PBL Netherlands Environmental
Assessment Agency

SCARCITY IN A SEA OF PLENTY?

GLOBAL RESOURCE SCARCITIES AND POLICIES IN THE EUROPEAN UNION AND THE NETHERLANDS

Policy Studies

Scarcity in a sea of plenty?

Scarcity in a sea of plenty?

Global resource scarcities and policies in the European Union and the Netherlands

Scarcity in a sea of plenty?
Global resource scarcities and policies in the European Union and the Netherlands

The Hague, 2011

ISBN: 978-90-78645-57-3
PBL publication number: 500167001

Corresponding author
Stephan Slingerland, stephan.slingerland@pbl.nl

Authors
Anne Gerdien Prins, Stephan Slingerland, Ton Manders, Paul Lucas, Henk Hilderink, Marcel Kok

Supervisor
Ton Manders

English editing
Serena Lyon

Graphics
Filip de Blois, Allard Warrink

Layout
Textcetera, The Hague

Printer
De Maasstad, Rotterdam

This publication can be downloaded from: www.pbl.nl/en. A hard copy may be ordered from: reports@pbl.nl, citing the PBL publication number or ISBN.

The PBL Netherlands Environmental Assessment Agency is the national institute for strategic policy analysis in the field of environment, nature and spatial planning. We contribute to improving the quality of political and administrative decision-making by conducting outlook studies, analyses and evaluations in which an integrated approach is considered paramount. Policy relevance is the prime concern in all our studies. We conduct solicited and unsolicited research that is both independent and always scientifically sound.

Contents

FINDINGS

FINDINGS

Scarcity in a sea of plenty?

- ***Policy attention has shifted from physical to economic and political dimensions of resource scarcity.***

The policy attention that is currently paid to resource scarcities is different from that of the past. In the past, such policy attention addressed physical depletion on a global level. Today, concerns about resource scarcity are mainly directed towards access to resources on a national level, as well as towards volatility of global market prices. The present situation regarding resource scarcity is also different because of current concerns about interactions between climate change, biodiversity loss and resources.

- ***The nature of, and driving forces behind scarcities vary greatly between the different resources. Hence, there is no one-fits-all approach to resource policies.***

Food and water are resources that are essentially renewable, whereas fossil energy and mineral resources are not. Fossil fuel use is a *causal* factor related to climate change, whereas food production is endangered as a result of the *effects* of climate change. Some minerals are abundantly available and have many present-day uses, whereas others are far more scarce, concentrated in specific locations, and used for high-tech applications. Resource scarcities can affect subsistence levels in developing countries, whereas impacts in Europe and the Netherlands are far more limited. Resource policies, therefore, require tailor-made approaches adapted to the various resources and countries.

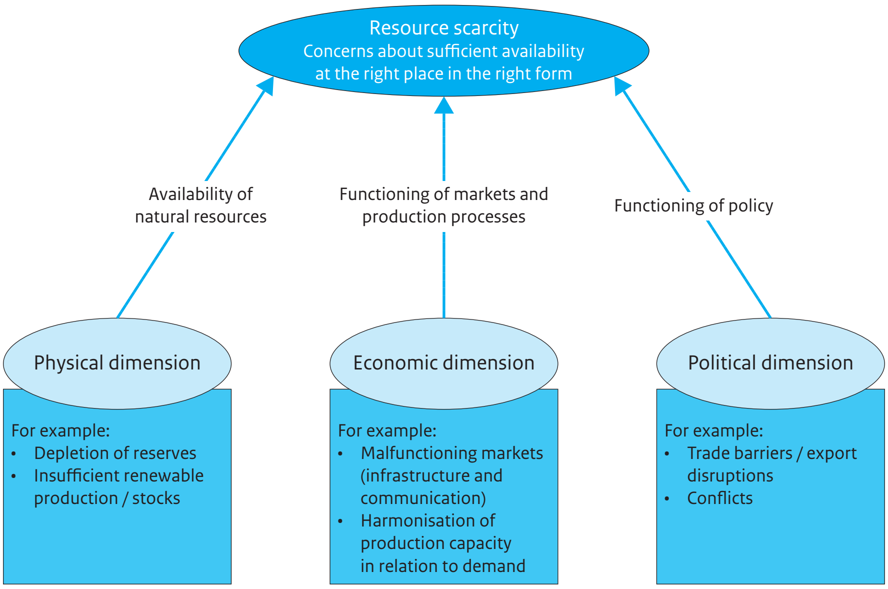
- ***Resource scarcities are interconnected and show trade-offs. An integrated framework of resource policies is therefore necessary.***

Biofuels can reduce fossil-fuel dependency, but because of land use competition they also can have negative effects on food production. Increasing food and mineral production may require larger inputs of energy and water. An increased use of renewable energy sources could involve increased use of metals and other minerals. Therefore, while a specific policy approach is required for each resource, an integrated framework of resource policies is needed that takes into account the trade-offs and interactions between resources.

- ***Present European and Dutch policies do not fully address all key resource policy objectives with the use of appropriate indicators, nor do they pay sufficient attention to trade-offs between objectives and to monitoring requirements.***

A stable and affordable resource supply are two of the key objectives of resource policies. Furthermore, the supply of resources should have the least detrimental effects on the environment and on the poorest people in developing countries. As there are trade-offs related to these four objectives, they cannot be maximised simultaneously. Understanding these trade-offs is important in formulating policies aimed at resource scarcities. The formulation of clear policy objectives of

Figure 1
Framework of the different dimensions of scarcities



resource policies, using appropriate indicators and recognising trade-offs between objectives, has not yet taken place in the Netherlands, nor at EU level. Appropriate indicators for security of supply are lacking, in particular, next to the integration of development concerns into resource policies.

- ***A close monitoring of resource flows and their effects is required for the formulation of effective resource policies.***

Trade-offs between resources, interactions with climate change and biodiversity loss, the identification of short-term market developments as well as long-term trends, crisis management in combination with long-term policies; resource policies require far more than statistical information on individual resources only. An interface between short-term and long-term statistical information on the one hand and policy action on the other, for instance, following the model of the European Energy Observatory, could improve upon this situation. On an international level, support for initiatives that promote transparency in international resource flows, such as the Joint Oil Data Initiative or the Extractive Industries Transparency Initiative, could improve access to crucial data, needed for the formulation of effective resource policies.

Introduction

In recent years, scarcity of resources again has been placed at the top of policy agendas worldwide, and not in the least on those of European and Dutch policymakers. However, there are many uncertainties regarding the exact size and shape of resource scarcities, regarding interactions, and regarding appropriate policies to address resource scarcities.

In this report, two main questions are examined:

(1) ***What future resource scarcities should the European Union and the Netherlands be concerned about?***

(2) ***What policy strategies are available to the European Union and the Netherlands to deal with these resource scarcities?***

Methodology

Answers to these questions are sought by looking in more detail into the key resources of energy, food, water and minerals, and the interactions between them, as well as the interactions with climate change and biodiversity loss.

This report distinguishes between a physical, an economic and a political dimension of resource scarcity, focusing on physical depletion of resources, failing markets and geopolitical concerns (Figure 1). The report also examines four main objectives of resource policies. The first two are aimed at a secure and affordable supply of resources to customers; the third is to ensure an environmentally friendly supply, from source to end-users, and the fourth relates to a fair supply, that is, with the least negative impacts on the poorest people within developing countries.

Concerns about current resource scarcities

Regarding the first research question, the following main observations have been made:

A changing world order, globalisation and interactions with climate change and biodiversity loss distinguish current scarcity concerns from previous ones

In the past, policy attention to resource scarcity addressed in particular the perceived global physical depletion of resources. Presently, concerns about interactions between resource scarcities and climate change and biodiversity loss seem to prevail over overall physical resource depletion.
Further distinctive features of the current period of resource scarcity are globalisation of the world economy and a changing world order. Together these factors stress distributional aspects of resource scarcity: Whereas previously OECD countries were the main party on the demand side, current scarcity concerns are characterised by increasing resource competition between OECD countries and emerging economies. On the supply side, many resources are increasingly concentrated in non-OECD countries, thus contributing to scarcity concerns in OECD countries.

Major concerns regarding resource scarcities are to be found less in the physical dimension…

Overall, it appears that the main scarcity concerns are currently not found in the physical exhaustion of resources, as there still seem to be ample margins in terms of reserves and potential production capacity expansions in the decades to come.

- *Energy* reserves are likely to be sufficient to meet demand in the coming decades, although slow adjustments of supply to changes in demand might cause temporary bottlenecks, the shift towards coal and to unconventional oil and gas resources might increase future impacts on climate, and the use of biofuels might increase impacts on biodiversity.
- There is ample potential worldwide to increase the productivity of land for *food* production or to expand agricultural land areas, but pressure on land will increase due to competing claims from other possible land uses.
- *Water* is a renewable resource and at a global level one of the most abundantly available substances on earth. Locally, however, its actual availability to humans for agricultural, industrial and drinking water purposes strongly varies over time. One fifth of the world's population currently lives in areas where physical water scarcity can occur – a proportion that is expected to increase in the future.
- At current production rates, reserves of most *minerals* will last for far more than a century. However, demand for minerals is likely to increase in the future, their extraction from locations with lower concentrations might increase environmental impacts, and reserves of some specific minerals might not be sufficient to meet the expected strongly rising demand in the future.
- Demand for resources will grow substantially in the coming decades, but in the longer term growth of demand is likely to slow down. The exception to this are some metals needed for high-tech energy solutions, for which demand might also rise steeply in the longer term.

… but rather in the economic and political dimension of resource scarcity

Economic and political considerations are main driving factors of current resource scarcity concerns.

- The concentration of fossil energy reserves, and in particular of oil and gas, in a limited number of countries increases fears in importing countries of the political misuse of market power. Also, competition on the demand side is rising as emerging economies increasingly rival OECD countries for fossil energy imports.
- Despite technical potential to increase food production, attempts to increase production have failed in recent decades, especially in sub-Saharan Africa, mainly because of insufficient infrastructure, ill-functioning markets and failing political governance.
- The major concern regarding water is the improvement and maintenance of infrastructure to deliver drinking water to households in developing countries. The appropriate establishment of institutions, including the proper pricing of water for all kinds of uses, can help to improve delivery.
- Reserves of some specific minerals that are necessary for raising food production (phosphate) or for alternatives to fossil fuels (some metals) are

Table 1
Major concerns about resource scarcities

	Dimension		
	Physical	**Economic**	**Political**
Energy	– Sharply rising demand increases pressure on remaining fossil resources		– Concentration of oil and gas reserves in a limited number of countries causes concerns about potential political abuse of monopoly power – Increasing competition between OECD countries and emerging economies about remaining fossil reserves
Food	– Lack of production increase to cope with increasing demand – Volatile demand for agricultural commodities due to the link between oil prices and bio-energy demand – Abrupt supply shortages due to extreme weather events	– Lack of access to markets/ incentives to farmers to increase production, particularly in developing countries	
Minerals	– Unexpected increase in demand for certain minerals due to the sudden rise of new high-tech applications		– Concentration of some minerals in a limited number of countries causes concerns about potential political abuse
Water	– Increasing demand increases pressure on freshwater resources – Adverse impacts of climate change could decrease resources	– Non-existent or improperly functioning markets and lack of infrastructure limit access to safe water, in particular for the poorest in developing countries	– Conflicts between parties in transboundary river basins limit access to water for downstream users

concentrated in a limited number of countries, causing concerns about potential political abuses of market power.

Economic and political resource concerns are shaped substantially by a still growing demand for resources in the decades to come. Increasing wealth and population growth are two key drivers for this growing demand, particularly in emerging economies and developing countries. In OECD countries, on the other hand, demand growth will slow down over time. The main underlying drivers here are dematerialisation of the economy and a slow population growth.

Reasons for concern are also to be found in complex interactions between resources on the one hand, and between resources and climate change and biodiversity loss on the other

Two main relationships exist between demand for resources. First, resources can be inputs for the production processes of other resources (e.g. water and energy for food production). Second, final products of resources can substitute each other (e.g. certain metals are needed for car batteries that substitute the use of oil for transport; crops can be used for food or for fuel). Policy options intended to deal with the scarcity of one resource can therefore aggravate the scarcity of other resources.
A dual relationship also exists between resource use and climate change and biodiversity loss. On the one hand, resource use can contribute to climate change and bio-diversity loss (e.g. fossil energy use contributes to climate change; increasing land use for agriculture can reduce biodiversity). On the other hand, climate change and biodiversity loss themselves can contribute to resource scarcity (e.g. climate change contributing to draughts in certain areas; pests induced by biodiversity loss reducing agricultural yields).

Vulnerability to resource scarcity is particularly high for importing developing countries and poor households that spend most of their incomes on food and energy

In this report, two quantitative case studies were carried out regarding the vulnerability of developing countries to increasing world market prices for oil and food.

It was found that vulnerability to increasing global oil prices, as a main signal of increasing energy scarcity, is likely to be the highest for the account balance of oil importing countries in sub-Saharan Africa, and for poor households in India and sub-Saharan Africa. Increasing oil prices in particular put a pressure on economic development when economies are highly oil intensive and unable to exploit alternatives. Furthermore, high oil prices put a pressure on government budgets when oil products are subsidised. In contrast, when energy is not, or only partly, subsidised, increasing oil prices make it more difficult for poor households to shift from traditional fuels for cooking and heating (coal and biomass) to modern oil-based energy sources (LPG and kerosene).
Vulnerability to food scarcity is also likely to be the highest in India and sub-Saharan Africa, due to a fast growing population and high existing levels of undernourishment. For both regions, increasing agricultural production becomes increasingly difficult as a result of projected impacts of climate change. In addition, as land in India is particularly scarce, expanding agricultural production there is only possible by increasing the production per hectare.

The European Union and the Netherlands are less vulnerable to resource scarcities, but substantial concerns remain

With respect to vulnerability, the food supply situation is relatively robust in the EU. The EU is a main food exporter, and food shortages in the near future are unlikely – although concerns exist in specific areas, such as for phosphate (for fertilisers), soy and vegetable oils. Water scarcity gives rise to concerns in particular in the southern Member States of the EU, although intensive use of water contributes to water scarcity elsewhere as well.
Main resource scarcity concerns are therefore to be expected in the areas of energy and mineral resources, where import dependency of the EU is already high and is likely to increase further in the future. This is especially true for some specialised metals that are used in high-tech energy applications that provide an alternative to current fossil-fuel use. Potential abuse of the monopoly power of a limited number of future suppliers is an area of particular concern; hence, most attention is paid here to the political dimension of resource scarcity.
If resource scarcities are expressed as price peaks, however, these can to a certain extent be absorbed by European economies. Impacts of such price peaks might be dampened by declining resource intensity in the European Union and the Netherlands, and can even be positive, as analyses of the effects of the 2008 oil and food price spikes suggest.

EU and Dutch policies to deal with resource scarcities

The complex interactions between individual resource policies and their relationships with climate change and biodiversity loss have been increasingly recognised by policymakers at both the European and Dutch policy levels in recent years. This has resulted in the initiation of several new policies and institutional changes at both levels.

In this report, current policy developments in the EU and in the Netherlands were assessed against three requirements for future resource policies, based on the analysis made in this report: 1) Attention to trade-offs between policy objectives at a more strategic policy level, 2) attention to trade-offs between policy options at a more practical level, and 3) attention to coordination and monitoring, making sure that a coordinating body receives sufficient information in time to address both short-term crises and long-term policies, and that it has the legal and practical competences to act regarding all policy objectives formulated. Geopolitical aspects of resource policies for the EU and the Netherlands were also discussed.

Approaches to resource policies on a Dutch level are substantially different to those on a European Union level

There are substantial differences between the European Union and the Netherlands regarding the coordination of resource policies. The European Union applies a more top-down oriented approach with a strong coordination by DG Environment, whereas the Netherlands so far has made use of a relatively weak, temporary body with few legal responsibilities. Further, on a European level, new policies ('Flagship Activities') are at the centre of attention, while in the Netherlands, policy steering so far mainly takes place via the formulation of research questions.

Present European and Dutch policies do not fully address all key resource policy objectives with appropriate indicators, nor do they pay attention to trade-offs between objectives and monitoring requirements

Resource policies initiated in recent years at the European and Dutch level do pay sufficient attention to interactions between resource policy options and to monitoring requirements, but no attention is paid to trade-offs between objectives. Clear objectives and indicators for achievement of these objectives are often lacking, in particular regarding the political dimension of resource scarcity. Attention in particular to development objectives in resource policies is often absent, despite announced intentions to integrate this objective into other policies, also clear indicators for security of supply are lacking.

