to this paradigm tend to think in the following ways:
– Both very short-term (today's challenges) and long-term (intergenerational) time frames
– A stakeholder-specific perspective that revolves around both transnational and localized narratives
– A rights-based framing of the problem
– People as the dominant unit of analysis

Common supporters

– Stakeholders linked to both environmental and human rights spheres
– Those who hold this paradigm in conjunction with paradigms 1-3

Figure 5. Worlds Apart: The Global Water Gap



* UNDP (2006)
Source: World Economic Forum analysis, based on FAO Aquastat database; UNDP (2006)

The perils of incomplete paradigms

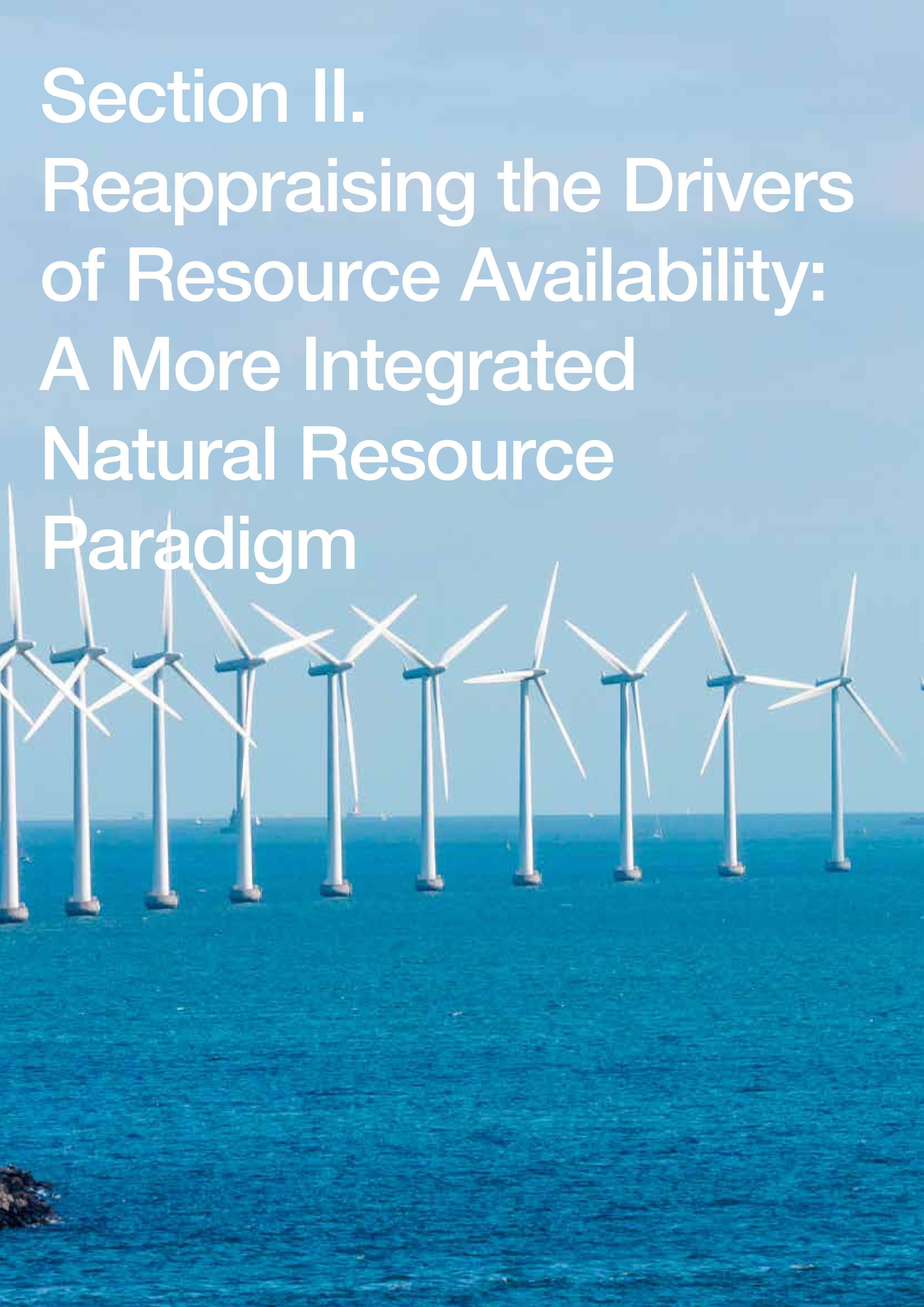
Much of the media and debate among experts focuses on trying to prove that one of these paradigms is true to the exclusion of the others. However, academic literature and expert interviews indicate, as suggested by the examples shown, that **each narrative is valid under specific assumptions, yet none tells the whole story about resource availability in general**.

Unfortunately, **stakeholders face significant risks by basing policy or strategic decisions on only one narrative**. First, the foundation for action is unstable, as each paradigm fails to tell the "whole truth" and is open to criticism through valid arguments and data favouring competing paradigms. This fragments decision-making and makes concerted action across stakeholders difficult to accomplish. Second, building long-term policy on a single paradigm creates risks in sectors where that paradigm may be suddenly disrupted. Finally, as the paradigms change depending on system boundaries, resources and users, the application of a single paradigm across multiple levels of analysis will reduce its effectiveness. Box 3 covers an example of the risk of incomplete paradigms.

Box 3. The Solyndra Incident: The Perils of Failing to Understand the Reliance on Conflicting Paradigms

In December 2011, the bankruptcy of Solyndra, the solar energy systems firm, showed how building business strategies around paradigms of single-resource availability can create huge risks. The faulty assumptions in Solyndra's business model were not about solar power demand, but rather concerning the future price of polysilicon, a key input for its competitors. The company assumed the price would remain high because of persistently greater demand versus supply. As producers responded rationally to high prices by entering the market and increasing supply, polysilicon's price dropped and Solyndra lost its relative cost advantage. This exposed the company to manufacturing challenges that made its technology uneconomic compared to that of competitors. While Solyndra was competitive in an environment where paradigms 1 (material exhaustion and crash) and 2 (rising costs) applied to certain resources, polysilicon's dynamics were, at least for that short period of time, within paradigm 3 (long-term abundance). Hence, and notwithstanding $535 million in federal loan guarantees, the company failed.[1]

Section II. Reappraising the Drivers of Resource Availability: A More Integrated Natural Resource Paradigm



Effectively managing natural resources at both global and local levels is possible, but only if decision-makers fully understand and address the reasons for their existing polarization. To better understand the validity of the four competing paradigms, it helps to reappraise the important drivers of resource availability. Five insights concerning these factors emerged from the Forum's research:

Insight 1: Underestimated drivers of supply and demand

The role of technology, preferences, policies, and prices is underestimated when forecasting supply and demand for natural resources.

Insight 2: Nuanced drivers of growth

Contrary to popular perceptions, population growth is and will be far less significant in spurring resource demand than economic growth and development in the period to 2035.

Insight 3: Resource interconnections

Physical, economic, political and social interconnections between resources are growing, and will increasingly influence resource availability, in both positive and negative ways.

Insight 4: Distributional issues

Defining natural resource availability often fails to consider how they are distributed, both between countries and between individuals within countries.

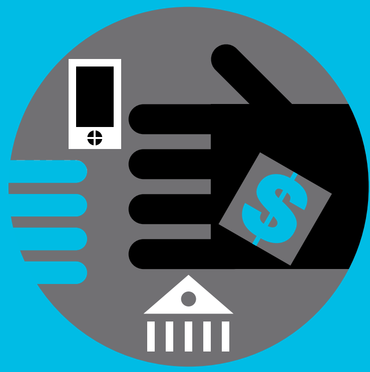
Insight 5: Environmental externalities

Environmental factors create local and global risks to resource availability, while resource production and use are the primary factors in environmental risks.

1

Insight

Underestimated drivers of supply demand

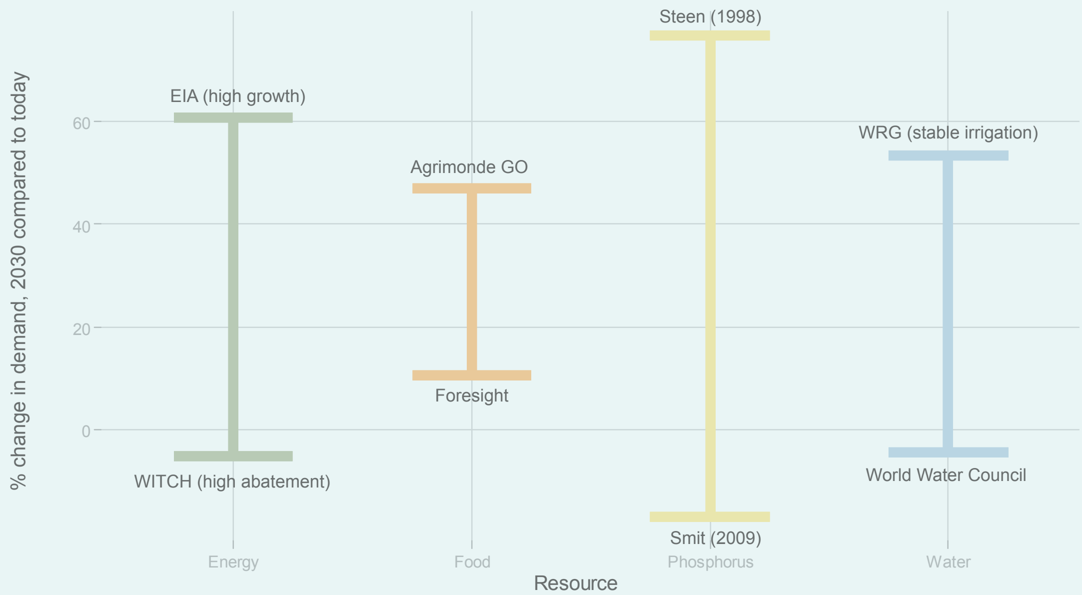


The role of technology, preferences, policies, and prices is underestimated when forecasting supply and demand for natural resources.

A particular resource's supply is not solely, or even primarily, determined by the presence of physical stocks of raw material or the potential to develop a renewable resource. Yet stakeholders, particularly those less familiar with energy and mineral markets, tend to overemphasize the biophysical availability of natural resources in known reserves or potential stocks. What matters most in a 20-year time frame, however, is the market or end-user availability, which cannot be accurately derived from dividing known stocks by current demand. Instead, resource supply is the function of an interplay of many factors – those that drive investment in resource exploration and development; influence production rates, refining processes and other forms of transformation (such as water processing); and affect the distribution of resources. All told, it is a highly complex value chain. On the demand side, estimating future market needs for materials is just as difficult.

Projections tend to be made using yearly growth based on past trends, combined with assumptions on anticipated shifts in population and per-capita income, often while holding future resource price levels fixed. As these estimates are already uncertain, **expert views vary substantially** on possible levels of natural resource demand approximately two decades into the future. Figure 6 shows results of a meta-analysis (conducted by the World Economic Forum in collaboration with Vivid Economics, a strategic economics consultancy) that examined established attempts by reputable organizations to project demand in 2030 relative to current demand, covering four resources. Across major models used to project demand for energy, food, phosphorus and water, the level of uncertainty for the 2035 scenarios is, by extension, very large indeed, as the differences among the Figure 6 projections for energy demand vary significantly, from a massive, nearly 70% increase to a small decrease of 10%.