The European Union and the Netherlands are relatively poorly equipped to deal with a situation of fierce resource nationalism

Finally, a geopolitical situation in which national interests in resource policies would become dominant would be the least desirable outcome for the EU and the Netherlands, as their ability to act in such a situation might be limited, compared to other main geopolitical players. Hence, robust resource policies of the EU and the Netherlands should in the first place be directed to preventing such a situation, and only in the second place to adaptation, should such a situation occur.

Scarcity in a sea of plenty?

Resource scarcities are crucially dependent on definitions and on the determination of underlying causes. Is a resource scarce on a global basis because of physical depletion, is it just not available at a certain point in time to a determined group of consumers because of market failures, or is a perceived scarcity in fact a concern of some resource importing countries relating to the potential political abuse of market power by some exporting countries? Answering these questions, as well as a clear determination of objectives, will be crucial for the successful implementation of future resource policies in the European Union and the Netherlands.

Furthermore, resource scarcities still have to deal with many uncertainties. Further research supporting resource policies is therefore required. Such research could involve, in particular, the establishment of scenarios in which each of the resource policy objectives described is maximised, and trade-offs with the other objectives are examined. Further research is also needed regarding the integration of development and resource policies, as intentions for such an integration have not yet materialised in practice. More detailed insight is also required regarding trade-offs between the implementation of individual resource policy options and other resources and with climate change and biodiversity loss.

Finally, it seems that resource scarcity has once again become a main policy topic, despite apparent technical possibilities for a sustained resource use in the decades to come. It therefore seems that scarcity is perceived in what might well be seen as a 'sea of plenty'. The key challenge for future resource policies therefore will be to navigate carefully across this sea in order to fully exploit the potential benefits of resources, whilst minimising their possible adverse impacts. The anchor of such policies in the European Union and the Netherlands has been raised, and now the proper course needs to be set.

FULL RESULTS

ONE

Introduction

An all-time oil-price peak of $ 147 on 9 July 2008; prices of food commodities such as vegetable oil, grains, dairy products and rice reach record levels in the first half of 2008; fears about the continuity of gas supplies to the European Union after two gas conflicts between Russia and the Ukraine in 2006 and 2009; rising corn prices in Mexico due to increased biofuel demand in the United States in 2007; Chinese export restrictions in 2008 on rare earth metals; commodity prices again on the way up after the world economic crisis of 2009.

1.1 Increasing resource scarcities?

A long series of events in recent years has spurred a growing feeling of unease in many countries about the increasing scarcity of natural resources, malfunctioning global markets and the political tensions that might be a consequence. Prospects for the future global availability of natural resources also seem dim. In the years to come the world population is expected to grow by an additional 2.5 billion, passing 9 billion in around 2050. This growth is expected to be accompanied by annual economic growth of around 5%, most of which will take place in emerging economies such as China, India, Brazil and the Republic of South Africa (OECD, 2008a).

Increasing population and wealth are likely to result in a rising pressure on key natural resources such as energy, food, minerals and water. Problems might be aggravated by climate change and biodiversity loss. However, not all consequences will be felt equally everywhere. In developing countries, higher prices for basic commodities such as energy, food and water might hit people harder than in industrialised countries. Particularly those that are already poor might be affected most. For instance, the recent price peak in food caused an additional 75 million people to suffer from hunger in developing countries in 2007 (FAO, 2008a).

While the problem of 'increasing resource scarcities' at first hand might appear straightforward, it turns out on close inspection to be very complex. What exactly is becoming 'scarce', to what extent, and for whom? What are the drivers for increasing resource scarcities that could be addressed by policies? And, perhaps even more importantly, how do resource scarcities interact with the availability of other resources, and with global environmental problems such as climate change and biodiversity loss? These are some of the key questions that need to be addressed to formulate appropriate policy responses for the future.

1.2 The European and Dutch policy context

Many policy measures have already been taken worldwide in recent years to address resource scarcities. At a multilateral level, many conferences and research programmes have been devoted to the topic. The United Nations Food and Agriculture Organisation (FAO) for instance initiated a global food security conference in 2010 and the United Nations Environment Programme (UNEP) has put resource scarcity firmly on its research agenda.

In the European Union and the Netherlands, the topic of resource scarcity has also resulted in several policy responses. At the European level, initiatives taken so far can be found for instance in the Common Agricultural Policy, the EU Sustainable Development Strategy, the Raw Materials Initiative and the Lisbon Strategy (Schaik et al., 2010). As an overarching framework, a 'Resource Efficient Europe' has been listed as one of the seven 'Flagship Activities' of the new Europe 2020 strategy (European Commission, 2010). In the Netherlands, the topic was addressed by a parliamentary resolution in November 2008 (Eerste Kamer, 2008). An interdisciplinary working group was formed consisting of representatives of several ministries and policy researchers from different institutes. The working group formulated a number of key research questions that are to be addressed in a research and advice trajectory by several institutes in 2010 and beyond (VROM, 2010).

Policy initiatives to address resource scarcities are therefore already underway. However, are the roads taken so far the right ones? What further measures are required for the future? And how can we prevent the creation of new problems by trying to solve individual parts of the puzzle? This is a second set of questions that needs to be answered when designing future resource policies.

1.3 This report

This report aims to help disentangle the complex web of 'increasing resource scarcities'. It provides recommendations for future resource policies for policymakers in the European Union and the Netherlands by focusing on two key questions:

(1) ***What future resource scarcities should the European Union and the Netherlands be concerned about?***
(2) ***What policy strategies are available for the European Union and the Netherlands to deal with these resource scarcities?***

These questions will be examined step by step in the report by taking a detailed look at the following key resources: energy, food, minerals and water. First, in Chapter 2 of this report a framework to analyse resource scarcities is developed. What is 'resource scarcity'? Is it a new phenomenon or not? And can resource scarcity be measured objectively? The framework distinguishes between three dimensions of scarcity: physical, economic and political. This framework is used for the analysis in the subsequent chapters.

Chapter 3 examines to what extent the resources energy, food, minerals and water are actually scarce. For that purpose, characteristic trends and policy responses regarding these resources are discussed and compared, also against the backdrop of climate change and biodiversity loss. Chapters 4 and 5 focus on who actually experiences resource scarcity and the impact of such scarcity on these people. Chapter 4 analyses vulnerabilities and the impacts of resource scarcities on developing countries based on the case studies of food and energy. Chapter 5 concentrates on likely effects in the European Union and the Netherlands.

Chapter 6 finally focuses on policies. It scrutinises the resource policies that have already been initiated at the European level and in the Netherlands. How are they organised? Do they address key elements of resource policies that were identified in the previous chapters?

TWO

Framework for analysing resource scarcities

In this chapter, a framework is developed for analysing resource scarcities that is applied throughout the report. The chapter examines past thinking about resource scarcities (Section 2.1) and current trends (Section 2.2). It then introduces three dimensions of resource scarcities (Section 2.3). Finally, the chapter discusses how to move from resource scarcity to policies (Section 2.4).

2.1 Resource scarcity: an old problem

Scarcity is the concept of finite resources in a world of infinite needs and wants. As such, there have always been concerns about the availability of natural resources for human development. Saint Cyprian, writing in AD 300, already complained: *The layers of marble are dug out in less quantity from the disemboweled and wearied mountains; the diminished quantities of gold and silver suggest the early exhaustion of the metals, and the impoverished veins are straitened and decreased day by day* (Saint Cyprean Ad Demetrianum 4-5, quoted in Tainter, 1990).

The modern scarcity debate began with Thomas Malthus in the 18th century (Malthus, 1798). He advanced the depressing theory that food production could not meet population increase and projected catastrophic consequences. Malthus has however so far been proven wrong as he failed to note the concept of technological progress. Long-run growth and declining resource prices have shown that productivity growth has more than offset the diminishing returns from limited resources.

In the 1960s, Barnett and Morse made the case in *Scarcity and Growth* (1963) that resource scarcity did not yet, probably would not soon, and conceivably might not ever halt economic growth. Market mechanisms were thought to be adequate to the task of allocating resources in an efficient and sustainable way. As a counterpart (see also Box 2.1), the *Limits to Growth* report in the early 1970s modeled the consequences of population growth and finite resource supplies and predicted economic collapse in the 21st century (Meadows et al., 1972).

From the 1970s onwards, views on resource scarcity were increasingly accompanied by a growing concern about an emerging new scarcity: the depletion of ecological assets and pollution as a consequence of resource use. Evidence of climate change and biodiversity loss, which became important policy issues from the 1990s onwards, showed the limits of the environment to absorb and neutralise the unprecedented waste streams of humanity. This other type of scarcity was labeled *new scarcity* by Simpson et al. (2005). Both climate and biodiversity provide global public goods. Everyone is affected by changes in climate and everyone may be affected by changes in ecological services that natural systems provide. Markets do not allocate public goods efficiently. This creates tremendous challenges for policies. By the end of the 20th century, concerns about the ability of earth systems to absorb the wastes resulting from the use of mineral products (*new scarcity*) had largely supplanted concerns about resource scarcity (*old scarcity*).

Resource scarcity became a policy topic again in the early 21st century. Rapid economic development in, for example, Asia and Brazil renewed concerns about resource availability. The most recent boom in commodity prices has been the most marked of the past century in its magnitude and duration. With resources becoming limited and more concentrated the EU sees a growing dependency on imports of energy and strategically

Box 2.1 Scarcity and growth, or limits to growth?

The reports of Barnett and Morse on the one hand and of Meadows et al. on the other express two fundamentally different visions of resource scarcity. Resources are needed to fuel economic growth. Economically speaking, any positive price in a market is proof of scarcity. In markets, tensions between resource demand and supply are displayed as the price of the resource (a rising price indicates that the resource is becoming scarcer). Markets clear as prices equalise quantity supplied and quantity demanded. The economic principle of diminishing returns however implies that economies relying on fixed stocks of land and other resources are destined for stagnation. No matter how much capital and labour is involved, a fixed factor will ultimately decrease productivity. The way out is technological progress. The law of diminishing returns can be opposed by improvements in production (technological change). Knowledge allows us to do more with limited means. Knowledge is not subject to diminishing returns.

The main question is if and for how long the implications of diminishing returns can be suspended or controlled by extending our knowledge and innovation. This depends very much on world views: pessimists versus optimists. Barnett and Morse are optimistic about the capacity of markets to stimulate innovation and hence to ultimately prevent resource depletion. In their view, true resource exhaustion is unlikely not least because, as resources become scarcer, their prices rise, consumption declines, and alternatives that once may have been uneconomic are substituted for the scarce (and expensive) commodity.

Meadows et al. do not take into account effects of innovation at all, and therefore might be regarded as pessimists in this respect. In their view, it is a fallacy to believe that market mechanisms are adequate to the task of allocating resources in an efficient and sustainable way. Markets do not allocate non-rival goods efficiently. Too little knowledge is likely to be produced, as innovators often generate spillovers that others can appropriate and from which they can benefit. Too much pollution is likely to be produced as polluters generate waste that spills over into the public domain.

So far, humans have been quite adept at finding solutions to the problem of scarce natural resources, particularly in response to signals of increased scarcity. Technological progress has until now mitigated the scarcity of natural resources. However, resource amenities have become scarcer, and it is far from certain that technology alone can remedy them in the future (Krautkraemer, 2005).

important raw materials which are increasingly affected by market distortions. More than in the past, Europe has to compete with new, emerging economies. Resources are more and more seen as strategic goods. This has added a geopolitical dimension to 'old' and 'new' scarcities.

2.2 Current trends causing resource scarcity

This section outlines some key drivers for the renewed policy attention for resource scarcities in recent years.

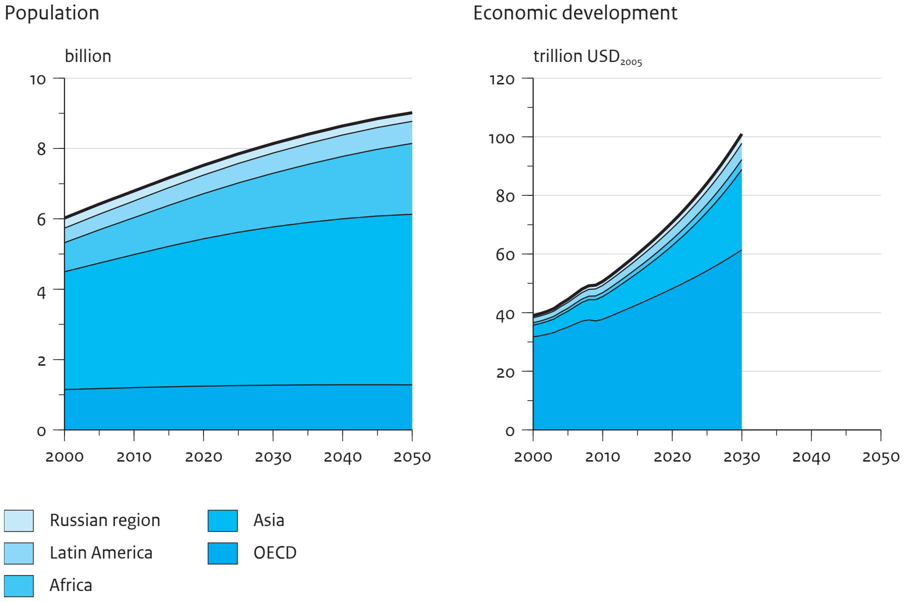
2.2.1 Growing demand

Population growth and economic growth are two key variables that drive increasing resource scarcities (see Figure 2.1). The UN projects the world population to increase to over nine billion in 2050 (UN, 2008). Most of this increase will occur in developing countries, especially in urban areas, while half of the world's population already lives in urban areas. The urbanisation rate is expected to reach 69% in 2050 (UN, 2010). Urbanisation is one of the drivers in the shift of traditional biomass to modern energy and of traditional diets to more Western diets with more meat (Ruijven, 2008; Pingali, 2004).

Regarding economic growth, the USDA (2008), based on projections of the World Bank and IMF, projects the global economy to be twice as large as in 2010, with the highest growth rates in emerging economies. Although the economic crisis lowered demand for industrial goods such as oil and metals in 2009, economic growth forecasts show a return to an increase from 2010 onwards (World Bank, 2010). While the projection expects an average 2% growth in GDP for the developed countries in 2010/2011, GDP in developing countries is expected to grow by more than 5%.

Demand for (and supply of) commodities over the past 35 years has been rising steadily. The quantity of energy consumed increased by an average of 2.2% a year during the period 1970–2005, that of metals and minerals by

Figure 2.1
Global population and economic development



3.1%, and that of food by around 2.2%. However, demand for these commodities has grown less quickly than GDP, albeit more quickly than population (World Bank, 2008).

Demand growth for resources is likely to slow down in the longer term future. The demand for agricultural commodities will slow as population growth slows and as incomes in developing countries continue to rise. At a certain point, for example as high levels of food intake per person are attained, demand for agricultural commodities responds less to income increases (the income elasticity of food decreases with rising incomes). For metals, a rise in the share of total output held by the less commodity-intensive service sector should slow demand in the long term.

Towards one world…

The world has become increasingly interconnected in recent decades. Growing transport and storing capacities have boosted trade: from 21% of GDP in 1970 to 52% of GDP in 2008 (World Bank, 2010b). Net migration between high and low income countries in 2005 has increased by 700% since 1960 (World Bank, 2010d). In addition, internet has enlarged the facility to share information all over the world. These developments imply that shocks in the supply of a commodity in one country or world region can be absorbed by the supply of other countries. However, it also implies that such a shock could have more and more impacts in other regions – although not all resources will be influenced similarly. For energy, there is a strong world market which interlinks all countries globally and strongly determines world energy prices. There is a similar world market for several agricultural commodities, although regional and local markets are more important. Water, on the other hand, has a local and regional character. However, the impact of climate change on water resources suggests that maintaining water availability at current levels also requires global action.