Figure 6. Substantial Variation in Estimates of 2030 Resource Demand



Note: EIA = U.S. Energy Information Administration; WITCH = World Induced Technical Change Hybrid; Agrimonde: The French National Institute for Agricultural Research; Foresight = UK Government Office for Science; WRG = The Water Resources Group

Source: Vivid Economics, for the World Economic Forum

Such models tend to use different estimates for population and economic growth on which to judge future demand patterns. Interestingly, an analysis of these quantitative models, and a comparison with interview and workshop data, indicate that supply and demand are highly sensitive to four other, less appreciated drivers: technology, preferences, policies and prices (Table). Indeed, these drivers are all critical inputs in estimating supply and demand. While they can create significant differences in projections, they are also regularly underestimated or simply assumed to be constant.

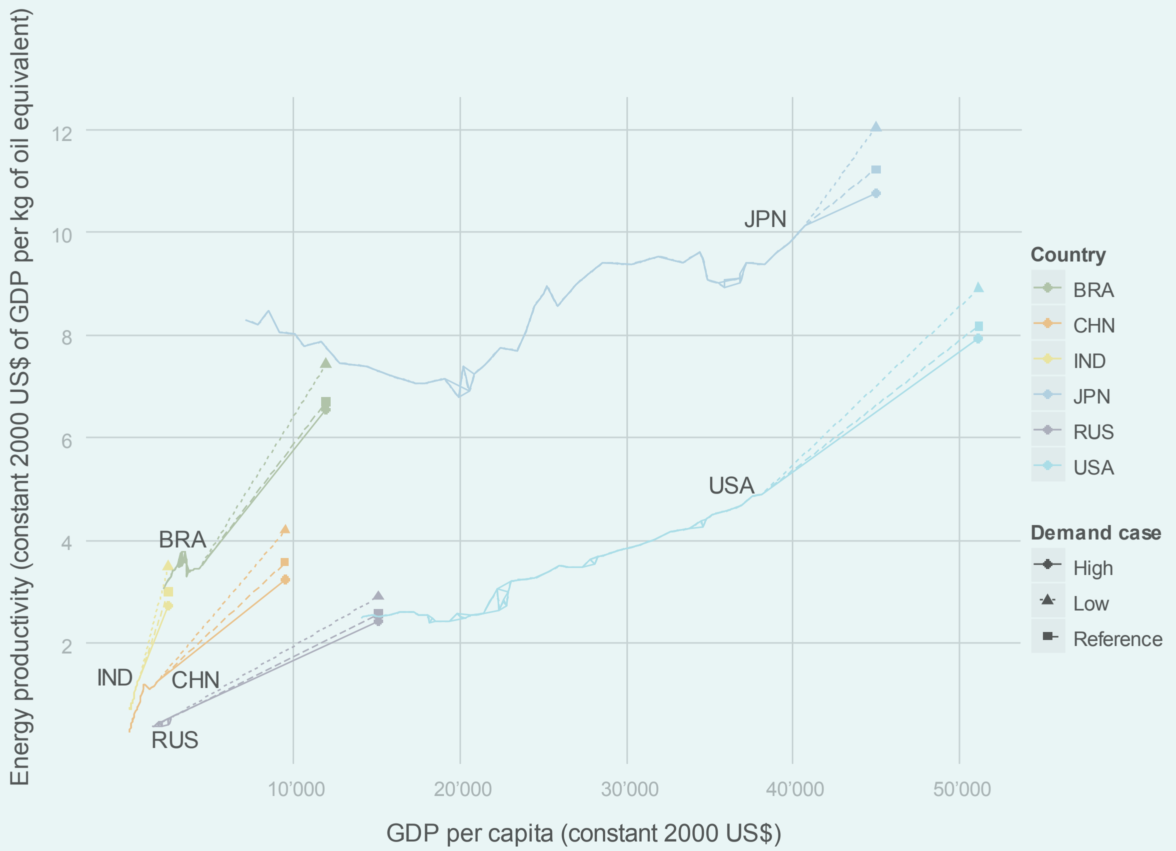
Table. Underestimated Drivers of Supply and Demand

Technology	As mentioned earlier, the **development of new technologies has been one of the important factors in keeping resources available, in the long-term context of constant or falling prices despite rising demand**. In 2014, the significant volume of unconventional fossil fuel extraction in the United States, enabled by horizontal drilling and fracking techniques, was enough to calm energy markets when significant geopolitical disruptions emerged in Eurasia and the Middle East. Technological development allows for resource substitution, lowers the cost of development, increases yields and recovery rates, and enables the discovery of entirely new forms of resources. However, while technology is viewed in many commodity markets as an ameliorating force on the supply side (increasing supply and lowering demand), technological progress can also drive additional demand (e.g. that for rare earths used in mobile phones and wind turbines).
Preferences	**Consumer preferences and behaviour with regard to resource use vary widely across countries and cultures, even at the same level of economic development** (Figure 7). These are influenced by social and cultural factors, which in turn are also heavily affected by the built environment. Behavioural aspects of resource consumption are significant, concerning both demand (e.g. people's willingness to engage in more efficient activities) and supply, as with their contribution to material for recycling. As groups such as the Transition Town movement have demonstrated,[2] concerted shifts in community behaviour and preferences can result in significant efficiencies regarding energy, food and water waste at the municipal level, as well as in developing the willingness and skills for individuals to invest successfully in local food and energy production.
Policies	**Government policies have a huge, uncertain and often underestimated impact on resource supply and demand**. The International Energy Agency's *World Energy Outlook* series views energy policy settings as a major unknown affecting energy demand. A government's ability to set resource taxes, award permits for extraction or development, encourage or inhibit international trade, set and enforce environmental standards, or provide subsidies for producers and/or consumers gives the public sector significant power over resource supply and demand. Moreover, foreign capital's role in most large resource projects means that even fears of policy instability or future changes in the law can act as a significant deterrent to investment and a brake on future supply.
Prices	**Few models of resource availability attempt to include dynamic price effects when estimating supply and demand; to do so requires a step change in model complexity**. Models projecting future resource availability therefore commonly assume a constant or trending resource price level. In reality, price levels and volatility are an important indicator of and factor in investment and output, particularly for resources linked to commodity markets. Conversely, prices may not exist for certain resources, particularly water and ecosystem services associated with forests or healthy fisheries, leading to distorted levels of demand and an absence of incentives to protect or increase supply.

Source: World Economic Forum

The difference in countries' energy productivity levels and pathways is stark, and can be explained by choices in technologies, policies and preferences, and not simply by economic factors. Brazil and India, for example, are assumed to have much higher energy productivity for a given income level than China or Russia (Figure 7). The relationship of gross domestic product (GDP) to productivity is important to economic growth in the BRIC countries.

Figure 7. Energy Productivity Generally Improves As GDP per Capita Rises



Source: Vivid Economics analysis, for the World Economic Forum

2

Insight

Nuanced drivers of growth

Contrary to popular perceptions, population growth is and will be far less significant in spurring future resource demand than economic growth and development in the period to 2035.

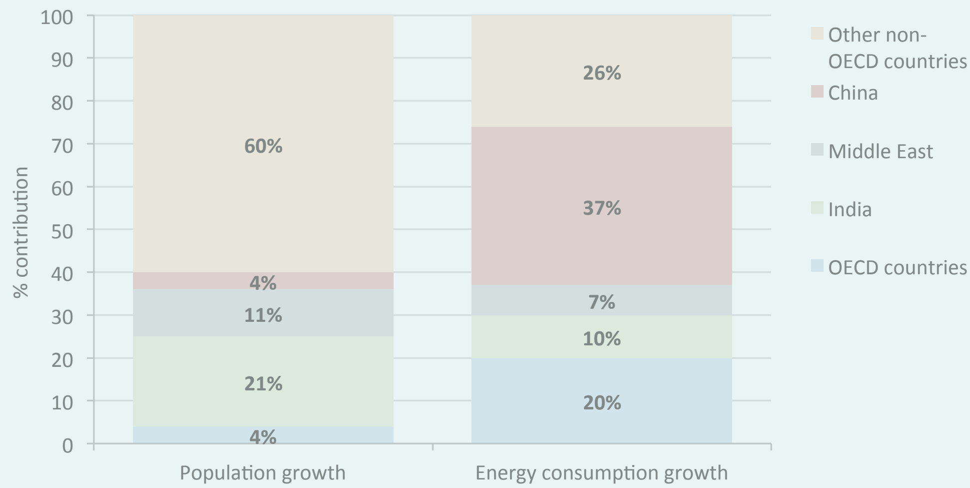
While the four drivers described mean that future supply and demand are very hard to predict, the majority of assessments of future global resource demand point to it rising based primarily on assumptions of continuing global economic growth. The so-called “emerging middle class”, a new set of consumers in emerging markets that could increase the global middle class from 1.8 to 5 billion by 2030,[3] has a desire for products and services that is coupled to an increased demand for natural resources.

Many commentators focus on global population growth as an important future challenge to resource availability. For example, a recent United Nations (UN) report and research at the University of Washington, Seattle (USA) on population growth up to 2011 resulted in headlines linking this to natural resources in the coming decades.[4] However, contrary to popular perceptions, population growth is far less significant in driving future resource demand than economic growth and development. Estimates based on trending energy and population demand indicate that while China will contribute only 4% of the world’s expected population growth over the next 20 years, it will account for almost 40% of additional energy demand (Figure 8). In the next few decades, the vast majority of rising demand for resources will come from current populations that are becoming wealthier, rather than from the additional burden imposed by new populations (people being born).

Nevertheless, and as previously mentioned, **the extent to which rising average incomes translate into increased demand for resources is far more malleable than most people presume.** As Figure 7 shows, societies and individuals consume very different amounts of resources at the same level of development or income; see, for instance, the difference in energy productivity levels between the United States and Japan.

Population growth does intersect dangerously with resource availability in a number of fragile states, as these have yet to show lower birth rates that come with increasing levels of economic development and education, particularly for women and girls. In countries such as Niger, rapidly growing populations place huge stress on local resource availability and threaten both environmental and social systems. This differs from the global level, where rising incomes drive demand. Hence, **the link between population and resource scarcity is, rather, a challenge of local development, and not a result of a global shortfall in resources. Ironically, the only path out of this dilemma is likely to be economic growth that would help accelerate demographic transitions and give local populations the ability to adapt.**

Figure 8. Regional Contribution (%) to Population Growth and Energy Consumption, 2010-2020

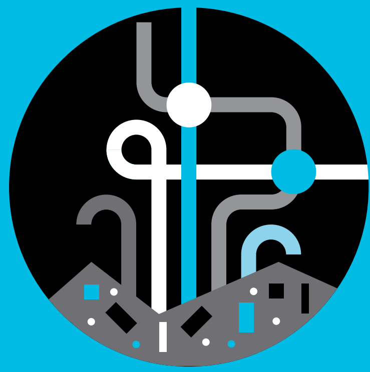


Source: World Economic Forum analysis, based on UN Department of Economic and Social Affairs/Population Division; U.S. Energy Information Administration

3

Insight

Resource interconnections



Physical, economic, political and social interconnections between resources are growing, and will increasingly influence resource availability, in both positive and negative ways.

A third, critical insight into resource availability is that interconnections between them act to spread risks across multiple types of resources, as well as multiple stakeholders and geographic regions. While resource interconnections have been studied and recognized more through frameworks such as the "food-water-energy nexus", participants at the Forum's workshop at the University of Oxford demonstrated that **these dynamics can be broken down into four domains that go beyond mere biophysical interdependencies** (Figure 9). Indeed, interconnections can transmit risks across resources and stakeholders, turning local resource challenges into global risks; and, while increasing attention is paid to physical resource interconnections, a multilayered model of resource interdependencies is more useful when assessing risks to resource availability.