… but a multipolar world

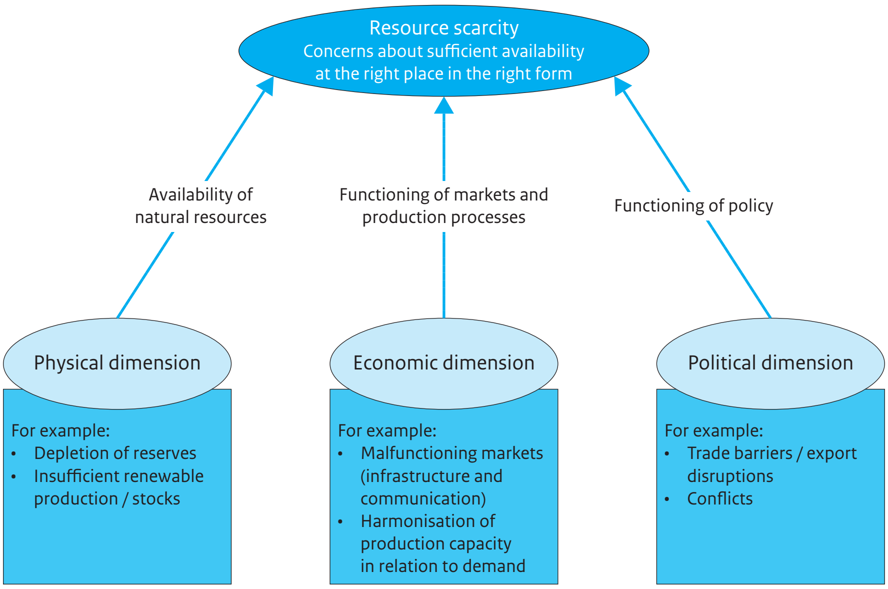
The world might have become more interconnected, it is also characterised by a more complex world order. After the fall of the Berlin Wall in 1989 the former bipolar Soviet–American world order vanished, to be replaced first by a seemingly mono-polar world order dominated by the United States as a hegemon. However, the 'End of History' that was proclaimed (Fukuyama, 1992) only lasted for a couple of years. It was replaced by a much more diffuse situation, in which the emerging powers of Brazil, Russia, India and in particular China gave rise to the coining of the present system as a 'multipolar' world order (Calleo, 2009). In this emerging new world order, the overall economic and political influence of the United States appears to decrease, while that of China is rapidly increasing (Subacchi, 2008). As a new equilibrium is not yet in sight, a growing potential for conflict arises.

2.3 Dimensions of scarcities

In discussions about 'resource scarcity' it is often unclear what is exactly meant by this term. Sometimes, the

Figure 2.2

Framework of the different dimensions of scarcities



physical depletion of non-renewable resources appears to be the focus. At other times, distributional aspects and high prices of resources seem to be the topic. On yet other occasions, the risks of becoming dependent on a limited number of countries for the supply of a resource are the actual theme.

In this report therefore, we distinguish between three dimensions, or groups of drivers, of scarcity (see Figure 2.2). In physical terms, scarcity is about global resource availability and demand: is there enough to meet everyone's needs? In the economic dimension we focus on the distribution of resources and on the functioning of markets: is a resource available at the right location and in the right form? The political dimension points at geopolitical actions that influence the availability or affordability of resources in a certain place or country. Obviously, these three dimensions are highly interdependent.

This framework will be used in the remainder of this document to analyse resource scarcities in more detail. Chapter 3 will discuss extensively the scarcities of the four resources energy, food, water and minerals in terms of the three dimensions identified. These four resources include the most important consumption goods, especially for poor people. These have all gained much political and social attention recently because of the fear of physical depletion, impacts on hunger, poverty and climate change, and fears of the political misuse of market power. The further analysis of food does not include fisheries, because of the different characteristics of the production process. Neither is scarcity of food equivalent to the scarcity of land. Scarcity of land, however, is included in the analysis as one of the drivers for food scarcity.

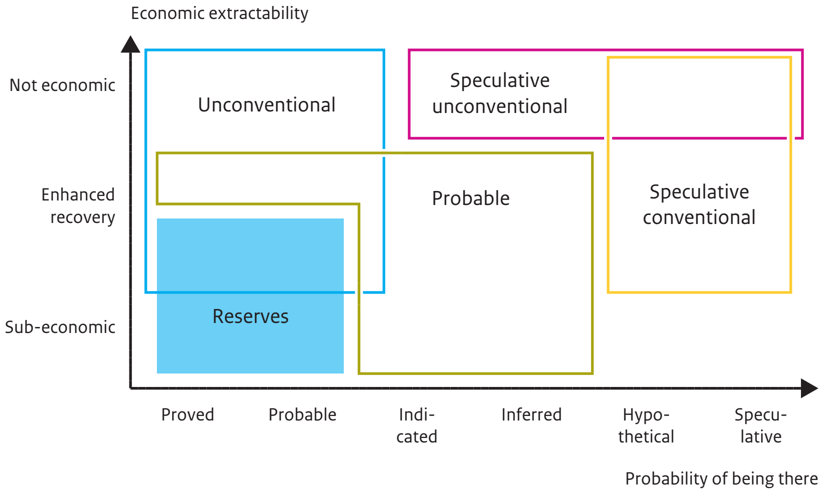
2.3.1 Physical dimension of scarcity

The physical dimension points at the availability of resources as determined by physical and ecosystem characteristics. Two kinds of resources can be identified in this respect: mineral resources such as fossil fuels or metals are finite resources and essentially non-renewable. Resources such as food and water however are generally renewed on a yearly basis. In the case of non-renewables, a certain amount is available in the earth's crust of which the total quantity is essentially unknown, but geologically expressed in different grades of probability of being there. Research and innovation can increase the total amount of known reserves available for physical exploitation. In the case of food, the physical dimension is defined by the yearly production together with the available stock. Underlying reasons for shortfalls in availability can be long-term developments such as slowing productivity increase with respect to demand or short-term developments such as adverse weather conditions causing sudden production shortfalls.

Many uncertainties exist in the long-term availability of resources. For renewables, short-term conditions (weather conditions) are hard to predict and developments determining long-term availability are

Box 2.2 Reserves and reserve base: what's the difference?
Geologically, different classes of reserves can be distinguished as elaborated in the McKelvey diagram (Figure 2.3). These classes depend on two variables: the probability of being present and the economic extractability. The reserve base comprises all resources from speculative and non-economic to proved and sub-economic. Reserves are only those resources that are proved and can be explored economically. However, several different definitions of these terms exist with slight variations.

Figure 2.3
Probability and economic extractability of classes of reserves of non-renewable resources
McKelvey diagram



Source: Rogner (1997)
McKelvey diagram showing the economic extractability and probability of being there of different classes of reserves of non-renewables.

highly uncertain, for example productivity increases in agriculture or the supply of freshwater from groundwater aquifers. The total availability of non-renewables in the earth's crust is unknown and the enlargement of reserves is dependent on research and innovation. Also, geologists apply a wealth of different definitions to resource reserves (see Box 2.2), despite attempts at harmonisation (UN-ECE, 1996). Transparency regarding the quantity of reserves can even be a political and strategic issue (IEA, 2005). Furthermore, the economy has an effect on physical availability. The higher the price of a commodity, the more can be explored.

Although non-renewable in nature, many metals and other minerals are not lost forever. The continued increase in the use of metals during the 20th century has led to a substantial shift from geological resource base to metal stocks in society. A recent assessment by the UNEP Resource Panel (UNEP, 2010) suggests large in-use stocks for certain metals. This opens up possibilities for recycling (rich 'anthropogenic mines' that have the potential to be tapped as sources of metal for the uses of modern society).

2.3.2 Economic dimension of resource scarcity

The economic dimension of resource scarcity focuses on the question whether the market functions appropriately. Is there enough at the right place at the right time to meet everyone's needs? This concerns potential bottlenecks over the whole supply chain and can include problems ranging from insufficient technical production capacities, to lack of infrastructures and transport capacities, to distributional inequalities at the end-user level.

Regarding food, for instance, there has been enough food available in recent years to properly feed the global population. However, while obesity is a problem in high income countries, people are starving in the developing world. As well as poverty, ill-functioning infrastructure is one of the underlying causes. Infrastructure is important in different ways: in the sense of roads or ways to transport goods, but also in the sense of the diffusion of information from markets to producers or consumers. If producers do not know that demand for a product is increasing, why should they produce more? For water, the distribution at a regional scale or within the river basin is of major importance for access to drinking water. Regarding energy, bottlenecks in refinery capacity were one of the causes for the recent oil price spike. Speculation and unfavourable exchange rates are other aspects of ill-functioning markets that have been shown to be important in the recent oil, food and minerals price spikes.

2.3.3 Political dimension of resource scarcity

Natural resources are unevenly distributed over the world. If the world reserves of a certain resource are concentrated in a limited number of countries, this can give rise to political fears in import-dependent countries that their dependency might be misused politically by exporting countries, or that their dependency might lead to sudden supply disruptions. For exporting countries, export restrictions can be a way to show their political power or to attain political and strategic goals that are not related to the resource as such.

Politically motivated scarcities ('supply disruptions') can occur from one moment to another and end just as abruptly. In recent years, several examples of scarcities caused by political reasons have occurred. Russia, as the most important gas supplier to the European Union, suddenly cut its supply to the Ukraine in 2006 and 2009, which also impacted on the gas supply to the European Union. Another example was the decision of several governments to increase export tariffs or to impose an export ban on food products such as rice and grains during the food crisis of 2008. In 2009, the Chinese government imposed export restrictions on rare earth metals, required for example for high-tech energy applications in the European Union.

2.4 From resource scarcity to policy objectives

Increasing scarcity of resources can have major impacts: decreasing availability of resources, either gradually through physical exhaustion or abruptly as a result of politically motivated disruptions, and/or increasing prices are the two prominent ones. But also environmental degradation, including climate change and biodiversity loss, and negative impacts particularly on the poorest in developing countries can be the result of increasing exploitation of resources. This section explores how to get from the notion of resource scarcity to resource policies.

Affordability and availability of resources are two major policy objectives for preventing resource scarcity. However, resource policies as such, and in particular those of the European Union (EU) and the Netherlands, have a wider scope than only preventing scarcity. The objective is not only to make resources available at all moments to all end-users in the Netherlands and the EU, it also has to be done in an environmentally sound way, without excessive pollution, greenhouse gas emissions or biodiversity loss. Furthermore, policies of the Netherlands and the EU seek to improve the living conditions of the poor in developing countries in particular. As many resources are imported from developing countries, minimising the negative impacts of resource extraction, production and use on developing countries needs to be regarded as an additional objective of integrated resource policies. In this report, we therefore focus on four policy objectives, two of which are the subject of resource scarcity policies in a narrow sense (affordable and available) and two of which fall within the scope of wider resource policies:

- **Affordable:** supply of resources to end-users (in the Netherlands and the EU) at affordable prices;
- **Security of supply:** a physically uninterrupted supply to customers (in the Netherlands and the EU);
- **Environmentally friendly:** an environmentally sound supply of resources from source to Dutch and European end-users (in the Netherlands and the EU);
- **Fair:** preventing negative external impacts of the affordable, available and sustainable supply of resources to end-users (in the Netherlands and the EU), in particular on the poorest in developing countries.

Scarcity has both short- and long-term effects, hence policies can focus on either the short or the long term. Emergency response policies in the case of political crises, measures against speculation in the case of price spikes or food aid to developing countries are examples of policy measures that are directed primarily at the short term. Research and innovation policies, substitution of resource use by more environmentally sound alternatives or measures to improve production efficiency are clearly more directed at the long term. However, the two types of policy interventions are closely related. Short-term events such as political crises, price spikes and natural disasters are often the initiator for combined policy packages consisting of both short- and long-term policy measures.

Since scarcity of resources can express itself not only as being unavailable as a resource, but also as being too expensive, no single indicator can capture all aspects of resource scarcity. To quantify the impact of future developments on scarcity in developing countries (Chapter 4) as well as in the European Union and the Netherlands

(Chapter 5), we use price levels and import dependency as two indicators that approximate affordability and availability of resources. Price does not take into account the political risk adequately and some resources – water, biodiversity and land – are not properly priced. Import dependency is not necessarily a problem, but can contribute to the fear of supply disruptions.

Furthermore, it has to be noted that there are objective as well as subjective uncertainties regarding resource scarcities. Potentially objectively determinable uncertainties are for instance the amount of reserves of a resource in the earth's crust, or the total available food for consumption. Subjective uncertainties are for instance which price level of resources is considered a trigger for policy intervention, or what concentration of resources in which countries is considered a policy risk that needs intervention.

The degree of priority given to each of the four general resource policy objectives identified above is also part of the subjective realm of politics. Often, more fundamental visions concerning the role of the market versus the role of the state, or the role of multilateral action versus bilateral action, determine these priorities. Chapter 6 elaborates on the interactions between policy objectives and the priorities that can be set.

THREE

To what extent are energy, food, minerals and water scarce?

This chapter examines to what extent the resources energy, food, minerals and water are 'scarce' exactly. Sections 3.1 to 3.4 examine the physical, economic and political dimensions of resource scarcity for these vital resources individually, as well as the policy options that are currently applied to deal with these scarcities. Section 3.5 then explores the interactions between resources and Section 3.6 compares the major concerns regarding scarcity of the four resources in the future. Section 3.7 finally provides some main conclusions.

3.1 Energy

Although renewable energy sources are experiencing fast growth rates, the present energy supply consists for 80% of fossil fuels (IEA, 2009). Continuing with presently announced national policies in the business-as-usual scenario of the International Energy Agency, in 2030 the world energy supply still might consist for 80% of fossil fuels, albeit – even taking the current global recession into account – at a 40% higher demand. Discussing the scarcity of energy therefore in the first place involves a closer look at fossil fuels. An important indicator of energy scarcity are prices. As causal factors for price development, physical, economic and political factors play a role, as suggested by a oil price developments from 1970 to 2010 (Figure 3.1)

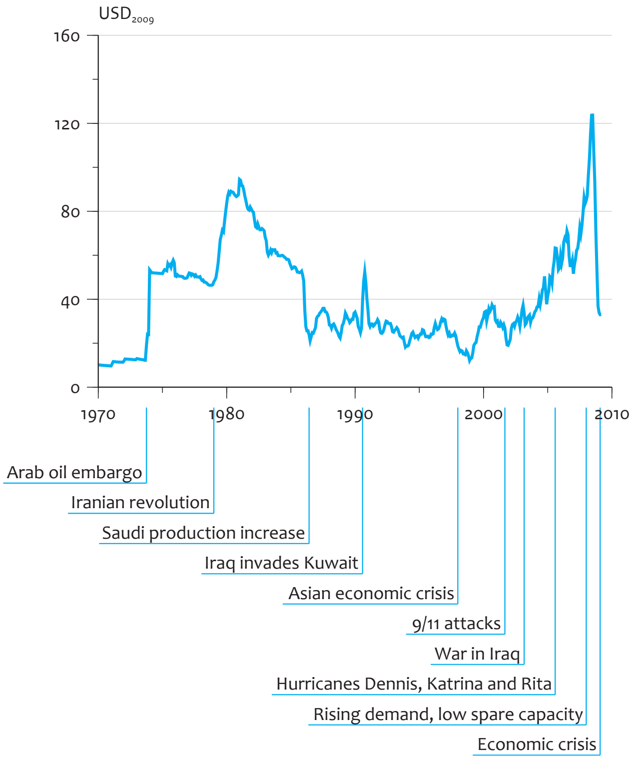
3.1.1 Physical dimension of energy scarcity

In recent years there have been two main views on the physical scarcity of fossil energy, mainly differing in speed of depletion of fossil reserves and urgency of response. The mainstream view is expressed for instance in the BP Statistical Review of World Energy and the International Energy Agency (BP, 2009; IEA, 2009). In this view, based on current proved reserves and present production rates, the depletion of conventional oil reserves would take some 40 years, that of gas reserves some 60 years and that of coal reserves far more than 100 years. However, this 'Reserves-to-Production ratio' (R/P ratio) does not take into account new reserves to be discovered, the upgrading of probable or inferred reserves to proven reserves or an increase in the recovery factor (currently 35%). Neither does this R/P ratio account for changes in production rates, and for non-conventional resources such as oil sands, oil shales and unconventional gas. Including these sources and developments can strongly increase the number of years that global fossil fuel reserves can still be used (see Box 3.1).

Exploitation costs of the different fossil resources however differ largely, as demonstrated by the example of oil – with typical costs of $ 10–40 per barrel for conventional sources, $ 10–80 per barrel for enhanced oil recovery and $ 50–100 per barrel for oil shales (IEA, 2008) (see Figure 3.2).

An alternative view on the physical scarcity of fossil energy and in particular the scarcity of oil that has received much attention in recent years is given by the protagonists of 'peak oil' theories. In this view, which is based on the work of the geographer M. King Hubbert dating back to the 1950s, depletion will take place at a much faster rate than assumed by mainstream calculations (cf. Campbell and Laherrère, 1998). However, peak oil theories are controversial. The main criticism is that, at a global level, geological factors are not leading factors for scarcity, but rather global demand as well as the development of new exploration and production technologies. Expanding Hubbert's ideas from a local to a global scale is therefore, according to critics, assumed to overstretch the model assumptions (Lynch, 2009).

Figure 3.1
World oil price



Box 3.1 The dynamics of fossil fuel reserves: gas reserves in the United States

Gas reserves in the United States have increased substantially in recent years, even despite high consumption rates. This is mainly due to the development of new technologies that have made it possible to add previously uneconomic unconventional shale gas resources into proved reserves. According to the Energy Information Administration, 'total U.S. proved reserves of dry natural gas rose by 6.9 trillion cubic feet (Tcf) from 2007 to 2008. That increase was on top of production of 20.5 Tcf and reflects another strong year of net proved reserve additions of natural gas in the United States. Natural gas proved reserves are now at their highest level since EIA began reporting them in 1977' (EIA, 2009).

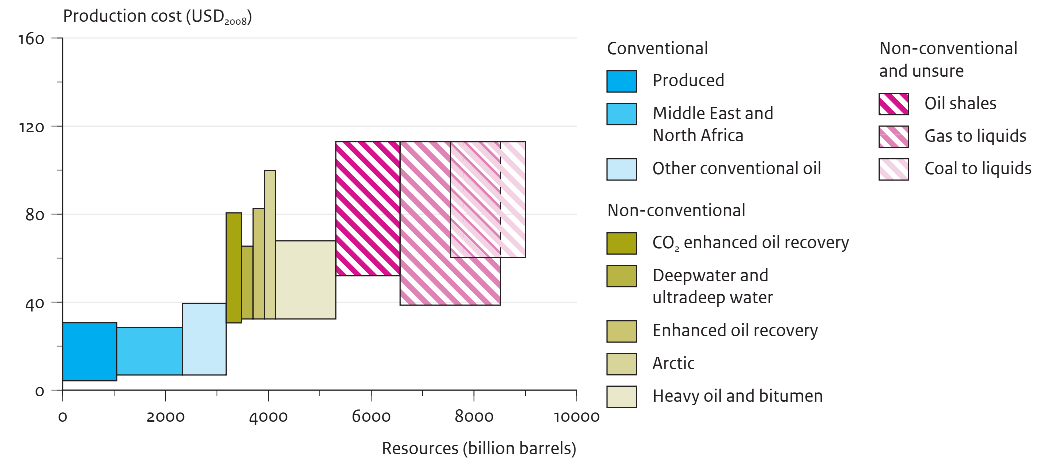
3.1.2 Economic dimension of energy scarcity

The exceptionally high and sudden oil price peak in 2008 cannot only be explained by a sudden rise in physical scarcity of oil. Rather, economic and political factors played an important role. According to the International Energy Agency (IEA, 2008), 'the recent shock has resulted largely from a tightening of market conditions, as demand (particularly for middle distillates) outstripped the growth in installed crude-production and oil-refining capacity, and from growing expectations of continuing supply-side constraints in the future'. This was also strengthened by political reasons (see Section 3.1.3). The IEA concludes that market fundamentals have had a key role in the price peak, although speculation may have amplified the effect of the crisis. Other analyses broadly support the IEA conclusions, although the weight given to different factors varies (ITF, 2008; European Commission, 2008; World Bank, 2009).

3.1.3 Political dimension of energy scarcity

Markets have recently become tighter. One of the ways this is expressed is in more competitors on the demand side and less suppliers. These developments increase the risk of occurrence of political drivers of scarcity. On the demand side, the OECD countries, which have been the main fossil fuel importing block in recent decades, is increasingly meeting the emerging economies as a new competitor. Just over 90% of the increase in world primary energy demand between 2007 and 2030 is projected to come from non-OECD countries, of which China and India in particular stand out as having very high growth rates (IEA, 2009). Unease about the growing share of emerging

Figure 3.2
Long term oil supply cost curve, 2008



economies in world demand has triggered political concerns in OECD countries, resulting for instance in the political prevention of the intended record take-over of the US energy firm Unocal by a Chinese state energy company (Klare, 2008) or in the close watch on growing Chinese energy investments in Africa (Percival, 2009). On the supply side, world reserves of in particular oil and gas are more and more concentrated in a very limited number of countries that export their resources to the rest of the world. More than half of world gas reserves are concentrated in just three countries: Iran, Qatar and Russia (IEA, 2009), and more than three quarters of the conventional oil reserves are located in the OPEC countries (BP, 2009). Depletion of reserves elsewhere will increase the dependency of importing countries on the remaining reserves in these countries. Importing countries fear that their increasing dependency might be abused by exporters for direct or indirect political blackmailing, or in a worst case might even lead to sudden supply disruptions and open conflict. In the short term, the political dimension of scarcity will probably lead to increasing prices on the world market, as in the past (Figure 3.2). Main examples of such supply disruptions are the 1974 oil crisis and the recent Russian–Ukrainian gas crisis. Whereas the former for instance led to a renewed interest in energy efficiency and to the foundation of the International Energy Agency as a counterpart to oil-importing countries of the OPEC, the latter caused 'security of supply' to rise to the top of European policy agendas in recent years.

3.1.4 Present policy options to deal with energy scarcity

There are a large number of potential policy options available to deal with the scarcity of fossil fuels. Many of these are already applied. Table 3.1 gives an overview of some of the key policy options to deal with energy scarcity.

Two fundamental directions to be taken to address the physical dimension of energy scarcity are expanding the resource base and addressing demand growth fundamentals. This can be done either by increasing exploration, by reducing demand or by stimulating the substitution of fossil energy with renewable energy sources. A wealth of more detailed policy options can be found behind each of the three key policy options, as there are many individual exploration technologies, renewable energy technologies – each in a different stage of implementation – as well as a variety of social-cultural and technical energy demand reduction options. Each of the individual policy options in turn can be stimulated by various policy instruments, varying from information and financial incentives to direct regulation.

The policy options to deal with the physical dimension also help to improve the functioning of markets, in other words, to address the economic dimension of energy scarcity. Other key options here are stimulating market functioning by multilateral agreements, in particular via the World Trade Organisation (WTO), improving physical infrastructure and interconnections, investments in production, conversion and transport capacity, and reducing the perverse price regulation of fossils and substitutes (e.g. reducing subsidies for fossils or introducing carbon taxes).

Policy options that address the physical and economic dimensions can also help to deal with the political dimension of energy scarcity, for example preventing politically

Table 3.1
Key policy options for dealing with energy scarcity

Scarcity dimension	Key policy options
Physical *Expand the resource base and reduce demand growth fundamentals*	– Increase domestic exploration of fossil reserves – Encourage demand reduction by energy saving, energy efficiency – Stimulate substitutes/renewable energy sources: research and development, stimulate implementation of new technologies
Economic *Improve functioning of markets*	– Options under 'physical dimension' – Improve functioning of national and international markets/stimulate competition: WTO, improve physical infrastructure and interconnections, stimulate investments in production/conversion/transport – Reduce perverse price regulation of fossils and substitutes
Political *Prevent politically motivated supply disruptions and market distortions*	– Options under 'physical dimension' and 'economic dimension' – Improve access to foreign energy sources via multilateral and bilateral relations – Crisis response policies, e.g. oil and gas emergency stocks

motivated supply disruptions or market distortions. Other specific options in this dimension are multilateral or bilateral actions intended to improve access to foreign energy sources and the formulation of crisis response policies (for example the build-up of emergency stocks in particular for oil and gas).

Most of these policy options are directed specifically at the long or the short term. Typical long-term options are in particular research and development, stimulating the implementation of new technologies and improving physical infrastructure and interconnections. Crisis response policies on the other hand are a typical example of a policy option directed at the short term.

3.2 Food

The price boom of 2008/2009 suddenly put the scarcity of food on the agenda again. For years, agricultural productivity had increased faster than demand for agricultural commodities. These trends caused long-term decreasing nominal food prices on the world market. The driving forces behind the price hike have been analysed by several institutions (Banse et al., 2008; FAO, 2008b; Mitchell, 2008; OECD, 2008b). Figure 3.3 shows us the range of driving factors and the timescale over which they were present. The factors differ in their origin; they are due to the physical scarcity, economic or political dimension of scarcity. We will elaborate on the causes of global or regional food scarcities along these lines, pointing to long-term and short-term developments in our framework.

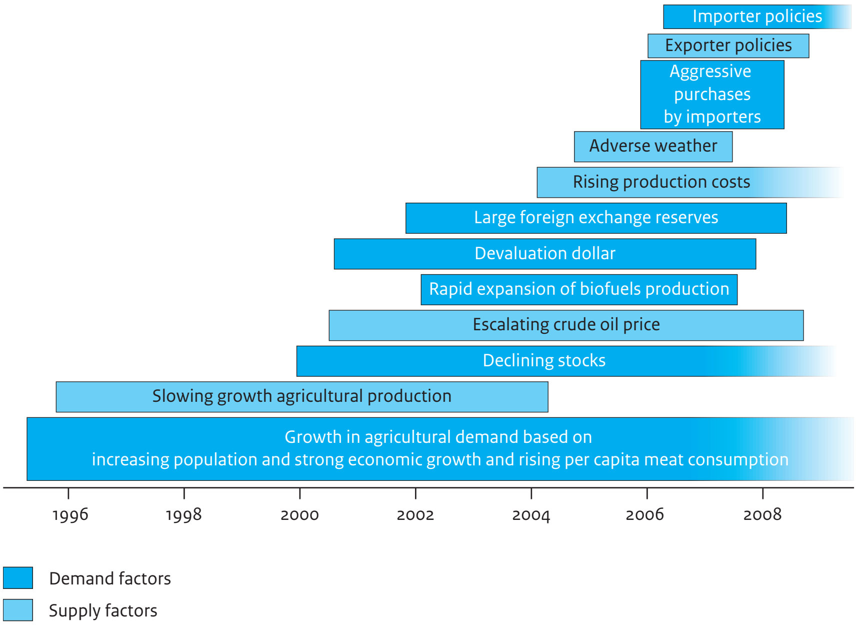
3.2.1 Physical dimension of food scarcity

Long-term and short-term drivers play a role in the physical scarcity of food. In Figure 3.3 we see that the long-term driving factors in the food price hike of 2008 were growth in agricultural demand and slowing growth in agricultural production. One of the reasons for the declining production increase that has been highlighted is the decreased attention for public investments in agricultural R&D. On the demand side, the increasing consumption of meat products in developing countries has doubled, and in East and Southeast Asia has even increased almost fourfold since 1980 (FAO, 2009a). The import of cereals, however, by China and India has been trending downwards since 1980 (FAO, 2009b).

Another driver that enhanced physical scarcity in the 2008 price peak was adverse weather that caused production shortfalls in major exporting countries (FAO, 2008b). In the decades before, stocks had been sufficient to solve the inadequate supply of food products. Since 1995, global stocks have declined, on average by 3.4% per year as demand exceeded supply (FAO, 2008b). In the same period agricultural trade policies focused on declining market distorting policies, including declining stocks. Lastly, the announcement of biofuel energy policies in the developed world increased the demand for maize, cereals and oil crops in these regions. These factors together made the world cereal market tight, which caused physical scarcity of food in individual countries.

Since demand is projected to increase in future decades, a tighter market is expected in the near future. A tighter market increases the possibility of physical scarcity. Important uncertainties are productivity increase on the production side and diet change on the demand side. Projections of population growth towards 2030 are more robust, since the major driving forces for this growth are already in place. In addition to these developments, the demand for biofuels will put an extra pressure on the market, depending on the implementation of policies and the crude oil price.

Figure 3.3
Drivers of rising foodprices



Box 3.2 Scarcity of land

Scarcity of food and scarcity of land are often linked to each other. Land is needed to produce food and other agricultural products. However, land can be partly substituted by other inputs, such as labour and fertiliser, to obtain higher yields per hectare and therefore scarcity of land does not directly imply increasing scarcity of food (see for example production in the Netherlands). On the other hand, to grow agricultural commodities (food, biomass or feed) some land, or space, is needed for each kilogram.

The phenomenon of land 'lease' or land 'grabbing' has recently gained a lot of attention. Since the period of old colonialism, national governments have had the sovereignty to govern over the land within the country's border. Leasing the land to other nations restricts these possibilities. Although the total amount of hectares leased is in most cases insignificant in comparison with the total area of a country, the area can be one of the most productive or accessible parts in a region and thus of major importance for feeding the local population (Cotula et al., 2009).

In theory, the potential to increase food production is enormous. Physically, yields could be increased in large parts of the world and there are large areas that are suitable for agriculture but that are not yet in use. However, most of these areas are currently used by marginal population groups or as natural areas. Food production can also be enlarged by increasing the production per hectare (see Box 3.2). In the past decades, increasing production per hectare went together with increasing pressure on the biophysical system, due to increasing inputs, for example water, which can be regionally scarce. More intensive agriculture (monocultures and high productive animal systems) are also increasingly vulnerable to pests and diseases. This development, together with the expected growth in extreme weather events due to climate change, could increase the risk of a more volatile annual production.

3.2.2 Economic dimension of food scarcity

In the build-up towards the last price peak, several drivers were present that can be defined as the economic scarcity of food, such as the escalating crude oil price, the devaluation of the dollar and rising input costs. Due to the ongoing growth in trade of agricultural products and the increasing use of energy for agricultural production, energy prices and exchange rates have become more and more important. The use of food crops for bio-energy even strengthens the link between energy and food.

Table 3.2
Key policy options for dealing with food scarcity

Scarcity dimension	Key policy options
Physical *Expand production, reduce demand growth and prevent supply disruptions*	– Investments in productivity (also of non-profitable crops/tropical crops) – Investments in capacity building/production systems that are resilient to climatic circumstances – Stimulate efficient consumption – Keep stocks at certain level
Economic *Improve functioning of markets*	– Keep stocks at certain level to avoid negative signals on the financial markets and to keep food affordable for consumers – Subsidies for sustainable production systems for farmers, instead of consumer subsidies – Investments in infrastructure and accessibility of (local) markets
Political *Prevent politically motivated supply disruptions and market distortions*	– Options under 'physical dimension' and 'economic dimension' – Extended trade arrangements to prevent abruptly applied import or export bans – Prevention of conflicts

Another aspect in the short term is the forward market in agricultural commodities. Tight stocks at the beginning of the season tend to put upward pressure on prices (FAO, 2008b).

Other elements that play a role in economic scarcity in the longer term are the functioning of markets and infrastructure. Access to markets is of crucial importance to farmers: not only physical access, but also the transmission of information from the market, for example prices or crucial information about demand. In such a way, farmers can adapt their production in the coming season to the demand of consumers. Ill-functioning markets are the most evident in Africa, where at the same time urbanisation is going on at full speed. This development even enlarges the gap between the largest consumer markets (the urban areas) and production (rural) areas. Another case of dysfunctional markets occurs when governments give subsidies on food. This depresses the market prices of food, which hinders farmers in producing more or investing in inputs as the price they get for their products is still low.

Expected developments that will affect economic scarcity are the increasing link between energy and food production, for example the fact that more and more fertiliser and energy will be used in agricultural production, and the ongoing urbanisation (the urban population is expected to reach 69% in 2050 (UN, 2007)). Until now, changes in food demand of the urban population in developing, especially African, countries have hardly been transmitted into changing production, due to poor infrastructure and information exchanges. Therefore, a major part of the food consumed in the big cities has so far been imported. Major investments are needed to bend this trend. Current information technology could play a major role in bridging this gap.

3.2.3 Political dimension of food scarcity

During the price peak in 2008, political choices proved to be the last straw. Both on the side of exporters and the side of importers, adverse trade policies were implemented which increased the price of staple food on the world market even more. Important export countries, such as Argentina and Thailand, imposed export bans, whereas major importing countries started a kind of panic buying. These reactions may have negative impacts in the longer term: incentives to expand domestic food supplies are lowered and supplies to the world market are further restricted, which pushes prices even higher (FAO, 2009b).