Figure 9's lowest level shows a number of **biophysical interactions** between resources. The most commonly cited example is first-generation biofuel production, which requires significant land and water in addition to energy for the processing and conversion to liquid fuel (ethanol), thus tightly linking these resources together. Another striking example is aluminium production under the Hall-Heroult process, which requires alumina to be dissolved in molten cryolite and electrolysed, consuming large amounts of energy. Similarly, generating solar power via photovoltaics requires significant use of land, as well as silicon as a mineral input to produce the photovoltaic cells.

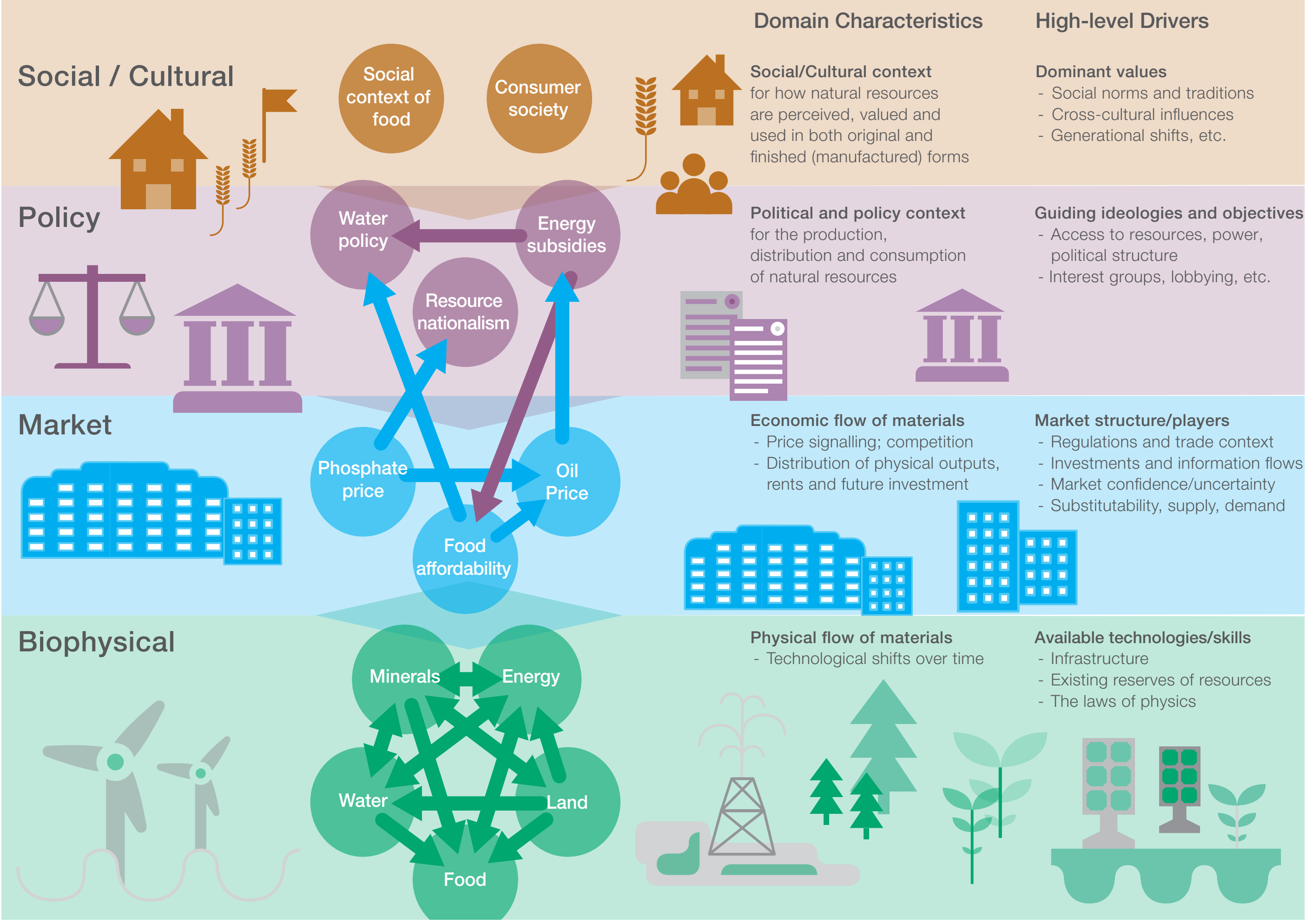
However, in addition to biophysical links, natural resources share **market interconnections** influenced by the economic flow of materials in the globalization process. Such economic links incentivize shifts in the adoption of technology where substituting is possible, thus influencing the incidence of different biophysical connections. The recent abundance of shale gas in the United States, for example, means that gas is displacing coal in power generation, lowering the cost of chemical inputs that rely on natural gas as a feedstock. Global markets also offer the opportunity to trade "virtual water", i.e. virtually embedded water (in traded commodities) as an input in place of production. This allows countries with scarce water supplies to effectively import it by purchasing water-intensive products from other countries.

As discussed earlier, economic resource interconnections are, in turn, heavily influenced by political and **policy factors** that can exacerbate certain resource interconnections by subsidizing or protecting resources (either in production or consumption), through trade laws, investment regimes and technology policies. A high-profile example was the Russian Federation's decision to impose an export ban on wheat in 2010 in response to a heat wave and drop in its grain crop. Designed to protect local consumers and meat producers, it failed to decrease food prices inside the country and, instead, lead to higher wheat prices on global markets, according to Oxfam impact assessments.[5]

Finally, **social norms and influences** serve to connect resources at an even higher level of abstraction than policy factors. Vegetarian cultures place very different demands on food production, water systems and ecosystems than those heavily meat-based. Societies that view water as a divine right, and bodies of water as critical sites of religious ritual, may face different challenges in managing their basins.

This **multilayered approach to analysing resource interconnections**, and understanding the future of resource availability, enables business leaders and policy-makers to expand their appreciation of potential shifts in resource supply and demand across a wider range of factors than simple input-output assessments.

Figure 9. The Four Domains of Resource Interconnections: Characteristics and Drivers



4

Insight

Distributional issues

Defining natural resource availability often fails to consider how they are distributed, both between countries and between individuals within countries.

Such complex interconnections increase the chance that local disruptions may impact other stakeholders and populations. **The last two decades have seen communities play greater roles in managing resources**, gain more influence over public policy to protect ecosystems, and capture and distribute the benefits of resources more equitably. But even now, more attention should be paid to who owns and benefits from the production and use of natural resources; a notion that, if underestimated, can create social, political and geopolitical tensions.

Distributional issues arise at multiple scales. First, **significant differences exist between nations in the physical and geographic distribution of natural resources**. For example, Morocco has about 75% of the world's phosphate reserves;[6] Venezuela holds approximately 20% of the world's proven oil reserves;[7] and the United States has 10% of the world's arable land.[8] Such differences have economic and geopolitical impacts, the most renowned of which relate to flows of energy and the Organization of Petroleum Exporting Countries' influence on oil pricing since the 1970s.

Economic access to resources between social and economic groups within nations presents important distribution issues as well. Wealth and income inequality is compounded and reinforced by unequal access to sustainable resources. Well-known examples include lack of access to clean water (for about 780 million people, or approximately 11% of the world's population[9]) and electricity in homes (affecting 1.3 billion, or roughly 18% of the world's population[10]).

Even for those populations with access to basic services, lower socio-economic groups are often threatened by global resource price volatility. This particularly concerns food and energy in countries relying heavily on imports. While the Arab Spring demonstrations are often seen as partly a consequence of high and volatile global resource prices, it is easy to overlook Bulgarian protests in February 2013 against higher energy prices; and, a year earlier, the Nigerian government's removal of a fuel subsidy and subsequent doubling of energy and transport costs that resulted in a general strike, several deaths and the reinstatement of subsidies.[11]

As citizens are mobilizing and finding voice with growing ease, **leveraging the internet and mobile technologies has increased the importance of both perceived and real distributional inequalities at national levels.** Moreover, the same technologies offer new channels to bolster national support for foreign policy as it concerns access to resources at the geopolitical level.

5

Insight

Environmental externalities

Environmental factors create local and global risks to resource availability, while resource production and use are the primary factors in environmental risks.

Resource interconnections and their dynamics are particularly worrying as to the environmental impact of resource development, extraction, conversion and consumption. A recent report from The Economics of Ecosystems and Biodiversity (TEEB) states: **"There is growing evidence that many ecosystems have been degraded to such an extent that they are nearing critical thresholds or tipping points, beyond which their capacity to provide useful services may be drastically reduced."**[12] Such ecosystem services go well beyond any moral, recreational or aesthetic values ascribed to the environment, and include provision services, such as wild foods, crops, fresh water and medicines derived from plants; regulating services, including climate regulation through carbon storage and water cycling; and critical supporting services, such as soil formation, photosynthesis and nutrient cycling. Specifically, the economic costs of irreversible climate change have been quantified at as much as 20% of global GDP per year through 2050,[13] while the TEEB initiative qualified environmental risks to the global economy from unsustainable natural resource extraction as potentially costing over $7 trillion annually through 2050.[14]

In addition, **damage to these services can create other direct and indirect risks to populations**, such as extreme weather events, rising sea levels and other distortions to climate and the natural environment that unsettle social, economic and political systems. These factors could significantly disrupt the flow of natural resources, particularly the availability of freshwater currently sourced from rivers and aquifers. Further, extreme events can impede commodity production and trade; these include agricultural products that rely on mild weather and consistent rainfall, off-shore drilling platforms which cannot operate in or may be damaged by high seas and winds, and logistics facilities and supply chains exposed to weather-related disruption.