Regional political scarcity can be due to conflicts, which increase the risk of food supply instability tremendously. People in most of the countries in which the global hunger index increased between 1990 and 2009 live in a politically unstable situation (Von Grebmer et al., 2009).

3.2.4 Present policy options to deal with food scarcity

Policy options to deal with food scarcity could be arranged along two lines, also called the twin track approach in FAO documents. The first line is to keep food affordable at any moment for the poorest group of consumers, which mainly implies short-term prevention of scarcity. The second line is to increase production and ameliorate the functioning of markets to decrease the structural risk for scarcity of food. Both lines involve the physical, economic and political dimension.

A certain amount of food stocks are needed to keep food affordable. This is an old policy measure that has received negative attention in recent decades, because stock policies were blamed for lowering the price on the world market. The profound believe in liberalism and well-

Box 3.3 Rare earth elements

The rare earth elements (REEs) are a relatively abundant group of 17 elements: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), lutetium (Lu) and yttrium (Y).

High-technology and environmental applications of REEs have grown dramatically in diversity and importance over the past 40 years. LCDs used in computer monitors and televisions employ europium as the red phosphor; no substitute is known. Ceriumoxide is uniquely suited as a polishing agent for glass. Permanent magnet technology has been revolutionised by alloys containing Nd, Sm, Gd, Dy or Pr. Environmental applications of REEs have increased markedly over the past 30 years, such as the widespread adoption of new energy-efficient fluorescent lamps (using Y, La, Ce, Eu, Gd and Tb) for lighting. As many of these applications are highly specific, in that substitutes for the REE are inferior or unknown, REEs have acquired a level of technological significance much greater than expected from their relative obscurity.

'Rare' earth element is a historical misnomer; persistence of the term reflects unfamiliarity rather than true rarity. Although actually more abundant than many familiar industrial metals, the REEs have much less tendency to become concentrated in exploitable ore deposits. Consequently, most of the world's supply comes from only a few sources.

functioning markets did enhance arrangements that stocks should be minimised. However, due to the dependence on natural/climatic circumstances of food production, stocks are necessary as an insurance against short-term food deficits, though at an appropriate level and only to serve this goal (not as a result of a policy that guarantees prices for farmers). Trade could also function as a buffer to increase regional food supply. Therefore, the extension of trade arrangements to prevent abruptly applied trade barriers could decrease the risk of the physical dimension of scarcity at the regional level.

Increased production needs a range of policy options that focus on driving forces in the physical dimension as well as in the economic dimension. These options range from investments in productivity increases for crops that are used as food crops by poor people, to amelioration of infrastructure and access to inputs for farmers and capacity building of farmers, to giving farmers the opportunity to react to markets and new developments. Consumer price subsidies keep market prices low and therefore give a negative incentive to farmers with respect to increasing production. They can also be expensive in the long run. Income transfers are less distortionary and can be better targeted at the poor income groups. However, subsidies on inputs such as fertiliser or seeds could enhance the sub-optimal use of these inputs (FAO, 2009b).

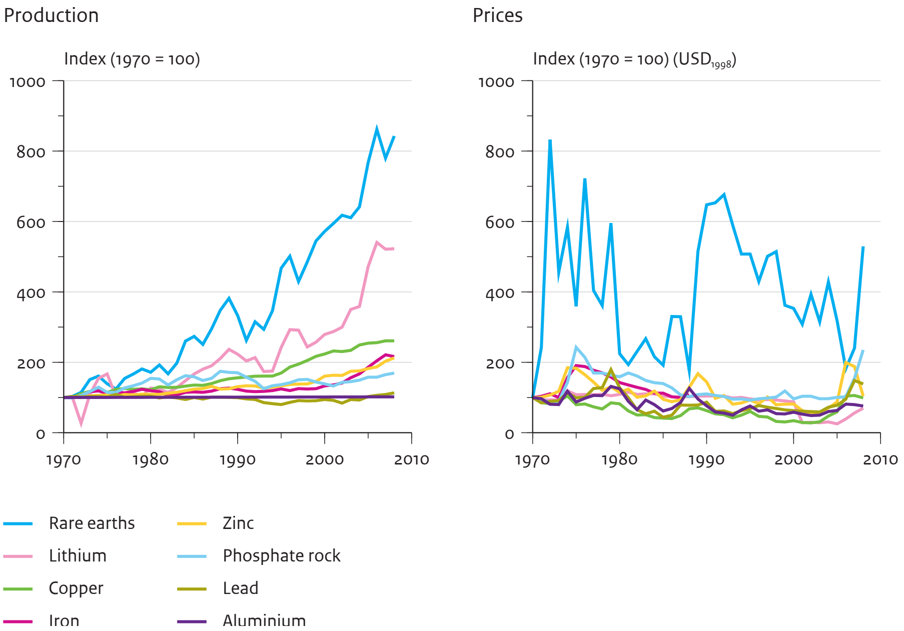
The physical dimension of food scarcity risk could also be decreased by stimulating efficient food consumption and less meat consumption. The impact of this could be two-sided: a decrease in the food price could increase the affordability of food for poor people and therefore decrease poverty, or it could increase consumption per person which could counteract the positive impacts of such policy options.

Lastly, the options that affect the political dimension could help prevent adverse political action in the case of perceived food shortages. Free trade and conflict prevention are the most important options in this respect.

3.3 Minerals

Modern societies are highly dependent on mineral resources. Society's dependence on minerals has resulted in periodic concerns about the adequacy of mineral supplies to continue to support the economy. Charcoal became scarce in Western Europe, especially in England, by the 17th century. Sperm whales, the preferred source of lamp oil and tallow for candles became scarce in the mid-19th century. Natural fertilisers – guano and nitrate deposits from the west coast of South America – were also largely exhausted by the end of the 19th century (Ayres, 2001). Concerns were recently triggered by the spectacular commodity boom in 2007/2008. 'Strategic' minerals and metals have also drawn much attention because of an increase in export restrictions. These metals and minerals are of particular interest for a number of reasons: they are generally geographically concentrated in a few countries, many are used in the production of high-technology goods in strategic sectors and there are few substitutes for these raw materials given the present state of technology. Examples are rare earth elements (REEs) and platinum group metals (PGMs).

Figure 3.4
Global production and prices of minerals



Scarcity has geological, economic and geopolitical aspects. Minerals cover a wide range of non-energy resources found in and on the earth's crust. In this study we restrict ourselves to metallic minerals and selected non-metallic minerals, such as phosphate and fluorspar. We do not address construction minerals such as gypsum or natural stone, which are widely available. In terms of volume, strategic metals may be negligible; their economic importance is much higher. The rare earths market (see Box 3.3) represented approximately $ 1.25 billion in 2008 and market growth has been in the range of 8–11 % per year.

The recent price spikes had little to do with depletion of resources. In general, prices reflect responses to accelerating or declining global demand, although supply disruptions have a role to play. For example, copper is among the few metals whose price remained elevated during the first half of 2008, despite weak demand; numerous supply disruptions tied to strikes in Latin America and delays bringing on new capacity kept copper prices high (World Bank, 2009).

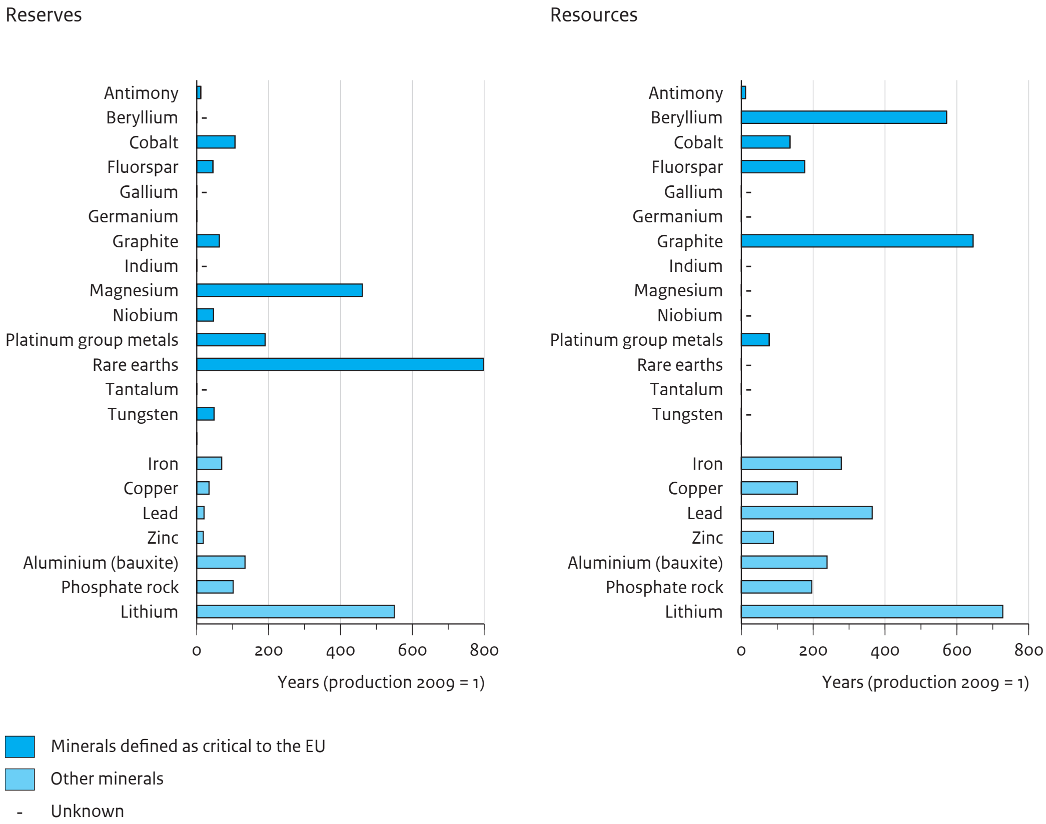
Figure 3.4 shows trends in world production and prices for a number of metals. Despite growing demand, prices do not show a rising trend. However, there are huge price fluctuations over time. Volatile markets increase uncertainty, making investment in the extraction of new reserves less attractive and further adding to supply restrictions. Volatility on minerals markets tends to stem mainly from demand shocks, in contrast to agricultural markets. The duration of booms and busts in the metal, mineral and oil sectors tends to be longer than in agricultural markets because of the longer lags between investing in new capacity and the eventual increase in supply. Hence, metals such as copper, lead and zinc have much higher price volatility than maize, soybeans and wheat.

Empirical data do not suggest increasing scarcity. Up to now, scarcities have not proven to be obstacles to economic growth; more often they have been stimulants to innovation. However, past successes are no guarantee of future success. The central question is: will the necessary mineral resources be available in time and at acceptable costs to meet burgeoning demand for current and emerging products and technologies?

3.3.1 Physical dimension of mineral scarcity

For most metals, global reserves are still much higher than current annual production (WWI, 2009). Figure 3.5 shows the global reserves of a number of resources in terms of production in 2008. Energy commodities are added as illustration. Reserves of iron (Fe), for example, are almost 75 times as large as production in 2008. The statistically proven reserves for rare earths amount to 800 years, to 280 years for cobalt and to 190 years for the platinum group metals. Despite the huge resource estimates, there are concerns that minerals will have to be extracted in lower concentrations and from difficult

Figure 3.5
Global reserves and resources of minerals, 2009



locations, leading to higher energy consumption. An energy crisis can then lead to a resource crisis and vice versa (Diederen, 2009).

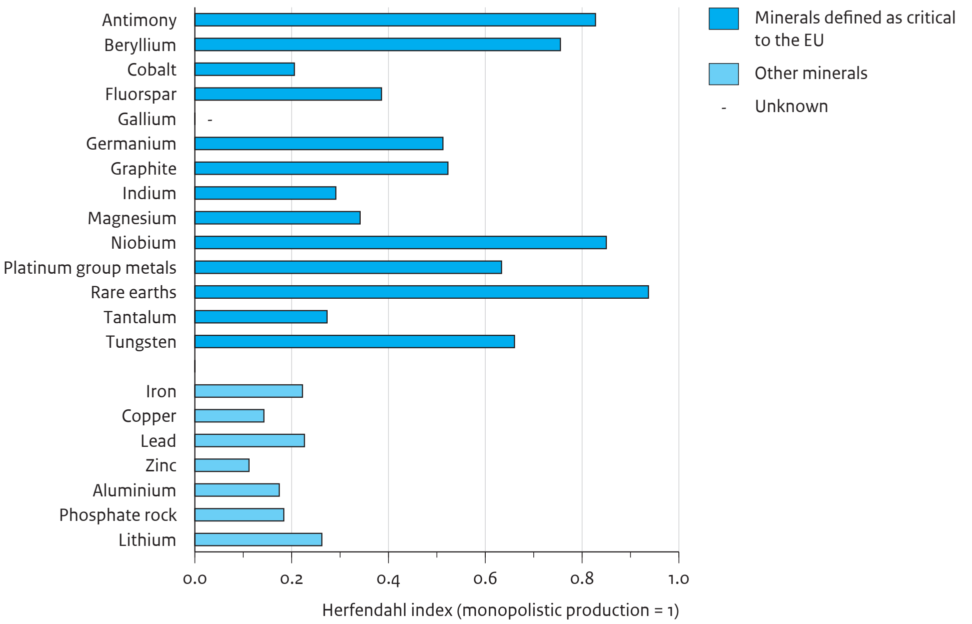
It should be noted that this static metric – relating known reserves to current production – is flawed. Demand and therefore production is not stable over time. For base metals such as iron, copper and others, growth in demand can be expected to slow. Population growth is slowing and the commodity intensity of economies is expected to decline as a result of a further shift towards services. However, for certain rare metals such as gallium, indium and tantalum, demand may increase sharply as a result of new technologies (Fraunhofer, 2009; EU, 2008b). This demand may lead to scarcity in the future, although possible substitutions still need to be specifically explored. Another powerful indication that the static metric is flawed comes from historical reserve data for different minerals: reserve figures have been stable or have even increased over time. The trends in the reserves series show increasing availability rather than increasing scarcity (Simon et al., 1994; Krautkraemer, 2005).

As well as primary production, recycling may form a significant factor in the supply of metals. In 2007, the United States recycled 72 million metric tons of selected metals, an amount equivalent to only 52% of the apparent supply of those metals (USGS, 2009). Recycling provides additional benefits such as energy savings and reduced volumes of waste (UNEP, 2010).

3.3.2 Economic dimension of mineral scarcity

Many minerals are found in a very limited number of countries. Figure 3.6 shows the Herfendahl index for a number of minerals. The Herfendahl index is a measure of the relative size of producers and an indicator of the amount of competition. The largest producing countries of various minerals hold more than three quarters of global reserves. Monopolistic producers may exert their market power, leading to high prices. Consolidation of ownership of minerals companies has given them increased pricing power. Market speculation may have driven up the prices of mineral commodities. These fundamental changes in commodity markets may explain why a rise in metal prices is not simply a cyclical or temporary phenomenon.

Figure 3.6
Concentration of mineral production, 2009



Concentration of mineral production expressed by the Herfendahl index. The Herfendahl index is defined as the sum of the squares of the market shares of producing countries. It can range from 0 to 1.0, moving from a huge number of very producers to a single monopolistic producer. A high index generally indicates less competition and high market power. A few countries with approximately equally market power is indicated by a relatively low number (e.g. phosphate rock).

Commodity markets for energy, food and minerals are characterised by fluctuating prices. This volatility is caused by slow adjustment between demand and supply (for example, it takes time to open a new mine). The turbulence of the markets in recent years was caused by the explosive take-off of the Chinese economy and the associated boom triggered for raw materials which many market actors were not expecting. On the other hand, the market was misjudged because technological developments were not anticipated in time. One example is the electrical and electronics industry switching to lead-free solders which contain higher amounts of tin. This led to a sharp increase in demand for tin and tin prices.