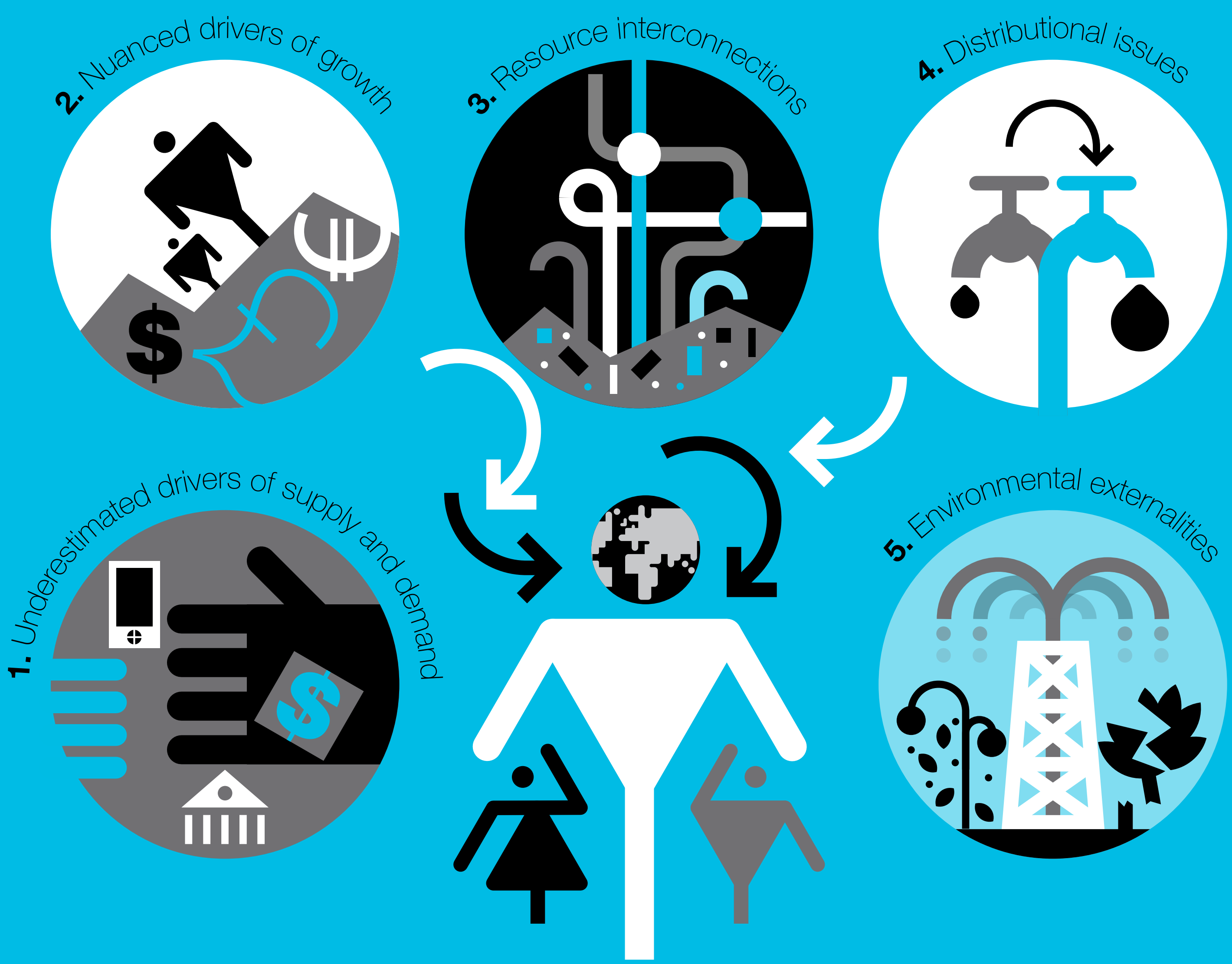
As global understanding and awareness of the complex relationship between the economy and the environment increase, **more companies and governments are looking for ways to manage and govern ecosystems.** This includes not only the ecosystems' (primarily) unpriced benefits, but also the corresponding losses, as such services are damaged when making decisions on resource-related activities. Rising insurance and compliance costs, as well as carbon tax systems, tighter environmental regulations and the threat of social action linked to environmental damage, are also affecting resource production and consumption. Evidence of this includes recent protests in Britain against fracking.

These direct and indirect factors imply that stakeholders must continue to incorporate more sophisticated assessments of environmental impacts into their policies, investment and operational plans. Rising community awareness of environmental costs and benefits, when combined with open flows of data and communication, will create additional pressure and transparency regarding externalities.

5

Paradigm

Glocal crises, contagion, and environmental imperatives



Towards an integrated paradigm: glocal crises, contagion and environmental imperatives

A fifth, more integrated paradigm can be proposed, building on these five insights and incorporating the views and assumptions of the over 300 global resource experts consulted through this project. This paradigm could allow experts and decision-makers to find a dispassionate common ground on important aspects of resource availability, thereby improving their effectiveness in tackling this challenge.

Characteristics:

– **The world has sufficient global stocks of natural resources** (without their needing to be locally produced and distributed) in order to meet the vast majority of society's demands over the coming decades – that is, if resources are used more efficiently and with greater diversification in production (e.g. rare earths). For instance, addressing energy, water and materials inefficiencies, as well as reducing global food waste, could meet 30% of global resource demand.[15]

– Even given expected limits in the stock of certain resources, most notably minerals such as phosphorus, **it is unlikely that these limits will be reached by 2035**, though better management of such resources will be needed to ensure economic availability beyond that time frame.

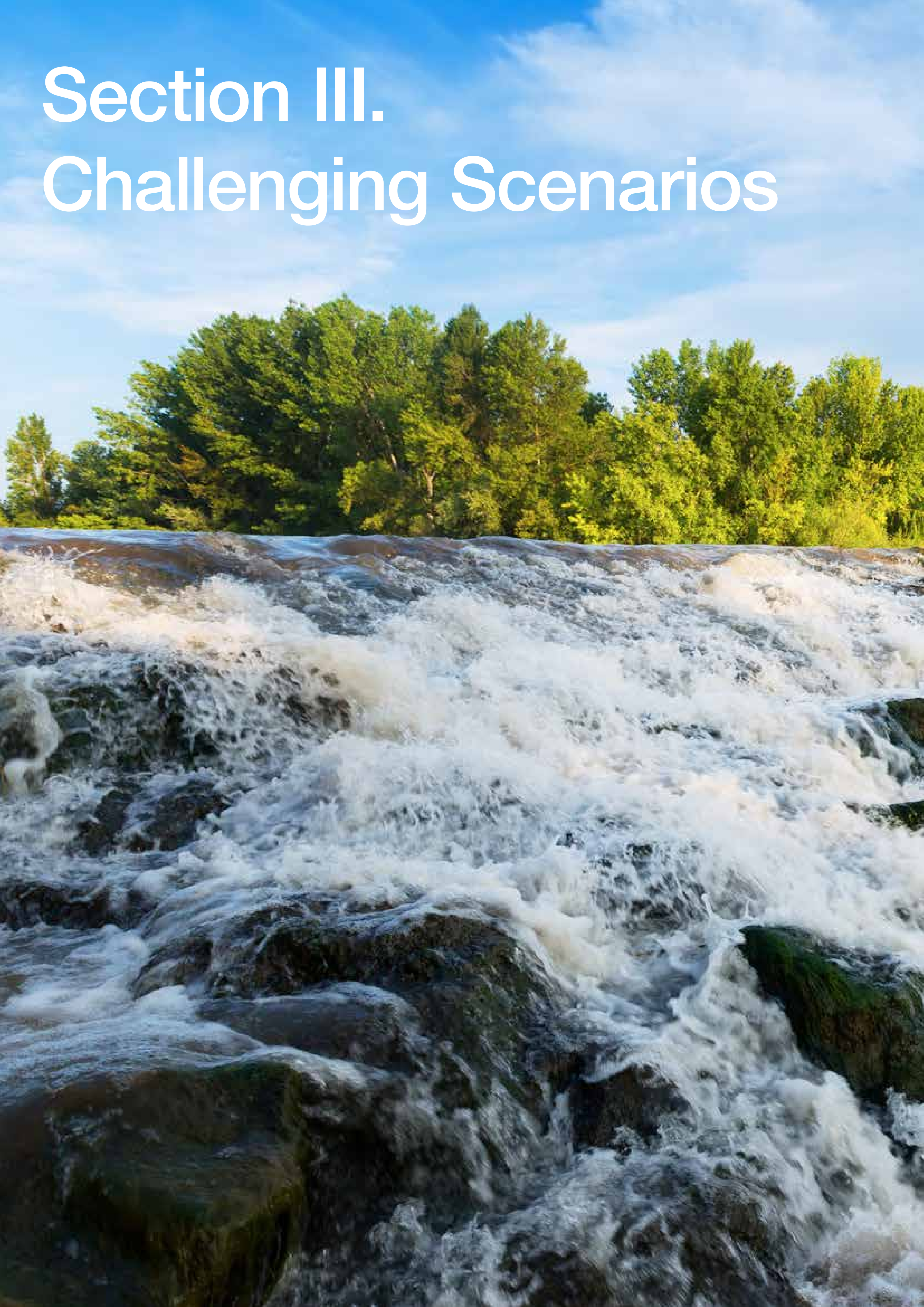
– **However, the global flow of natural resources faces increasing risks of interruption and higher costs.** Factors that could interrupt global production and supply chains will increasingly threaten getting the resources to those who need them. Such factors stem, in particular, from highly uncertain "above ground" influences, such as geopolitical threats, extreme weather events, infrastructure failures and even regulatory and compliance costs, as resource production increasingly moves into more environmentally, socially and technologically challenging areas.

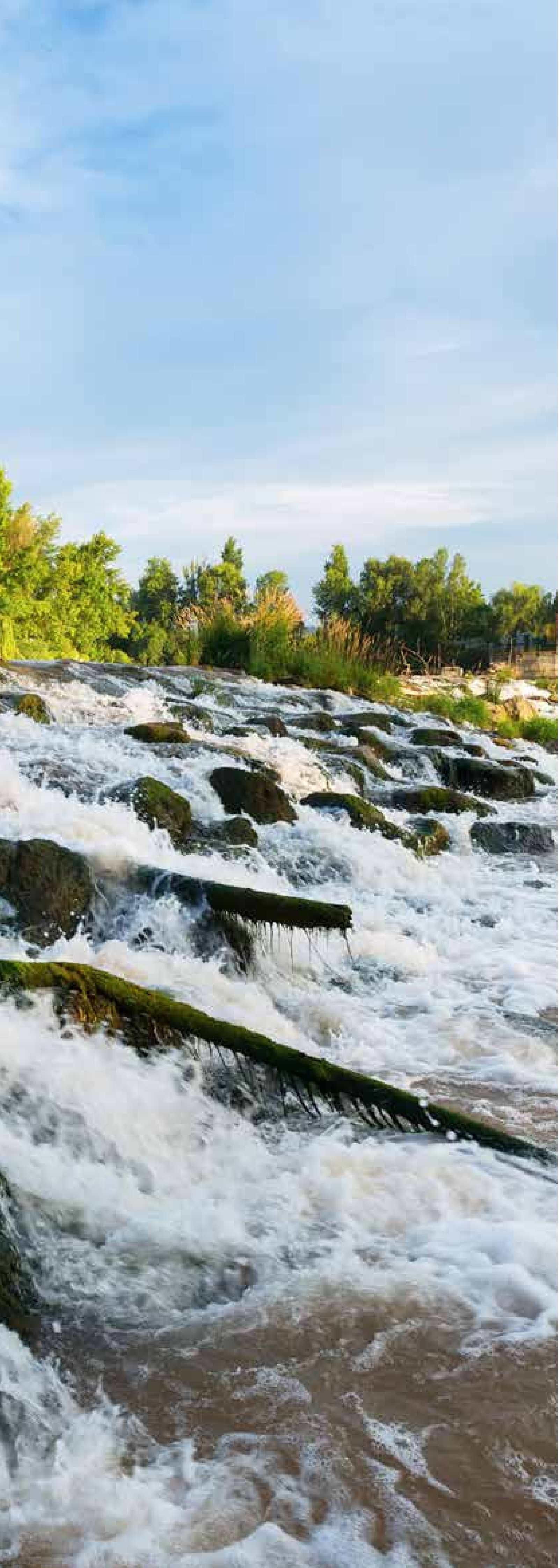
– Meanwhile, **certain local geographies will inevitably experience intense pressure on and shortages of specific natural resources**, particularly water and those more difficult to trade across borders. This will create local resource crises, disproportionately affecting low-income households, with the **potential for global impact** via direct and indirect means often reduced to the concept of bread riots. Global pressures increasingly put on local situations will reinforce this trend further, such as distant land leases or purchases by capital-rich nations seeking to guarantee their access to supply.

– **Resource interconnections from climate, resources and the food-water-energy nexus will complicate such local crises**, and mean that resource shocks, previously geographically constrained, are more likely to affect multiple resources and stakeholders. This will increase global price volatility and transmit risk across countries and sectors.

– Finally, the cumulative **environmental and social impacts** from resource production and consumption will become more obvious over time, creating significant pressure on both governments and companies, thereby making preventive action recommendable.

Section III. Challenging Scenarios





The report has provided paradigms to help stakeholders gain a deeper appreciation for commonly-held beliefs on resource availability (Section I), insights on less obvious or underappreciated drivers of resource demand and supply, and a possible "integrated paradigm" (Section II). It now turns to **narratives for the future. These illustrate the challenges and opportunities associated with resource availability in the time ahead, in an attempt to enable better decision-making strategies among today's government and business stakeholders** (Box 4).

The three plausible scenarios focus on natural resource availability, and are neither normative, predictive nor completely exclusive of one another. Instead, their aims are to:

1. **Challenge dominant but fragmented paradigms** already identified, in order to sensitize decision-makers to potential future settings that are at odds with their assumptions
2. **Highlight the strategic challenges** for governments, corporations and civil society stakeholders implied by the different scenarios
3. **Further reveal existing signals** of potential new worlds that society may need to begin preparing for

It is recommended that these scenarios should serve as a starting point for stakeholders to think about how an exogenous strategic context might influence resource availability at global, regional and local levels.

Box 4: Why Scenarios?

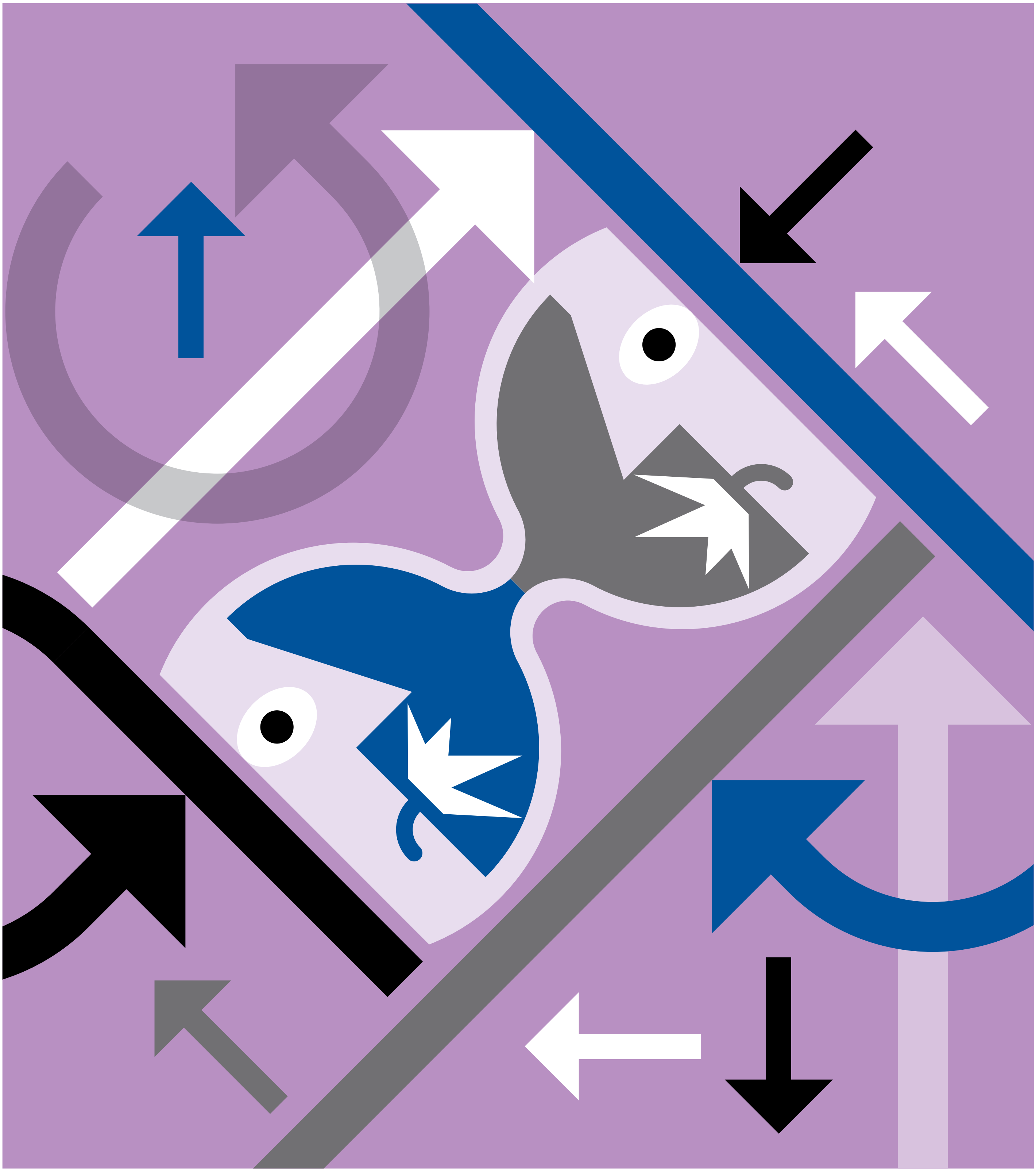
When situations are crucial but highly uncertain, it would be unwise to rely on predictions. Yet, it is necessary to assess how future contexts might appear to assist with current decision-making. Scenarios provide this assessment: they are not forecasts, but plausible views of different possible futures, and they open up understanding of how things could be.

Scenarios are not ends in themselves. They provide a framework for stakeholders to develop new ideas and solutions, and for better-informed and more robust decision-making in light of future developments. The process itself allows the building of social capital to drive change from the learning generated in the process.

Scenario

Clash of interests

A world where resource scarcity plays out because of pre-emptive geopolitical measures taken by countries acting on psychological fears. Market deficiencies appear as the world's geo-economic commons are divided into myriad competing channels of exchange.



Pathway

International tensions linked to border disputes and national concerns about access to natural resources flare into a series of major and prolonged conflicts over the period 2015-2020, including in the Middle East, Asia and sub-Saharan Africa. The conflicts lead to heightened security for, in particular, the production and trade of energy and mineral commodities, with knock-on effects for state relations. These measures create major physical and economic barriers to trade that limit the movement of goods, capital and people, and consequently lead to increasing resource prices, lower total output and depressed global growth.

Geo-economic commons, such as the freedom of the seas, have been divided into myriad parallel and competing channels of exchange. This world's most striking characteristic is that its geopolitical tensions, the result of the very real scarcity of resources, could have easily been avoided with greater confidence in mechanisms for global politics and economic governance. Indeed, **the biophysical stocks of most resources remain perfectly sufficient. However, in a classic example of a suboptimal, game-theoretic outcome, national fears linked to resource control and subsequent attempts to increase geo-economic leverage have precipitated competing states to escalate counterproductive interventions**.

Military stand-offs begin to develop into significant global issues. A combination of sanctions and "rogue" submarine activity along major shipping lanes leads to the emergence of regional trading alliances and the eventual acceptance of imperfectly re-established "secure trading routes", which ensure that vital goods can still move around the world. All internationally traded commodities become extremely expensive because of the need to physically protect convoys from both state- and non-state-sponsored attacks. This puts huge stress on vulnerable populations in resource-importing economies, and leads to severe political and social instability, as well as humanitarian crises, particularly in Africa and South Asia. Additional stress is created by fears of global military action, and the associated energy and minerals material required by countries to build additional defensive and offensive capabilities. **In effect, the psychological drivers of this competition have increased demand for resources while pressuring their supply.**

With many countries in a state of war and concerned with internal instability, national governments exert increasing control over the internet, as cyberattacks, a common tool of strategic competition, are used against resource-related infrastructure. As nationalization threatens many resource companies and operations, much of the private sector focuses on corporate survival in a volatile world.

Signposts

(Early indicators of this future)

> **The prices of everyday staples such as bread, flour and beer are set to rise sharply after Russia imposed a ban on grain exports, triggering panic in commodities markets and sending wheat prices to their highest since the 2007-08 global food crisis.**

Financial Times, August 2010

> **Chinese leaders may have decided that international condemnation is a small price to pay for leveraging their growing maritime capability [in the South China Sea] to ensure that resource development in waters claimed by China occurs with Beijing's blessing and under Beijing's rules.**

The Jamestown Foundation, *China Brief*, June 2014

> **On 15 August 2012, the computer network of Saudi Aramco was struck by a self-replicating virus that infected as many as 30,000 of its Windows-based machines. … Viruses frequently appear on the networks of multinational firms but it is alarming that an attack of this scale was carried out against a company so critical to global energy markets.**

International Institute for Strategic Studies, April 2013

Implications

- Fears and other psychological factors may precipitate resource scarcity, regardless of biophysical reserves.
- The interlinkages between geopolitics and natural resource availability are evident in the oil and gas sphere, but may be underestimated for other resources where they are just as relevant.
- Producers and consumers would likely lose from a stand-off or, worse, an open confrontation. Corporations have a particular interest in ensuring the sustained openness of the world's geo-economic commons.

Scenario

Alarming abundance

The apparent benefits of plentiful fossil and renewable energy risk being overshadowed in this world by their impact on associated resources such as water, and by their social and environmental consequences.

Pathway

Concerns over continued geopolitical instability, in European relations with the Russian Federation as well as in the Middle East, lead both the European Union (EU) and China to invest heavily in their shale gas resources as a way of reducing their dependence on foreign energy supplies. This includes those from the United States, whose supplies had at first been heralded as a valuable injection of fluidity into the global market, but are increasingly shunned as a result of EU and Chinese political motives.

Rapid development of unconventional fossil fuels has quickly evident consequences, as it places more stress on local water supplies via increased consumption and isolated but repeated incidents of contamination. Despite these concerns, the need to continue maintaining employment and supporting low prices creates “lock-in” incentives to continue extraction efforts, and results in a global oversupply of natural gas. Local community groups are concerned more than ever with the “true cost” of gas. Efforts to enforce new procedures to protect water basins and reduce methane leakage are resisted by companies operating on extremely thin profit margins, and by governments convinced that their unconventional resource strategies are a political necessity.

Though many had warned of these first alarming and unintended consequences of the new abundance in unconventional energy resources, few had realized that a push into renewable resources could have equally disturbing effects. Indeed, a series of investment efforts in alternative energies have finally led to breakthroughs. The partial adoption of these new resources, at first expected to help reduce carbon emissions, leads instead to a rebound effect of increased economic activity and personal consumption that, paradoxically, creates more pressure on global warming. **This results in some critical voices disparaging renewable energies as irrelevant if not pernicious. Other voices highlight the need to frame the thinking about resource consumption with a holistic focus on responsibility, rather than technical capacity.**

Signposts

(Early indicators of this future)

“

Europe will need to tap more diverse sources of gas and develop more supplies of controversial shale gas within the continent, amid concerns over the Ukraine crisis, according to a new energy security strategy unveiled by the European commission on Wednesday.

”

Guardian, May 2014

“

Overall, 38 per cent of viable shale gas deposits worldwide are in areas where water supplies are a potential problem. Of those with the biggest shale reserves, 40 per cent have severely limited freshwater supplies.

”

Financial Times, September 2014

“

Energy productivity improvements over time reduce the implicit price and grow the supply of energy services, driving economic growth and resulting in firms and consumers finding new uses for energy (e.g. substitution). This is known in the energy economics literature as energy demand ‘rebound’ or, when rebound is greater than the initial energy savings, as ‘backfire’.