3.3.3 Political dimension of mineral scarcity

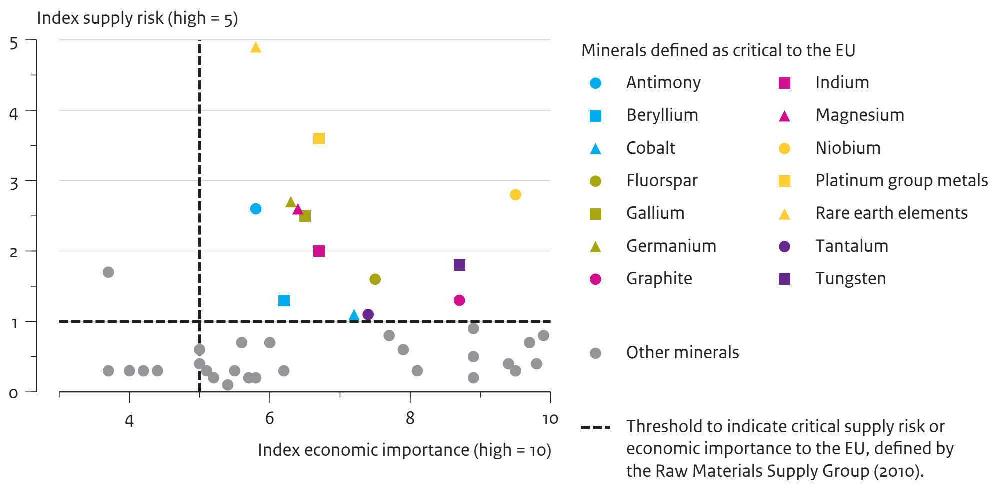
High and volatile prices may be an economic reason for political concern. An increase in import dependency and a tendency in exporting countries to restrict trade add to the fear that countries are using minerals more and more as strategic goods. Mineral scarcity is seen in this perspective as a threat to national security. There are increasing concerns over securing supply. The Hague Centre for Strategic Studies (HCSS) analysed the security implications of mineral scarcity and concluded that Europe's policy response has been rather slow (HCSS, 2010).

A mineral can be classified as critical if it is both important in use and if it is subject to potential supply restrictions (USGS, 2009). 'Importance in use' carries with it the concept that some minerals will be more fundamental for specific uses than other minerals, depending on the mineral's chemical and physical properties. This is especially the case for 'high-tech' metals such as cobalt, platinum, rare earths and titanium. Such metals play an essential role in the development of innovative 'environmental technologies' for boosting energy efficiency and reducing greenhouse gas emissions. The supply risks primarily relate to the fact that global production is concentrated in a handful of countries: China, Russia, the Democratic Republic of Congo and Brazil, some of which are considered politically instable. The greater the difficulty, expense, or time to find a suitable substitute for a given mineral, the greater will be the impact of a restriction in the mineral's supply. The low recycling rates of these materials add to

Box 3.4 Minerals defined as critical by the European Union

A mineral is labelled "critical" by the Raw materials Supply Group (European Commission, 2010a and 2010b) when the risks of supply shortage and their impacts on the economy are higher than for most of the other minerals. In a recent study committed by the EU (Fraunhofer, 2009) the criticality of a mineral was based on an assessment of the supply risk and the economic importance to the EU economy. The supply risk is dependent on the level of concentration of production linked to political and economic stability. Economic importance of a mineral is measured by breaking down its main uses and attributing to them the value added of the economic sector that has this mineral as input. Figure 3.7 shows the result for 41 selected minerals. Some minerals, e.g. iron, have a high economic importance, however, the supply risk is considered to be low. Others. like talc, are of limited importance and do not face supply risks. A group of 14 minerals can be characterized by both a high economic importance *and* a high supply risk. These 14 minerals - antimony, beryllium, cobalt, fluorspar, gallium, germanium, graphite, indium, magnesium, niobium, PGMs, rare earth elements, tantalum and tungsten - are considered to be critical to the EU.

Figure 3.7
Economic importance and supply risk of minerals, 2006 – 2009



their 'criticality'. The EU is dependent on foreign supplies for a large number of metallic minerals.
An EU expert group recently identified 14 raw materials regarded as 'critical' for EU high-tech and eco-industries (European Commission, 2010a and 2010b; see Box 3.4). In the US, the Research Council determined that platinum group metals, rare earth elements, indium, manganese and niobium are currently highly critical, meaning they are difficult or impossible to substitute, essential in their use, and have potentially at-risk supplies (NRC, 2008).

China, which is responsible for 95% of global rare earth production, plans to ban exports of some of them as of 2015. World prices are now typically 20–40% higher than Chinese domestic prices. Beijing's plans are a cause for concern among manufacturers of high-tech products, ranging from computers to electric car batteries and wind turbines. Efforts to bypass market power and import dependence have resulted in extraction from more expensive marginal reserves, while cheaper conventional sources remain underused. The European Union has asked the WTO to rule on a dispute with China over raw materials. China is accused of distorting competition and increasing global prices by setting trade restrictions to limit certain raw materials from leaving the country.

Export restrictions of all kinds exist among major exporters of metals and minerals. Export restrictions come in a variety of forms. One of the most common forms of export restriction is export taxes or duties. Export restrictions are used by policymakers to respond to a number of social, economic and political objectives. These include objectives such as environmental protection and promotion of domestic industries, revenue maximisation, and preservation of reserves for future use. There is consensus that export restrictions create economic inefficiency by distorting resource allocation and can negatively affect the welfare of trade partners. Export restrictions can impact potential investments in mining facilities worldwide. In the case of

Box 3.5 Phosphorus

Phosphorus is an essential raw material in fertilizer and therefore agricultural production. It is a non-renewable resource for which there is as yet no substitute. It can be recycled, but this only occurs to a very limited degree. The expected growth of the world population to nine billion people by 2050 calls for a sharp increase in food production. On the basis of this prognosis and the economic growth of densely populated countries such as China and India, much more fertilizer is likely to be used in agriculture to increase productivity to an acceptable level. Demand for phosphate will also rise as a consequence of the increasing demand for and production of biofuels. That these factors can have a disruptive effect is already visible in the development of prices in 2008. The phosphate price increased by 700% over a period of 14 months, but then collapsed again.

Phosphate is largely extracted from phosphate ore, reserves of which are only found in a small number of countries, primarily Morocco, China, South Africa and the United States. With this restricted number of producing countries, phosphate scarcity is related to geopolitical relations. China – with more than three quarters of the total reserves – has imposed an export tariff of 135% on phosphate to secure supply for the domestic market. Some of the phosphate comes from the disputed Western Sahara, making supply uncertain. In total, phosphate from Morocco and the Western Sahara accounts for a third of the global supply of high quality phosphate ore. Various geological studies show that there are still considerable reserves of phosphate, which will certainly be sufficient for the coming decades. PBL scenarios even suggest that there will be no serious shortages through physical scarcity in the next century (Van Vuuren et al., 2010). The fertilizer industry, however, already has to contend with a decline in the quality of phosphate ore, partly due to increased radioactivity.

rare earths, the possibility of export restrictions being imposed makes industry participants assess the risk in the industry differently. As many of these raw materials are produced in a limited number of countries, export restrictions that are imposed in one country may motivate other countries to follow if importers massively move to buy their raw materials. The restrictions imposed by the first country then lose their effectiveness in limiting exports. This can in principle lead to retaliation.

3.3.4 Present policy options to deal with mineral scarcities

Policies to deal with scarcities of minerals can be shaped in many ways and can be applied at different points in the supply chain. For example, policies could focus on the prevention of potential disturbances to the supply or on the reduction of negative impacts of an actual disruption to the supply. Policies can have a national focus or can be targeted at the international/global level.

Policy measures should aim to improve access to primary resources and stress the need to increase recycling and promote research into substituting and improving the efficiency of materials. Recycling is a significant factor in the supply of many of the metals used in our society. It provides environmental benefits, such as energy savings, reduced volumes of waste, and reduced emissions associated with energy savings. In addition, recycling reduces the amount of virgin metals that must be mined to support our lifestyle. For example, less than 1% of the millions of cell phones discarded annually are recycled. When large numbers of cell phones become obsolete, large quantities of valuable metals end up either in storage or in landfills (USGS, 2006). By contrast, the recycling rate for aluminum is high, the principal source being recycled aluminum beverage cans. As demand for minerals is largely driven by downstream markets, it would seem logical that policies to influence resource use are targeted at the value chain and the end-user, and include developing alternative materials and optimising resource use.

Possible policy measures imply: efficient recovery infrastructure, product designs that simplify dismantling, and other changes needed to facilitate the growth of recycling.

Apart from the options mentioned above, a general policy measure would be to invest in more knowledge. The U.S. Geological Survey's Minerals Information Team is the most comprehensive source for this sort of information, but the quantity and quality of its data are not sufficient because the agency lacks the resources, authority and autonomy of a principal statistical agency. Up to now the high level of interconnectedness and the impacts of raw material use in industrial sectors have not been systematically studied at all.

Resource efficiency – or dematerialisation – seems a silver bullet. However, there are two countervailing trends that are often forgotten. One is the 'rebound effect'. As dematerialisation is accompanied by lower costs and real savings to consumers, demand for the products tends to increase. Secondly, indirect material consumption may be very large to bring about resource

Table 3.3
Key policy options to deal with mineral scarcities

Scarcity dimension	Key policy options
Physical *Expand the resource base and reduce demand growth fundamentals*	– Build strategic reserves for critical minerals, e.g. rare earths, as a buffer against supply disruptions (long-term) – Open/reopen mines, invest in exploration (not an option for the Netherlands, but may be an option for Europe) – Bilateral agreements with supplying parties, establish strategic partnerships with important producer countries – Improve recycling – Improve resource efficiency – Reduce resource intensity: encourage substitutes, focus R&D on substituting elements
Economic *Improve functioning of markets*	Options under 'physical dimension' – Anti-trust legislation
Political *Prevent politically motivated supply disruptions and market distortions*	– Options under 'physical dimension' and 'economic dimension' – Invest in global governance (liberalise world markets and collaborative governance, stabilise tight markets, prevent conflicts) – Develop bilateral cooperation in the field of raw materials and work together on issues such as governance, infrastructure, investment and geological knowledge and skills – Invest in development cooperation (development aid, transparency, good governance) – Consider shaping a new EU-wide policy on foreign investment agreements to 'better protect EU investments in raw materials abroad' – Consider the merits of pursuing dispute settlement initiatives at WTO level 'to include in such initiatives more raw materials important for EU industry' – Proactive acquisition

efficiency, for example, miniaturisation in electronics is a complex manufacturing process, requiring large amounts of photoresists, acids, solvents and neutralisers.

Until recently, mineral scarcity was not on the EU agenda. In 2008 the European Commission (2008b) proposed a new strategy to address EU critical needs for raw materials. This Raw Materials Initiative tries to identify critical materials, identify and challenge trade restrictions, promote recycling and resource efficiency and improve conditions for resource extraction within Europe.

Individual countries have a longer history in policymaking. The HCSS has examined the national mineral policies of several countries (HCSS, 2010). Four types of policies were identified: trade restrictions, technological development, proactive acquisition and development cooperation. The majority of mineral policies, with the exception of the US, China and Japan, do not focus on the issue of scarcity and security of supply. They concentrate on technological advancement and environmental sustainability. Countries that view minerals as a security issue focus on the identification and stockpiling of critical minerals.

3.4 Water

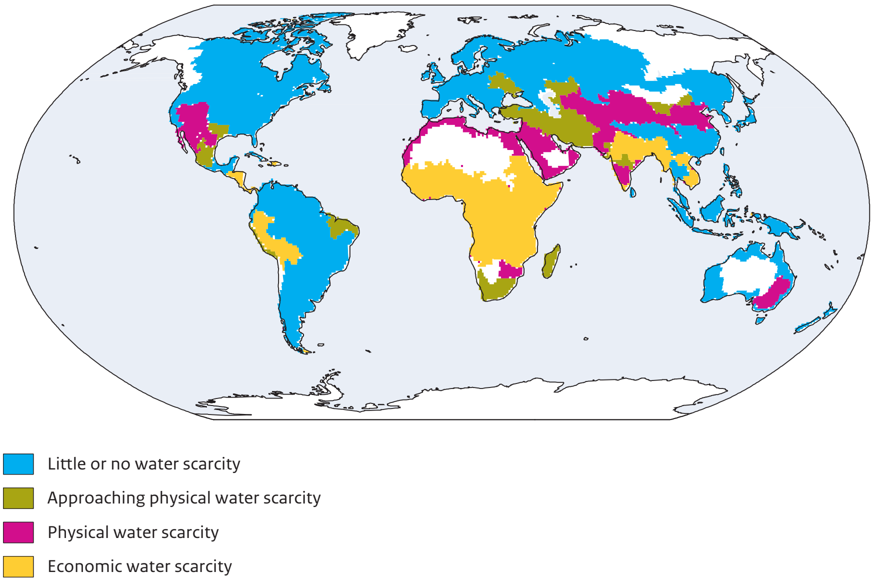
Water is one of the most abundantly available substances on earth. However, only 2.5% of the world's water resources are freshwater, most of which is trapped (thus inaccessible) in polar ice caps, glaciers and deep aquifers, leaving only about 0.03% easily accessible to humans. Furthermore, the availability of this essential resource hugely varies with time and place. Although freshwater is a renewable resource, its availability is not unlimited; on the contrary, renewable freshwater is an increasingly scarce commodity. Agriculture (70%), industry (22%) and drinking water (8%) (UNESCO, 2003) are the main human applications of water.

Population growth, coupled with industrialisation and urbanisation, will result in an increasing demand for water. Access to water combined with adequate sanitation can prevent millions of deaths each year (WHO/UNICEF, 2004). Given the importance of water to sustainable development and poverty alleviation, water scarcity currently receives renewed attention in development policies, as expressed for instance in the inclusion of water in the United Nations Millennium Development Goals. According to the WHO/UNICEF Joint Monitoring Programme (2004), over 1.5 billion people in 2004 still needed access to an improved water supply to reach the Millennium Development Goal on access to water. The majority of these people live in Asia, the Pacific and sub-Saharan Africa.

3.4.1 Physical dimension of water scarcity

There are several indicators that measure water scarcity, each of which stresses different aspects of water resources

Figure 3.8
Physical and economic water scarcity, 2025



Source: International Water Management Institute (2007)

(Rijsberman, 2006). Figure 3.8 shows a set of indicators developed by the International Water Management Institute that distinguishes between physical and economic water scarcity (IWMI, 2007). Physical scarcity occurs when there is not enough water to meet all demands, including environmental flows. Arid regions are most often associated with physical water scarcity, but water scarcity also appears where water is apparently abundant, but when water resources are overcommitted to various users due to the overdevelopment of hydraulic infrastructure, most often for irrigation. In such cases there simply is not enough water to meet both human demands and environmental flow needs. Examples are the South-Western part of the United States and Southern Europe.

Symptoms of physical water scarcity are severe environmental degradation (e.g. river desiccation and pollution), declining groundwater levels, and water allocations that favour some groups over others. A fifth of the world's people, more than 1.2 billion, presently live in areas of physical water scarcity (IWMI, 2007). This number is expected to increase in the future due to a variety of factors, including economic growth, population growth, changes in lifestyles and diets, and expansion of irrigation systems needed for food production.

Water scarcity leads to migration to other areas with better living conditions and/or where usable water is still available in sufficient quantities (environmental refugees). Large displacements of population can cause instability or conflict in the host country, country of origin, or within a region. They entail even more depletion of water (and other scarce resources), over-population, shortage of potable water and unsanitary conditions that can lead to disease epidemics. If sustainable systems are not put in place, water sources may be depleted and/or contaminated, which eventually could be a source of serious friction with local host communities.

Half of the world's people now live in cities and by 2050, that share is expected to go up to 70% (UN, 2007). This migration to cities also leads to an additional pressure on water resources because, as people migrate to cities, they often change to more water intensive diets, in particular characterised by higher meat consumption (Pingali, 2004).

3.4.2 Economic dimension of water scarcity

The economic dimension of water scarcity is a major problem in developing countries in particular. It occurs especially due to investment constraints that hamper the development or maintenance of infrastructure. These constraints rise from an overall lack of good governance, monetary means, and possibly political and ethnic conflicts that allow the condition of unequal distribution of water to persist. Much of sub-Saharan Africa is characterised by economic water scarcity, and worldwide about 1.6 billion people live in water-scarce basins where

Table 3.4
Key policy options to deal with water scarcity

Scarcity dimension	Key policy options
Physical *Expand the resource base and reduce demand growth fundamentals*	– Preparation of national water management plans – Attention to gender aspects of water demand – Stimulate water-efficient management practices in agriculture – Climate change adaptation
Economic *Improve functioning of markets*	– Focus on delivery of water services instead of physical infrastructure only – Introduce pricing of facilities, whilst assuring that needs of poorest are met – Capacity development and knowledge management
Political *Prevent politically motivated supply disruptions and market distortions*	– Multilateral or bilateral coordination of water management

human capacity or financial resources are likely to be insufficient to develop adequate water resources. An important symptom of economic water scarcity is scant infrastructure development, whether small or large scale, so that people have trouble obtaining enough water for agriculture or drinking. Even where infrastructure exists, the distribution of water may be inequitable or insufficient to meet growing demand.