”

Breakthrough Institute, February 2011

Implications

- While newfound abundance in some resources (e.g. gas) can create economic benefits ranging from competitiveness advantages to employment, such glut can also lead to new scarcity in other resources (e.g. water), in addition to social consequences.
- Short- and medium-term economic concerns can distract decision-makers from the longer-term challenge of climate change, with possibly underestimated humanitarian and economic implications.
- Even for renewable energies, taking a holistic approach to reducing carbon emissions is important, rather than placing too much hope in technical breakthroughs.

Scenario

Challenge of transition

In this world, governments, consumers and companies realize and accept the full costs of their transition to a low-carbon, durable and sustainably sourced economy. They suffer through what they perceive as a change in their use of natural resources – one that is essential for social and environmental sustainability.

Pathway

A range of broad-based political and social movements favouring rapid shifts to low-carbon energy technologies are created by an increase in the acute consequences of local environmental degradation in emerging markets, as well as a series of extreme shocks to both weather and climate at a global level. A number of emerging economies, led by China, adopt radical and rapidly enforced plans for environmental reform, despite continued resistance to harmonizing such measures globally. At the same time, building awareness in the United States of the challenges linked to climate change leads to an openness to political reform in favour of a "greener economic path", aligning the country with increasingly concerted European efforts to lower carbon output.

As the average global consumer's aspirations rapidly shift towards low-carbon, durable and sustainably sourced goods, the corporate sector begins to adopt localized mass-market strategies. These compete on perceptions of quality and sustainability, with sourcing monitored via material tracking and consumer activism, and enabled through ubiquitous use of technology. With fossil fuels increasingly shunned as an energy source for electricity and transport, some countries choose to drive growth through major investments in the switch to renewable energy, adopting electric vehicles for corporate and government users, and trying to solve the challenge of energy storage. Other countries fast-track carbon-capture technologies, while employing nuclear energy sources as "transitional fuels". Many governments use the shift in social attitudes to reform tax systems which, as a result, affect resource use and consumption far more than labour, and exempt green products and services.

This transition is not smooth, however. Significant deficit spending is required to drive investment in energy storage and renewable sources, and reforming national grids causes significant political strife in many countries. The early retirement of "dirty" technologies for energy production consumes significant capital, at what some economists cast as a relatively high opportunity cost. Geopolitical tensions rise from the perception that some countries are "free riding" on green investments elsewhere in the world; and, the UN programme to scan and monitor national airspaces using drones, satellites and other sensors is a source of constant controversy and finger-pointing.

Further complicating the transition are the larger-than-anticipated land-use requirements for scaling up solar and wind technologies, which create pockets of social resistance from local communities. In addition, consumers have to be reminded constantly that their acceptance of higher energy prices is a painful though temporary price to pay for a cleaner atmosphere. The global community also struggles with compensating poor communities for the added costs throughout the resource value chain that are created by a carbon price and the adoption of relatively more expensive infrastructure options.

Perhaps the most radical element of this new order is that, despite the challenges, few if any key stakeholders would even consider returning to the high-carbon world they left behind. Notwithstanding these challenges, an important transformation has occurred, and its transition costs are seen as a significant but necessary burden.

Signposts

(Early indicators of this future)

“

Business interruption risk and price volatility mean that an increasing number of businesses are taking a strategic approach to energy procurement. 'Direct procurement of renewable energy might just prove to be one way for the sector to reduce its dependence on government policy,' […]

”

Guardian, July 2014

“

Even as environmentalists welcome solar energy's rising global profile, they worry that the [solar-related] Sino-U.S. trade dispute may hinder the adoption of a leading form of renewable energy.

”

Bloomberg, August 2014

“

A more fundamental challenge is that renewable generators […] impose costs on the wider electricity grid. The best sites are often far from big cities […] which makes them expensive to connect. Many common types of renewable generators only produce power intermittently […]. That means countries which have a lot of renewable generation must still pay to maintain traditional kinds of power stations ready to fire up when demand peaks.

”

The Economist, January 2014

Implications

– The low-carbon discourse must be more aware of the transition challenges and costs involved with implementing new technologies.

– Doing so is not only a question of intellectual honesty, but also a way to help stay resilient in the face of inevitable pushbacks that will punctuate such a transition.

– A major transformation is conceivable, but must be anticipated with forethought in both government policy and corporate strategy circles.

Section IV.
Response Strategies

The development of "meta-learnings", in the form of response strategies for stakeholders to use in a complex, interconnected resource environment, was the final outcome of this project's research and workshops. Drawn on the entirety of the work from this report, from the paradigms to the scenarios, the following six strategies may be considered domains of focus for those interested in understanding and mitigating risks related to future resource availability.

1. **Understand and acknowledge one's own assumptions, and those of related stakeholders, with regard to natural resource concerns.**

   Where a diverse set of stakeholders interacts with business plans or policy-making, a great advantage is simply acknowledging the different paradigms of resource availability employed by different individuals. As described earlier, these paradigms can differ widely according to various factors, such as the system boundary, time frame, and the resource's relevant end user. **Understanding how and why different stakeholders hold their views, as well as mapping these and discussing them openly, can immediately create opportunities for constructive dialogue** and shared understanding of contentious issues.

2. **Consider technology, preferences, policies and prices as key drivers of resource availability.**

   While people and decision-making are necessary to evolve these drivers (and whose evolution, as a result, becomes highly unpredictable), the drivers also play a significant role in determining future resource supply and demand.

   – **Technology** is often viewed as a driver at the frontier of resource discovery, production and efficiency. Commonly overlooked, however, is the need for basic, well-established technological improvements in resource management, to be implemented fully in countries where food yields are low, energy conversion losses are high, or water is severely wasted through insufficient infrastructure.

   – Consumer **preferences**, shaped most powerfully by the cultural context and, in terms of energy use, by the built environment and incentives, are another, malleable factor. Providing transparency to consumers on product emissions profiles is one way of enabling action on conservation preferences and of changing behaviour, as described in the Forum's Sustainable Consumption initiative's series of reports.

   – Through their **policies**, governments possess significant power to shape natural resource production and consumption. Currently, the fossil fuel economy is heavily underpinned by subsidies to both producers and consumers around the world – to producers because of their desire to support jobs and investment in resource-rich economies, and to consumers in resource-importing countries. Tax regimes, fuel content requirements and trade policies all heavily influence the levels of investment and the cost of resources to end users (and, thus, their consumptive behaviour), and are also a key determinant of technology pathways.

   – Finally, these factors combine with a range of other drivers in resource **prices**. While governments or businesses have difficulty controlling prices (and, if attempted, this can often prove very costly), attention paid to the relative pricing of different resources is important to appreciating future availability. That resources are priced at all is an important aspect; resources will be misallocated and in danger of overexploitation without effective pricing strategies that reflect their true value to the environment and other stakeholders.

3. **Exploit all opportunities to increase resource efficiency.**

   This entails prioritizing infrastructure that assists with the shift to low-carbon economies, while actively managing any "rebound" effect.

   It is common knowledge that resource efficiency represents the achievable goal of increasing resource availability. With the exception of food in the developed world, the opportunity to achieve major resource efficiencies lies largely in the industrial supply chain rather than with end consumers. Improving energy conversion, the transport of water, irrigation and other production systems represent opportunities to lower demand for natural resources and, hence, conserve supply.

   At the same time, it must be remembered that increased efficiencies could have perverse effects. The "rebound" effect, for example, may result in higher efficiencies being offset by stakeholders consuming more of the resource; this can be caused by lower prices, or changing perceptions of a resource's abundance or negative externalities. Where price effects result, efficiencies in one resource may also cascade into negative impacts on other resources – for example, evidence exists that falling diesel prices in India resulted in excessive pumping from the water table. **This highlights the need for resource efficiency efforts to mark the beginning, rather than the end state, of resource management efforts, and for proponents to create price and behaviour "ratchets" that ensure feedback loops do not create perverse outcomes.**

4. **Invest in "integrated specialization" in natural resource management.**

   A repeated and obvious finding of this project was the need for better ways of thinking about interconnections between resources, the drivers of resource availability, and the environment for resolving resource dilemmas in ways that benefit all stakeholders. At the same time, the deep expertise in specialized fields that allows for concentrated progress in understanding the world must be maintained.

Promising developments include emerging models of interdisciplinary, multistakeholder resource management, with dialogue among governments, the corporate sector, local communities and civil society, often with the support of academics and the scientific community. Such initiatives are becoming more common in mining, water management and shale gas, and need to be ultimately expanded into **cross-resource management**.

Unfortunately, efforts to uncover a set of concrete case studies of integrated specialization found numerous people attesting to its importance, but very few examples of corporations or government departments that have successfully managed to create strategic plans, let alone implemented projects across disciplines and resource domains.

5. **Invest heavily in the social and political dimensions of addressing resource management.**

The ability to solve technical challenges in resource discovery, extraction, processing, transportation and delivery to markets has led to much of the reduction in resource prices and expansion in overall resource availability over the past 100 years. Given the role of resource interconnections and rising social and environmental issues, **a core resource-related challenge of the coming two decades will be to solve the political and social demands produced by the current system** for developing, distributing, consuming and managing the externalities linked to natural resources.

Acknowledging and grasping the assumptions that shape stakeholder perspectives are becoming increasingly important; so, too, is gaining a deeper understanding of the political and social dynamics that impact, and are influenced by, resource availability. Demands on innovation will therefore be just as applicable to the social, political and economic domains as to technical matters. Without social and political innovation, it seems impossible to achieve the required step change in resource efficiency, supply resources from more environmentally sustainable sources, and produce equitable outcomes by 2035 and beyond.

6. **Build expertise in environmental mitigation and adaptation.**

Such expertise should address climate change, resources and the food-water-energy nexus. Those investors, businesses and governments "on the frontier", with regard to the interaction of economic models and the environment, will be better placed to mitigate negative impacts and adapt to changes affecting resource availability over time.

Given the scale and speed of change needed to address risks of resource commodity price increases and negative environmental externalities associated with resource usage, a multiple-track approach is needed to:

- **Reform the traditional educational system**
  Rapid curricula renewal should update and embed climate change, resources and the food-water-energy nexus into the traditional educational system, especially in existing courses and majors for climate change, water management, sustainable energy, mining and metallurgy, and sustainable agriculture. Opportunities need to be urgently seized to embed "nexus" considerations into the growing number of climate change/carbon management courses offered by universities and vocational colleges. Other critical areas for embedding nexus considerations include economics, business and accounting schools; sustainable design-related disciplines such as engineering; teacher training and, especially, international relations and history majors.

- **Engage current decision-makers from different disciplines**
  Few decision-makers appreciate that constructively addressing resource availability and cost risks, as well as the energy, water, resource and food nexus issues, could add up to $2.9 trillion to global productivity by 2035.[16] Sensitizing decision-makers to these matters is required to help support them with the skills and data they need to embed climate change, energy, water, resource and food security nexus issues and solutions into their decision-making and policy-making, as soon as possible.

Conclusion

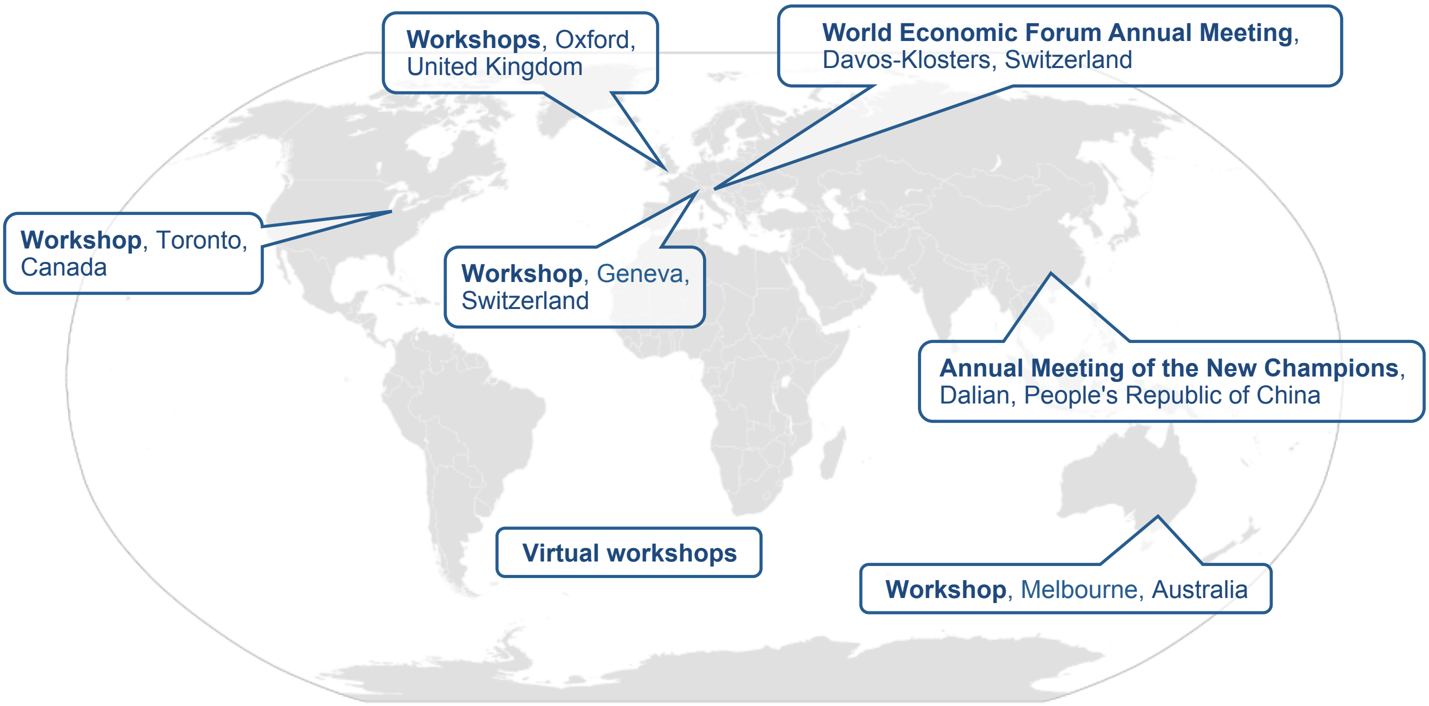
Accurately anticipating the world's supply and demand of resources over the period 2014-2035 is impossible because of the complex, uncertain and interconnected drivers of availability, at both global and local levels. However, assessments of the available literature, combined with extensive interviews and workshops with a wide variety of global experts, suggest that **shifting to an integrated perception of future resource availability is a critical part of tackling the social, political and economic shifts required to reach three goals: sufficient supplies of natural resources, flourishing natural ecosystems and sustainable prosperity for global populations.**

The world already possesses the vast majority of technical knowledge to serve its resource needs. To ensure that these goals are complements rather than trade-offs, the world needs **concerted and collaborative innovation in social, political and economic systems.**

Currently, perceptions of resource scarcity are conflicting. In fact, unless narratives converge, impending bottlenecks that limit availability, and externalities that threaten the environment, are unlikely to be attended to and corrected. **Clear, coherent domestic and international policies could remove barriers and drive investment where most needed**, such as for infrastructure upgrades to make supply chains more resilient and improve resource efficiency. Yet, even with clear frameworks effective at mitigating environmental risks, the world will bear rising costs of regulatory compliance and still suffer from acute and chronic damage to ecosystems that will, in turn, reduce the quality of life for many, particularly those least able to afford it. Therefore, such **policies and frameworks need to embrace both deep specialization and cross-cutting, interdisciplinary approaches** to managing multiple resources simultaneously.

This report presents a fresh perspective on a new paradigm for global resource availability, one that links global and local concerns, and acknowledges the complexities of interconnections across resources, nations and stakeholders. The challenge of designing resource management frameworks that effectively address these concerns and complexities is beyond the scope of this work; that challenge, however, is vitally important to the sustainable global availability of natural resources to 2035 and beyond.

Annex: Process and Stakeholder Engagement



Bibliography

Associated Press (AP), 2012. "Nigeria restores fuel subsidy to quell nationwide protests", 16 January 2012, *Guardian*, at: http://www.theguardian.com/world/2012/jan/16/nigeria-restores-fuel-subsidy-protests.

Belton, C.; Farachy, J.; Blas, J. "Russia grain export ban sparks price fears". 5 August 2010, *Financial Times*, at: http://www.ft.com/intl/cms/s/0/485c93ae-a06f-11df-a669-00144feabdc0.html#axzz3GaJAuznN.

Breakthrough Institute, *Energy Emergence: Rebound & Backfire as Emerging Phenomena*, 2011.

Bronk, C.; Tikk-Ringas, E. 2013. "The Cyber Attack on Saudi Aramco", in *Survival: Global Politics and Strategy*, Vol. 55, No. 2, April-May 2013, pp. 81-96.

Clark, P.; Crooks, E. "Water shortages pose larger than expected threat to shale gas". 2 September 2014, *Financial Times,* at: http://www.ft.com/cms/s/0/d6004afe-32b8-11e4-93c6-00144feabdc0.html#axzz3GaJAuznN.

Dobbs, R. et al. 2011. *Resource Revolution: Meeting the world's energy, materials, food, and water needs.* McKinsey Global Institute, McKinsey & Company.

The Economist, 2014. "The Economist explains: Why is renewable energy so expensive?", 5 January 2014, at: http://www.economist.com/blogs/economist-explains/2014/01/economist-explains-0.

Food and Agriculture Organization of the United Nations (FAO), 2012. *The State of World Fisheries and Aquaculture 2012.* Rome: FAO.

Gerland, P. et al. "World population stabilization unlikely this century", 10 October 2014, in *Science*, Vol. 346, No. 6206, at: http://www.sciencemag.org/content/346/6206/234.abstract.

Harvey, F. 2014. "Shale and non-Russian gas imports at heart of new EU energy strategy", 28 May 2014, *Guardian*, at: http://www.theguardian.com/environment/2014/may/28/shale-gas-russia-eu-renewables-ukraine-crisis.

International Energy Agency (IEA), 2014. *Special Report: World Energy Investment Outlook*. Paris: IEA.

The Jamestown Foundation, *China Brief*, Vol. 14, Issue 11, June 2014.

Jenkins, J.; Nordhaus, T.; Shellenberger, M. 2011. *Energy Emergence: Rebound & Backfire as Emergent Phenomena*, Breakthrough Institute. Oakland: Breakthrough Institute.

Kharas, H. 2010. "The Emerging Middle Class in Developing Countries", Working Paper No. 285, OECD Development Centre. Paris: OECD Development Centre.

Lott, M.C. "Solyndra – Illuminating Energy Funding Flaws?", 27 September 2011, in *Scientific American*, at: http://blogs.scientificamerican.com/plugged-in/2011/09/27/solyndra-illuminating-energy-funding-flaws/.

Lynch, D.J.; Schmidt, R. "Obama's Green Dilemma: Punish China, Imperil U.S. Solar". 18 August 2014, *Bloomberg*, at: http://www.bloomberg.com/news/2014-08-18/obama-s-green-dilemma-punish-china-imperil-u-s-solar.html.

Organisation for Economic Co-operation and Development (OECD), 2012. *OECD Environmental Outlook to 2050: The Consequences of Inaction.*

Paddison, L. "10 things you should know about investment in renewable energy". 16 July 2014, *Guardian*, at: http://www.theguardian.com/sustainable-business/investment-renewables-10-things-climate-change.

Stern, N. 2007. *The Economics of Climate Change: The Stern Review*, Cambridge: Cambridge University Press.

Stevens, P.; Kooroshy, J; Lahn, G.; Lee, B. 2013. *Conflict and Coexistence in the Extractive Industries.* Chatham House. London: The Royal Institute of International Affairs.

The Economics of Ecosystems and Biodiversity (TEEB), 2010. *Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB*.

United Nations Development Programme (UNDP). 2006. Human Development Report 2006. *Beyond scarcity: Power, poverty and the global water crisis*, New York: UNDP.

U.S. Geological Survey (USGS), Mineral Commodities Summaries, 2010 and 2014, at: http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/.

von Weizäcker et al., 2014. *Decoupling 2: technologies, opportunities and policy options*. A report of the Working Group on Decoupling to the International Resource Panel, United Nations Environment Programme, at: http://www.unep.org/resourcepanel/Portals/24102/PDFs/IRP_DECOUPLING_2_REPORT.pdf.

Welton, G. 2011. *The Impact of Russia's 2010 Grain Export Ban*, Oxford Research Reports. Oxford: Oxfam GB.

Xstrata, 2011. "Transformation through Organic Growth and Operational Excellence", Investor presentation by S. de Kruijff, see: http://www.glencorexstrata.com/assets/Uploads/xcu-speech-201104052.en.pdf.

Acknowledgements and Project Team

This publication synthesizes the ideas and contributions of many individuals whom the project team would like to thank for their time, energy and insights. In particular, the team thanks the following individuals for their engagement with the project (with their affiliation at the time of participation):