3.4.3 Political dimension of water scarcity

Political scarcity of water is a regional topic that is geographically confined to river basins. The question as to who controls access to freshwater in a river basin, and who can influence water quantity and quality available to other riparian parties by means of dams, irrigation or pollution is often of high importance to regional development. Conflict over access to river water might occur in particular in the case of transboundary river basin areas in developing countries. As water becomes scarcer, tensions among different users may intensify, both at the national and international level. There are 270 river basins shared by two or more countries (Bakker, 2009). In the absence of strong institutions and agreements, changes within a basin, either of a physical or institutional nature, can lead to transboundary tensions. In particular when major projects proceed without regional collaboration, they can become a point of conflict, heightening regional instability. So far, no outright 'water wars' have been fought, but access to water is disputed in several transboundary river basins in developing countries, such as the Nile, Jordan, Tigris and Euphrates rivers. For example, access to water at the Jordan River has been disputed for a long time between the Israelis and Palestinians, or at the Nile between Egypt and Ethiopia (Zeitoun and Warner, 2006).

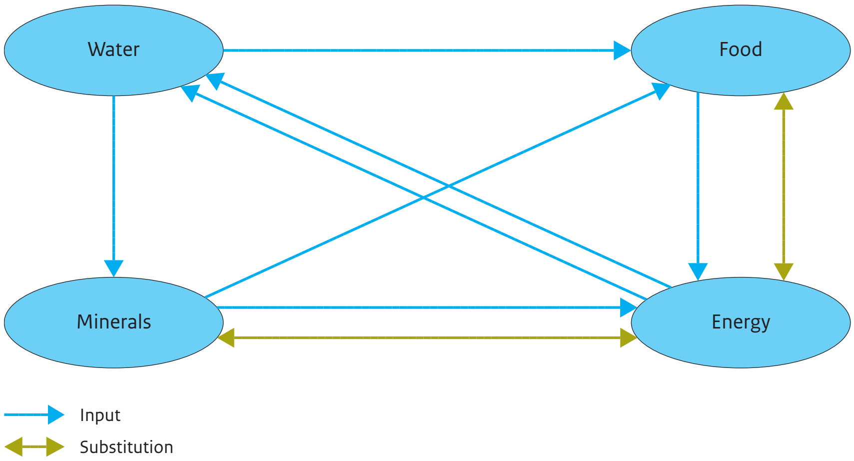
3.4.4 Present policy options to deal with water scarcity

Water scarcity is mainly a problem in developing countries, in particular in sub-Saharan Africa and South Asia. Policies to manage water scarcity have to solve at least three main problems: reducing physical freshwater scarcity mainly for agricultural purposes, securing access to drinking water and sanitation for the poor and a fair distribution of water to all riparian parties in river basins. This has to be realised in a time when population growth, economic growth, lifestyle and diet changes, climate change and variability and biodiversity loss increase pressure on water resources.

Policy options that counteract physical water scarcity are the preparation of national water management plans, attention to gender aspects of water demand, water-efficient management practices in agriculture and climate change adaptation. Whereas the first three point directly at current physical water scarcity, the last should be taken into account to avoid future water scarcity. Attention to gender aspects could enhance water availability for domestic use, since women have different priorities than men: they often take care of water for domestic use, while men want irrigation water for cash crops. Increasing the role of women in control and access to water could increase the priority given to the domestic water supply in relation to irrigation water (UN Millennium Project, 2005). Water-efficient management practices could decrease water demand for agricultural irrigation (major source of withdrawal) and at the same time increase production per crop (IWMI, 2007). To make these policy options effective, it is also necessary to invest in the capacity building and education of farmers.

Improving access to reliable water supplies is one of the key steps. This implies not only that the infrastructure has to be in place, but that it also has to be maintained. Therefore the focus should be on the service instead of the physical infrastructure. To overcome financial constraints in keeping the service working and meeting a growing demand for water, facilities should be priced. At the same time, access to the service for the poor

Figure 3.9
Relations between food, energy, minerals and water



should be assured, which requires targeted policy measures (UN Millennium Project, 2005).

To avoid a political scarcity of water, multilateral or bilateral coordination of river basins is needed. This will become more important in the case of increased physical water scarcity.

3.5 Interactions affecting resource scarcities

Energy, food, mineral and water scarcities are described separately in the previous sections. However, scarcities of all resources share two fundamental underlying factors: population growth and increasing welfare. Both are especially pronounced in developing countries and part of the emerging economies. In addition to the increasing pressure on the individual resources, the interaction between resources as well as interactions between resources, climate change and biodiversity can aggravate scarcities.

3.5.1 Interactions between resources

The previous sections already touched on interactions between energy, food, minerals or water. The products or production processes are linked and scarcity of one resource can result in a scarcity of another resource. Two main relationships between the four resources can be distinguished: 1) one resource is an input in the production process of the other and 2) the final products of the two resources are substitutes of each other. The input relationship can also be a *competing claims* relationship in case one resource is used as input for several other resources, for example water or land.

Within the context of the scarcities described in this report, both relationships do occur (see Figure 3.9). The input relationship can directly increase the scarcity of both products: if energy becomes scarce (or more expensive), agriculture has to deal with higher input prices for fertiliser and fuel (or it has to cope with less inputs implying less productive management), which increases prices or scarcity of food. On the other hand, if food production rises, the demand for energy is likely to increase as well, and the same development counts for water and phosphate. Water and energy are often used to mine energy and minerals. Shifting to mines with lower quality ores or unconventional forms of energy (such as oil sands) increases the need for energy and water to produce the same amount of, for example, oil or phosphate.

Secondly, there is a 'substitution' relationship between, for example, energy crops and oil. Both products can be used for energy production. Large industries will probably look for the alternative should one of the two become scarcer or more expensive, which was one of the developments that took place in 2008. This can result in higher prices or a reduced availability of energy crops, which can also be used for food. The same relationship is hidden in the use of electricity instead of oil for transport. Electric cars need batteries in which minerals such as lithium are used, which are not available in very large quantities and only at certain places in the world.

Table 3.5
Major concerns about resource scarcities

	Dimension		
	Physical	**Economic**	**Political**
Energy	– Sharply rising demand increases pressure on remaining fossil resources	– Lagging behind of refinery capacities to fulfil demand	– Concentration of oil and gas reserves in a limited number of countries causes concerns about potential political abuse – Increasing competition between OECD countries and emerging economies about remaining fossil reserves
Food	– Lack of production increase to cope with increasing demand – Volatile demand for agricultural commodities due to the link between oil prices and bio-energy demand – Abrupt supply shortages due to extreme weather events	– Lack of access to markets/ incentives to farmers to increase production, particularly in developing countries	
Minerals	– Unexpected increase in demand for certain minerals due to the sudden rise of new high-tech applications		– Concentration of some minerals in a limited number of countries causes concerns about potential political abuse
Water	– Increasing demand increases pressure on freshwater resources – Adverse impacts of climate change could decrease resources	– Non-existent or improperly functioning markets and inadequate infrastructure limit access to safe drinking water in particular for the poorest people in developing countries	– Conflicts between parties in transboundary river basins limit access to water for downstream users

3.5.2 Relations between scarcities and biodiversity loss or climate change

Scarcities of the four resources are not only interrelated, they also have a causal or effect relationship with bio-diversity loss and climate change, which can in turn affect a resource scarcity. Different time horizons play a role here: the current ways to avoid scarcity are by impacting the environment, whereas probable impacts of climate change or biodiversity loss will affect resource scarcity in the long term. Biodiversity loss and climate change are linked to resource scarcities because the production, the mining or the use of the resource has negative out-puts that affect climate or biodiversity. For example, the increasing exploitation of unconventionals might come at a high environmental cost, particularly regarding the emission of greenhouse gases. Expanding the agricultural area in carbon rich areas increases CO_2 emissions and in most cases affects biodiversity as well. Biodiversity is also affected if production per hectare is increased in an un-sustainable way, for example through management that leaves little space for species other than the cultivated one or that emits lots of chemicals to the surroundings.

Biodiversity and agriculture (for energy or food crops) also have a competing claim relationship for water: increasing agricultural production using the same amount of water per product has negative impacts on bio-diversity. Loss of biodiversity can in turn have negative impacts on future increases in crop productivity. This can be because the gene pools for genetic improvements to crops are more limited or because organisms such as bees are needed for pollination to produce vegetables and fruits, or because insects and other organisms can be used for sustainable pest management. Loss of bio-diversity can also affect patterns of water supply (along river borders), although this is especially the case when whole ecosystems have been damaged. The exact impacts of climate change are uncertain, but expected changing precipitation patterns will affect agriculture and water supplies and more extreme weather events in particular, such as long dry periods or heavy rainfall, will decrease the current productivity of crops immediately.

3.6 Major concerns about resource scarcities

Causes of scarcities in energy, food, mineral and water have been unravelled to the three dimensions in the previous chapters, and the most obvious/prominent policy options have been linked to these dimensions. Sections 3.1 to 3.4 elaborate on drivers of resource scarcity in all three dimensions. These drivers are summarised in Table 3.5, in which the major concerns about resource scarcities in the coming decades are listed.

For energy, a large increase in demand in the coming years is expected from emerging economies. This will lead to increasing pressure on remaining fossil-fuel reserves and in particular on oil and gas. Unconventional resources that can now be increasingly exploited economically, due to the development of new technologies, make the depletion of fossil fuels in the decades to come unlikely, although their exploitation comes at a higher environmental cost. In addition, as oil and gas reserves are concentrated in a few countries, fears in importing countries about the political abuse of the dependencies on exporting countries are increasing. This holds, in particular now that emerging economies increasingly compete with OECD countries for the remaining reserves. It is therefore the political dimension that presently dominates the debate about energy scarcity.

For food, the major concerns particularly relate to the lack of increase in productivity, due to the lack of infrastructure and incentives for farmers to increase production (economic dimension), and the expected impacts of future climate change (physical dimension). Other concerns reflect the risk of increasing volatility in demand and supply. Due to the strengthened link to energy prices, projections show an increasing demand for bio-energy crops, in the case of higher oil prices. However, more extreme weather events, due to climate change, could have major impacts on the supply side. The coincidence of these two effects had a major impact on food prices in 2008. Hence, in the case of food, the political dimension seems to be subordinate to the other two dimensions of food scarcity, and in particular to the functioning of local markets, something which is presently most prominent in the food scarcity debate.

Concerns about minerals can be partly compared to those about energy, because both are non-renewable, strategic resources, the reserves of some of which are concentrated in a limited number of countries. Particularly regarding some metals, the political dimension of scarcity currently receives much attention, as, for example, reserves of rare earth metals or phosphate are concentrated in certain countries. With respect to the physical dimension, minerals differ from energy, in the sense that particularly their demand can grow sharply over short periods, due to their application in high-tech solutions, such as in technologies that mitigate energy scarcity (e.g. solar cells, car batteries).

Water scarcity is mainly a concern in developing countries. Increasing physical scarcity due to population growth, climate change and sometimes industrialisation, is a main concern here. The lack or poor functioning of markets also compounds the water problem. Hence, the creation of well-functioning markets seems crucial. Of lesser concern, although sometimes they receive quite some regional attention, are political conflicts that are potentially induced by large upstream infrastructural projects, such as dams and irrigation projects.

Comparing the four resources, it appears that all have to deal with increasing demand and therefore increasing pressure on the resource base, although this base seems to be sufficiently large to not lead to overall depletion, in the coming decades. In the short term, concerns about scarcities of food and water have their roots in the economic dimension, whereas the concerns over non-renewable energy and minerals originate mainly from the political aspects of scarcity.

Major concerns with respect to interactions are the increasing links between resources, especially the link between energy and agriculture, which aggravate scarcities, should they occur. With respect to the interaction between scarcity and climate change or biodiversity, a major concern is the future effect of current methods that are applied to avoid scarcity. The most prominent cause-and-effect relationship is that of increasing emissions and biodiversity loss, caused by the attempt to increase the physical resource base for energy, minerals and agriculture. In turn, the expected impacts on climate change and biodiversity will probably affect agricultural production and water supply, in the future.

3.7 Conclusions

In this chapter, the major drivers of increasing scarcities of energy, food, water and minerals have been discussed, also in terms of the physical, economic and political dimensions of scarcity. When talking about increasing scarcities, it is crucial to identify in more detail the exact effect that is observed, as well as the underlying reasons for the perceived increasing scarcities. This shows that effects that are often generalised under the same heading of 'increasing resource scarcities' differ hugely according to resource. The framework of the three dimensions introduced in this chapter provides a first basis for adequate policy responses.

Overall, it appears that current, main scarcity concerns are not to be found in the physical dimension. For the decades to come, there still seem to be ample margins for reserve and production capacity expansion. Depending on the resource, most policy concerns currently are raised particularly over the economic and political dimensions of scarcity. Regarding food and water, the functioning of markets seems to be central to these concerns, whereas for energy and minerals, in particular the concentration of reserves in certain countries and increasing competition on the demand side, brings the political dimension of resource scarcity to the forefront.

Interactions between resources can aggravate scarcity problems. New technologies that substitute one resource with others (e.g. in the case of biofuels) increase the links between resources. Most of the simple possibilities for increasing the resource base of minerals, energy and food, have negative impacts on climate or biodiversity. Expected impacts of climate change and biodiversity loss, however, will probably affect the future resource base of water and food.

Dimensions of resource scarcities not only vary per resource, they also vary according to country or actor. Two important different perspectives, in this respect, are the development side of resource scarcities, and the European and Dutch perception of resource scarcities. These will be the subject of Chapters 4 and 5.

FOUR

Consequences of resource scarcities for developing countries

The impacts of recent resource scarcities are especially felt by people in developing countries, who are most vulnerable to increasing prices of basic commodities, such as food and energy. Saghir (2006) estimated that, as a result of the high and fluctuating oil prices of 2005, the total population living in poverty rose by 4 to 6%. Furthermore, as a result of increasing food prices, the people that suffered from undernourishment rose to 915 million in 2008, 67 million more than in 2003 to 2005 (FAO, 2009). This chapter first addresses the specific vulnerabilities (exposures, sensitivities) of developing countries including emerging economies, to oil and food scarcities. Next, two model-based analyses are presented, assessing the impacts of physical and economic scarcities on developing countries and emerging economies. Based on this, the scope for policy responses is sketched by identifying a number of directions for policymaking.

4.1 Vulnerability of developing countries to food and energy scarcity

The current vulnerability of countries or regions to global oil and food price increases are presented in Table 4.1. Both the oil import dependency and food self-sufficiency relate to the dependence on import to fulfill national demand. Countries that are more dependent on the international market are therefore more vulnerable to global price increases. With respect to oil, current vulnerability is the highest for the oil importing countries of sub-Saharan Africa, India and South Africa, but China and other Asian countries also have a relatively large share of their GDP devoted to oil imports. For food, many countries in Asia are self-sufficient, while in Africa and the Middle East self-sufficiency is relatively low, hence their vulnerability to scarcity of food is higher.

Current impacts of food and oil scarcity are also presented in Table 4.1. For food, this is indicated by the prevalence of undernourishment, which refers to the fraction of the population that suffers from hunger. With respect to oil scarcity, the impacts are indicated by the fraction of the population that has access to modern energy sources for cooking and heating (LPG and kerosene, which are both oil-based fuels). Prevalence of undernourishment is especially high in sub-Saharan Africa and India, but also in other parts of Asia, especially Southeast Asia. Access to modern energy is the lowest in sub-Saharan Africa and India. Oil-exporting countries generally have higher levels of access to modern energy.