Abdulkhaleq Abdulla, UAE University
Celina Agaton, The Tapscott Group
Anthony Andrews, Prospectors & Developers Association of Canada (PDAC)
Hadley Archer, WWF Canada
Clive A. Armstrong, International Finance Corporation
Lamees Al Baharna, Bahrain Mumtalakat Holding Company B.S.C.
Lauren Baker, Toronto Food Policy Council
Pradeepta Narayan Banerjee, Essar Group
David Banister, University of Oxford
Rye Barcott, Duke Energy Corporation
John Barrett, Department for International Development (DFID)
Usama Barwani, MB Holding Company LLC
Nariman Behravesh, IHS
Robert Berendes, Syngenta International AG
Elaina Berry, The Wellcome Trust
Patrick Bindon, Barrick Gold Corporation
Don Blackmore, eWAter
Wen Bo, Global Greengrants Fund
Rina Bohle Zeller, Vestas
Jacques de Boisseson, Total (China) Investment Co.
Maria Boulos, WWF International
Dan Brock, Fasken Martineau
Mark Buckingham, Monsanto
Leslie Butterfield, Hill International
Gerald Butts, WWF Canada
Ruth Cairnie, Royal Dutch Shell
John Calverley, Standard Chartered Bank
James Cameron, Climate Change Capital
Nicola Cantore, Overseas Development Institute
Andrew Charlton, Wesfarmers Limited
Nuttachat Charuchinda, PTT PLC
Cheng Siwei, International Finance Forum (IFF)
Gary Chu, General Mills China
Paul Cleary, Australian National University
Gary Collar, AGCO
Aron Cramer, Business for Social Responsibility
Paul Crook, International Labour Organisation
Mark Davies, Rio Tinto
Jaime De Bourbon Parme, Ministry of Foreign Affairs of the Netherlands
Ronald Denom, SNC-Lavalin International Inc.
Paul Dibb, Australian National University
Paul DiPaola, Chartis Insurance
Michael Doane, Monsanto
Guan Dongyuan, Embraer SA
Neville D'Souza, Trimex International FZE
Sriwan Eamrungroj, PTT PLC
Robert Eberschalag, Mcleod Dixon LLP
Mark Eckstein, WWF
Charles Emmerson, Chatham House
Dan Esty, US Environmental Protection Agency
Alex Evans, Center on International Cooperation
Jesse Fahnestock, Vattenfall
Nils Ferrand, Cemagref
Joshua Fink, Enso Capital Management
William Forde, Lynas Corporation Limited
Aldo Fozzati, Fozzati Partners
Douglas Frye, Colliers International
Dana Gampel, Eskom Holdings SOC Limited
Dustin Garrick, University of Oxford
Damien Giurco, Institute for Sustainable Futures
Richard Gledhill, PwC
Charles Godfray, University of Oxford
Andrew Goldstein, Agriculture and Agri-Food Canada
Nandha Govender, Eskom Holdings SOC Limited
Richard Goyder, Wesfarmers Limited
Terry Gray, World Vision Canada
Mina Guli, Peony Capital Limited
Jim Hall, University of Oxford
James D. Hamilton, University of California, San Diego
Paul Dudley Hart, Mercy Corps
Tatsuya Hayashi, Unison Capital Inc.
Helen Henton, Standard Chartered
Kenneth Hersh, NGP Energy Capital Management
Shannon S. Herzfeld, Archer Daniels Midland Co.
Darcy Higgins, Food Forward
Julie Hill, Green Alliance
Samantha Hill, Canada Pension Plan Investment Board (CPPIB)
Martin Hoffman, Department of Resources, Energy and Tourism of Australia
Peter Hong, Alcoa
Robert Horn, Stanford University
Sam Hsu, Ecolab Inc.
Christian Hudson, European Commission
David Humphreys, Independent Consultant
Kirsten Hund, WWF
Linda Hwang, Business for Social Responsibility
Tan Chin Hwee, Apollo Global Management
John Ingram, University of Oxford
Brian Innes, Energetics
Mohammad Jaafar, The Kuwaiti Danish Dairy Company KCSC
Shirley Ann Jackson, Rensselaer Polytechnic Institute (RPI)
Carol Jadraque, Melbourne Water
Ian Jameson, Eskom Holdings SOC Limited
Erica L. Johnson, Eskom Holdings SOC Limited
Peter Kalkandis, Glencore Australia
Malobi Kar, University of Oxford
Alexey Karakhan, Otkritie Financial Corporation JSC
Gary Kass, Natural England
Renate Kenter, De Ruijter Strategy
Masa Kogure, TABLE FOR TWO International
Philip Krinks, The Boston Consulting Group
Tim Kruger, University of Oxford

Roland Kupers, SciencesPo.
Klaus Lackner, Columbia University
Upmanu Lall, Columbia University
Chris Lambe, The Mosaic Company
Jane Langdale, University of Oxford
Peter Lednor, Peter Lednor Consulting
Sandra Lee, UniSuper
Francis Lefèvre, Arcelor Mittal
Moritz Lehmkuhl, ClimatePartner
Steve LeVine, Georgetown University
James Z. Li, E. J. McKay & Co. Inc.
Michael Liebreich, Bloomberg New Energy Finance
Stewart Lindsay, Bunge Limited
Chris Llewellyn Smith , University of Oxford
André Loesekrug-Pietri, A CAPITAL
Michael Looker, The Nature Conservancy
Kevin Lu, MIGA - World Bank Group
Mindy S. Lubber, Ceres
Jay Luo, S.A.C. Capital Advisors (Hong Kong) Limited
Andrew MacDonald, QR National
Liz MacKinlay, World Vision Australia
Bob (James Robert) Maguire, Perella Weinberg Partners (Europe) LLP
Diana Mangalagiu , Reims Management School
Kiren Marahaj, Eskom Holdings SOC Limited
Robert Mathlener, PwC
John McArthur, Millennium Promise
Robert McEwen, US Gold Corporation
Amish Mehta, Vector Capital
Jock Mendoza-Wilson, System Capital Management
José Antonio Miranda, Gamesa Corporación Tecnológica SA
Vineet Mittal, Welspun Energy Ltd
Kieren Moffat, Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Rabi Mohtar, Qatar Environment and Energy Research Institute (QEERI)
James Moody, Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Blayney Morgan, Roy Morgan Research
Dambisa Moyo, Author
Kala Mulqueeny, Asian Development Bank
Gavin Murray, International Finance Corporation
Thomas George Muthoot, Muthoot Pappachan Group
Iftikhar Nasir, Essar Energy Plc
Margot Naudie, Canada Pension Plan Investment Board (CPPIB)
Mark New, University of Oxford
Peng Ningke, The Dow Chemical Company
Jon Norman, Ontario Ministry of Energy
Maria Ligia Noronha, The Energy and Resources Institute (TERI)
Richard O'Brien, Newmont Mining Corporation
Stefan Ogden, Glencore Singapore Pte Ltd
Dermot O'Gorman, WWF Australia
Chris O'Leary, General Mills Inc.
Stuart Orr, WWF International
Ondra Otradovec, ArcelorMittal
Stephen Owen, Victorian Managed Insurance Authority
Nick Palousis, 2XE
Jonas Palsson, Eton Park Asia Limited
John Pearce, UniSuper
Richard Pike, Wolters Kluwer
Wendy Poulton, Eskom Holdings SOC Limited
Kavita Prakash-Mani, Syngenta International AG
Juan A. Pujadas, PwC
Noah Raford, Global Business Network
Rafael Ramirez , University of Oxford
Usha Rao-Monari, International Finance Corporation
Tennant Reed, Australian Industry Group
Sue Riddlestone, BioRegional Development Group
Kristina Ringwood, Rio Tinto
April Rinne, Water.org
Natalie Rose, QR National
Yuriy Ryzhenkov, DTEK
Armen Sarkissian, Eurasia House International
Jeff Seabright, The Coca-Cola Company
Anand Sen, Tata Steel Limited
Rose Shabet, Viking Global Investors LP
Bill Sharpe, University of the West of England
Justin Sherrard, Rabobank International
Harinder Sidhu, Australian Government
Bill Singleton, Canadian International Development Agency (CIDA)
Judy Slatyer, WWF International
Samantha Smith, WWF International
Zdzislaw Sokal, National Bank of Poland (NBP)
Jo Spencer, Australian Business Foundation
Tony Su, DuPont China Holding Co. Ltd
Michael Sullivan, S.A.C. Capital Advisors LP
Richard Swannell, WRAP (Waste & Resources Action Programme)
Peter Sykes, The Dow Chemical Company
Yo Takeuchi, Development Bank of Japan
Frank Kui Tang, FountainVest Partners (Asia) Limited
Alex Tapscott, Canaccord Genuity Inc.
Alison Tarditi, Commonwealth Superanuation Corporation
Mark Tercek, The Nature Conservancy
Arjun Thapan, Asian Development Bank
Wim Thielemans, University of Nottingham
Victoria Thom, World Vision Australia
Scott Thomson, Talisman Energy Inc.
Jodie Thorpe, Oxfam
John Tilton, Colorado School of Mines
Vijay Vaitheeswaran, The Economist
Helen Van Hoeven, WWF
Noé Van Hulst, International Energy Forum (IEF)
George Vegh, McCarthy Tetrault
Jochem Verberne, WWF International
Paul Verschuer, Westpac Banking Corporation
Marius Verwoerd, Rio Tinto
David G. Victor, University of California, San Diego
Fleming Voetmann, Novozymes
Julian Von Fumetti, Barrick Gold Corporation
Peter Wallace, Government of Ontario
Tim Wang, Clifford Chance
Michael Warhurst, Friends of the Earth
Brian Watt, Newmont Mining Corporation
Gerard Weisbuch, Ecole Normale Supérieure
Jack Wen Yuezhong, General Electric Company
Jette Westerdahl, Novozymes
Adam Whitmore, Rio Tinto
Gian-Marc Widmer, Ecolutions New Energy Investment Co. Ltd
Angela Wilkinson, Smith School of Enterprise and the Environment (SSEE)
Duncan Williamson, WWF United Kingdom
Flora Wood, Inmet Mining
Changhua Wu, The Climate Group
Mahesh Yagnaraman, First Energy Private Limited
Anita Zeng Yubei, Glencore (Beijing) Trading Co. Ltd
David Zimmer, Altira Group

Special thanks go to Michael Smith, Research Fellow, Australian National University, for his time and expert input into the environmentally focused sections of this report.

The project team expresses its gratitude to the following colleagues from the World Economic Forum for their advice and support throughout the project:

Roberto Bocca
Jose Garcia (2011-2014)
Anuradha Gurung (2006-2012)
Tik Keung
Randall Krantz (2005-2012)
Irwin Mendelssohn
Alex Mung
Philipp Schroeder
Lisa Sweet
Michael Tost (2012-2014)
Tiffany West

Project Team

The project team includes the following individuals at the World Economic Forum:
Andrew Bishop, Senior Manager, Strategic Foresight, World Economic Forum
Nicholas Davis, Director, Head of Europe, World Economic Forum
Diane Davoine, Associate, Strategic Foresight, World Economic Forum
Kristel Van der Elst, Senior Director, Head of Strategic Foresight, World Economic Forum
Natalie Hatour, Associate Director, Strategic Foresight, World Economic Forum
Darko Lovric, Associate Director, World Economic Forum (2011-2014)
Beatriz Martinez Alvarez, Associate, Strategic Foresight, World Economic Forum
An Tran, Intern, Strategic Foresight, World Economic Forum (2012)

Editing: EditOr Proof
Layout: Ruslan Gaynutdinov
Illustration: Peter Grundy

Endnotes

[1] Lott, 2011.

[2] More information on Transition Town at http://www.transitionnetwork.org/.

[3] Kharas, 2010.

[4] Gerland et al., 2014.

[5] Welton, 2011.

[6] U.S. Geological Survey, Mineral Commodity Summaries, February 2014. See: http://minerals.usgs.gov/minerals/pubs/commodity/phosphate_rock/mcs-2014-phosp.pdf.

[7] *BP Statistical Review of World Energy 2014*. See: http://www.bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf.

[8] FAOSTAT Database. See: http://faostat.fao.org/site/377/default.aspx#ancor.

[9] UN-Water, Water Cooperation/Facts and Figures. See: http://www.unwater.org/water-cooperation-2013/water-cooperation/facts-and-figures/en/.

[10] International Energy Agency (IEA), Energy Poverty. See: http://www.iea.org/topics/energypoverty/.

[11] AP, 2012.

[12] TEEB, 2010.

[13] Stern, 2007.

[14] TEEB, 2010.

[15] Dobbs et al., 2011.

[16] von Weizäcker et al., 2014.

COMMITTED TO IMPROVING THE STATE OF THE WORLD

The World Economic Forum is an international institution committed to improving the state of the world through public-private cooperation in the spirit of global citizenship. It engages with business, political, academic and other leaders of society to shape global, regional and industry agendas.

Incorporated as a not-for-profit foundation in 1971 and headquartered in Geneva, Switzerland, the Forum is independent, impartial and not tied to any interests. It cooperates closely with all leading international organizations.

World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744

contact@weforum.org
www.weforum.org