Future changes in the vulnerability to global oil and food price increases depend on a combination of factors, the most important of which are the expected increase in demand and the ability to increase production. The demand for oil and agricultural products is expected to increase in all regions, over the coming decades, due to population growth and economic developments (see Table 4.1). Although economic development and related energy and dietary shifts are difficult to predict, projected population growth is rather robust towards 2030. Even a very fast demographic transition in countries with expected high growth rates, for example, towards fertility levels that are comparable to those in developed countries, cannot bend this trend. Population growth towards 2030 is especially high in sub-Saharan Africa, but also in North Africa, the Middle East and Asia (except China). India will be confronted with the highest absolute increase in number of people, while growth rates for the Chinese population are expected to decrease up to 2030 and subsequently to become negative. This implies that, up to 2030, the Chinese population will continue to increase only slightly, after which it will begin to decrease. The expectations with respect to economic growth are highest for China and India. An economic crisis such as the current one could, to some extent, change these expectations. However, projected growth in world GDP in the coming years is especially slow in high-income countries, while projections for developing countries,

Table 4.1
Major characteristics of regions and some countries, to indicate high risk regions

	Vulnerability		Scarcity impacts		Demand drivers	
	Oil import dependency (% import of GDP) 2004	Food self-sufficiency (cereals; % domestic production of total utilisation) 2005-2007	Prevalence of under-nourishment (% pop) 2005	Access to modern energy for heating and cooking (% pop) 2005	Population growth (%) 2005-2030	Expected GDP growth (%) 2005-2030
Latin America	-2	98	7	82	25	126
Middle East	-23	54	< 5	92	50	117
China	2	101	10	42	12	446
India	4	102	22	29	31	334
Indonesia	0	90	16	45	25	154
Rest of Asia	2	106	19	43	40	134
Central Asia	-15	117	9	100	27	173
North Africa	-9	55	< 5	97	38	133
Sub-Saharan Africa	-26	82	29	13	75	97
Oil importing countries	7	82	32	8	81	95
Republic of South Africa	2	79	< 5	83	14	181
World	-	-	13	54	28	78

Sources: Badri Narayanan and Walmsley (2008), EIA (2010), FAOSTAT (2010), UNDP-WHO (2010), United Nations (2008), USDA (2010)

especially for China and India, are expected to be more robust (World Bank, 2010b).

Dietary shifts are related to people's economic situation, but are also determined by cultural aspects. The dietary shifts occurs especially during the transition from low income to average income. It seems that, in that sense, the largest transition in diets in China has already passed, at least in relation to food supply: in China, the average calorie intake per person, per day, is around 3000 kcal (Figure 4.1). In India, this is still below 2400 kcal, and in Indonesia around 2500 kcal. In sub-Saharan Africa large regional differences exists: the lowest calorie intake takes place in Central Africa, with an average of less than 1800 kcal per person, per day (2002-2007). For West Africa, however, this is around 2500 kcal. Therefore, largest increases in demand for food are expected for sub-Saharan Africa and India.

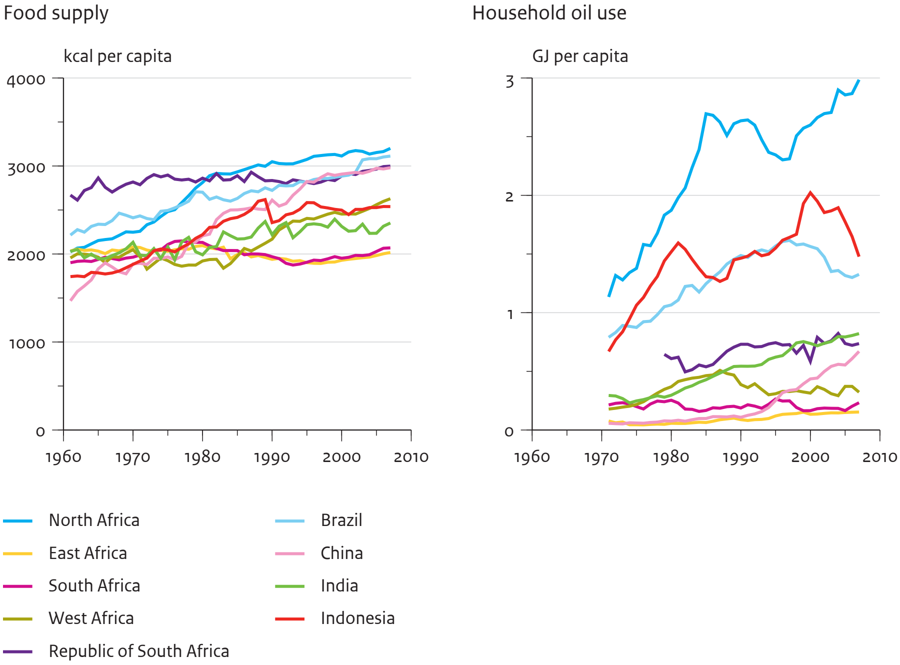
In 2008, 1.5 billion people (22%) had no access to electricity, and 2.5 billion people (37%) relied on traditional energy sources (biomass and coal) as their primary source for cooking and heating (IEA, 2009). Most of these people live in rural areas in South Asia and sub-Saharan Africa. Demand for oil is expected to increase due to the projected economic growth, the accompanying switch to modern energy sources (electricity, LPG and kerosene), increase in industrial production, and in freight and passenger transportation. This is especially true for low- and middle-income countries, which are in the middle of an energy transition. The IEA (IEA, 2009) estimates that 93% of the increase in global energy demand between 2007 and 2030 will come from non-OECD countries, driven largely by China and India. The share of fossil fuels in the total energy demand will remain constant, with a slightly lower increase in demand for oil than for coal, of around 1% per year.

4.1.1 Vulnerability to oil scarcity

On a macroeconomic level, vulnerability to oil scarcity depends on the expected growth in demand, oil import dependency and oil intensity of the economy (IEA, 2004). Substantial increase in demand is expected for all developing countries, especially for China and India. Developed countries have more means at their disposal to tackle the effects of an oil price shock, whereas the means of developing countries may be more limited. Furthermore, the latter will be more adversely affected by high oil prices due to their higher dependency on imported oil, and because energy is used less efficiently (IEA, 2004). Although there have been recent oil discoveries in, for example, Brazil, Sao Tome and Principe, there are many countries that do not produce oil themselves, or only a small share of their current use. Furthermore, exploration and building refining capacity are very costly activities, especially for the least-developed countries. The same holds for

Figure 4.1

Food supply and household oil use per capita



Source: FAOSTAT (2010), UNDP-WHO (2010)

increasing energy efficiency. Middle income countries can perhaps afford to invest, whereas the least-developed countries might not be able to.

On household level, access to modern energy (electricity, kerosene and LPG) is a necessary condition for human development, including poverty reduction, improved education and health services, increased mobility and increased agricultural productivity (Modi et al., 2005). The use of traditional energy sources for cooking exposes people, especially woman and children, to indoor air pollution and is a major cause of respiratory diseases (WHO, 2006). Increasing oil prices can prevent or limit the transition to modern energy sources, while they can also force people to return to the use of tradition fuels. The largest improvements in modern energy use are required in sub-Saharan Africa and India. In many developing countries, households are shielded from global price increases, for example, by subsidies or reduced taxation. However, when global oil prices increase, so do government expenditures on these measures, thereby transferring vulnerability from households to governments. This could force governments to cut down subsidies, expenses or other services, including health and education.

In general, oil-exporting countries are less vulnerable than importing countries as they are generally self-sufficient. Oil-exporting countries will experience an increase in revenues as a consequence of an oil price increase, but they may also suffer from 'Dutch disease' or the 'resource curse' (Collier, 2010). Furthermore, in many oil exporting countries, revenues are spent unsustainably, or accrue to an elite, while the poor only marginally benefit from the huge revenues. Longer term effects depend on the cause of scarcity – whether it is due to increasing demand or decreasing supply. In the case of increasing demand, exporters might profit, while in the case of a decreasing supply, revenues tend to be lower as the increasing oil price might not fully compensate for the loss in production.

The main oil and gas exporting countries are located in the Middle East, North Africa and Central Asia (including, for example, Kazachstan). Sub-Saharan Africa includes both oil exporting and oil importing countries. Although some major oil exporting giants (Angola and Nigeria) export several times their own domestic use, many other sub-Saharan African countries are fully dependent on imports, with an national oil bill sometimes exceeding 10% of their GDP (African Union, 2006). Most countries in Asia (including China and India) are also net energy importers.

China and India have been somewhat shielded from higher oil prices by their strong economic performance and their access to alternative energy sources, notably coal. For India, however, access to modern energy is still rather low, making the poor more vulnerable when they climb the energy ladder. In sub-Saharan Africa, economic performance is moderate, while the share of oil in primary energy consumption is large. Furthermore, the level of modern energy use is among the lowest in the world. Therefore, the macroeconomy as well as individual households are very vulnerable to oil-price increases.

4.1.2 Vulnerability to food scarcity

Vulnerability to food scarcity depends on several aspects: expected growth in demand, stability of imports, and possibilities for increasing domestic production. As shown, substantial increases in demand for food can be expected in India, Indonesia and sub-Saharan Africa. Vulnerability can be lowered by increasing domestic production; relying on imports introduces the risk of supply disruptions or rising import bills, in case of scarcity on the world market.

Sub-Saharan Africa has the possibility to expand its agricultural area, although it is unclear whether all areas that are marked as non-agricultural are in fact not being used by marginal groups (Cotula, 2009). Increases in productivity, however, have barely been attained in the past decades, in this region, while other areas in the world have succeeded in achieving an enormous increase in production per hectare. Some of the main reasons for this, have been indicated to relate to the economic dimension of scarcity: poor access to inputs, capital and markets, insufficient infrastructure and lack of investments by farmers (for example, investments in good water management at farm level). The lack of capacity to increase domestic production in the past decades, and the fact that large numbers of people live in cities on the coast, have favoured food imports by boat instead of obtaining it from the hinterland. This relatively simple way of meeting food demands has, in turn, reduced the need to increase the domestic supply. Although food prices were high in 2008 and 2009, most farmers did not profit from this rise, therefore domestic production in sub-Saharan countries did not increase (FAO, 2009a). Major efforts are needed to increase production here.

Countries and regions with land constraints, such as China, North Africa, the Middle East and India, are even more dependent on yield increases to raise domestic production. In the last decades, global cereal yields have increased by 2 to 3% annually. It is uncertain whether these rates will persist in the coming decades. A constraint on water supply is one of the factors that may hinder this. Currently, groundwater levels are declining in areas of China, India, Mexico, Egypt and other parts of North Africa (IWMI, 2007). This implies that more effort will be needed to increase production. Another reason for concern is the impact of climate change on these regions and on sub-Saharan Africa. Regions where impacts are expected to have serious effects on yields, due to temperature increases or changing precipitation patterns, are South and Southeast Asia and Africa.

Although imports could help to meet demand in the coming decades, this increases the risk of dependency on other regions, prices on the world market, and climatic circumstances in other major exporting countries. In Table 4.1 the current self-sufficiency rates for cereals are shown. North Africa and the Middle East, in particular, are not at all self-sufficient. Sub-Saharan Africa depends on imports or stock use for more than 20% of their cereal consumption. China and India, however, still produce enough cereal to meet their demand for feed, food, seeds and so on. The expected tighter world market and the stronger link with the oil price are both ingredients that could increase the volatility of food prices on the world market, in the coming decades. Increased volatility enlarges the uncertainty or fluctuations in government expenditure on food imports.

Based on these characteristics, it seems that India and sub-Saharan African countries, particularly, will need more food in the future, to feed their growing populations. India is highly dependent on productivity increases due to low expansion possibilities and will probably have to deal with impacts of climate change. Sub-Saharan African countries, in general, have the physical opportunities to increase production through land expansion or productivity increase. However, it has proven to be very difficult to attain this, due to economic and social barriers. It seems that major efforts are needed to decrease the vulnerability of these regions to food scarcity. Countries in North Africa and the Middle East remain vulnerable to high food prices on the world market. These regions are physically the most constrained, and the expected increase in population will increase their dependency on the world market.

4.2 Impacts of food and energy scarcity

For importing countries, the short-term macroeconomic impacts of increasing food and energy prices include inflation, increasing production costs and budget deficits (especially when commodities are subsidised) and a negative impact on the current account balance, all of which impact on economic growth. Furthermore, in many developing countries retail prices of food and energy are heavily subsidised for poor households. Increases in global oil and food prices can make such policies unsustainable and force governments to revise this strategy and allow retail prices to increase. Exporting countries can observe a boost to their GDP growth through increased earnings in the short term. In the longer term, however, part of this gain would be offset by lower demand, while a rise in the exchange rate, as a result of an increasing trade balance, can impact on the export opportunities for other commodities.

Increasing commodity prices also impact individual households. Poor people in importing countries in particular face severe challenges. Decreased economic growth cuts sharply into real incomes, pushing more people into poverty, and worsening the situation of those already poor. In general, increasing food prices have a more severe effect on poverty than increasing energy prices, because poor households tend to spend more than half their incomes on food and only a tenth on fuel (World Bank, 2008). Poor people in cities are dependent on the market and suffer most from increasing food prices. However, farmers can gain, if they are net sellers of food products and if the increase in commodity prices is not due to higher input prices (i.e. fertiliser or irrigation). The higher returns can be invested in means to increase production. With respect to higher energy prices, urban populations are hit harder as generally they make more use of petrol products, for example for cooking and heating, than rural populations. For rural populations, increasing oil and energy prices might impact on agricultural inputs (especially fertiliser but sometimes also irrigation), as well on transport costs. The former increase production costs, while the latter makes it more costly to bring their produce to the market. Increasing oil prices and thereby also increasing LPG or kerosene prices also make it more difficult to make a transition from traditional to modern energy sources, for those who still depend on traditional sources, or force people to currently use modern sources to switch back to more traditional biomass-based fuels, causing indoor air pollution and negative health impacts.

Here, two model-based analysis are presented that assess macro- and microeconomic impacts of increasing oil and food prices, as a result of economic and physical scarcities.

4.2.1 Impacts of increasing oil prices

Increased energy scarcity can be due to several developments (see Section 3.2). In general, increasing oil prices impact on economic growth. They lead to a transfer of income from importing countries to exporting countries through a shift in terms of trade, i.e. the increase of the relative prices of their exports compared to their imports. Gains in terms of trade offer an advantage as countries pay less for the products they import, or they have to give up fewer exports for the imports they receive. For oil importing countries, the immediate magnitude of the direct effect on national income depends on their vulnerability, in other words the ratio of oil imports to GDP. However, there are many more factors, related to the demand side, the supply side or external, that determine the overall impact (Kilian, 2008). In the short term, price increases generally decrease employment and production and increase inflation. In the longer term, however, the impact might be reduced due to national responses such as reduced consumption, a switch to other sources and increased domestic production. For net oil exporting countries, increasing oil prices increase real national income through higher export earnings. In the longer term, however, part of this gain would be offset by lower demand, generally due to the decline in GDP suffered by trading partners, and possibly to a fall in non-oil exports caused by a rise in the exchange rate. Impacts are greater if the price increase is sudden and sustained, and are magnified by the negative impact of increasing prices on consumers and business confidence.

Here, we assess the impacts of an increased global oil price on the macroeconomy and poverty in developing countries and emerging economies, using a general equilibrium modeling framework (Lucas et al., 2010); Annex I). The increased oil price is simulated by a decrease in global oil supply, which can be the result of lower reserves (physical reason) or a lack of investments in infrastructure (economic reason). The analysis compares a scenario in which the global oil price doubles towards 2020 with respect to 2004 with a scenario in which the oil price quadruples with respect to 2004 (Bakker et al., 2009; van Ruijven and van Vuuren, 2009). Both projections are in line with the projections of the IEA (IEA, 2009). The price shock cannot be interpreted in terms of short term impacts of a high oil price spike as only the structural adjustments due to a sustained energy price shock are addressed. Impacts in terms of changes in per capita income, private consumption, vulnerability and poverty are presented in Table 4.2.

In the high oil price scenario the regional production of oil and gas is 30% to over 40% lower, compared to the business-as-usual scenario. Furthermore, the high oil prices reduce economic growth in all importing regions as a larger share of their production costs is devoted to oil imports. The exporting regions gain in economic growth as the oil price increases more than their production drops. Expressing the growth in constant 2004 prices however results in a decreasing GDP as they sell less oil. The impacts on consumption are more mixed. Exporting regions can gain in terms of trade, and can thereby partly offset or even reverse the negative GDP impacts with respect to total consumption. On the contrary, oil import-

Table 4.2
Percentage change of specific variables of the high oil price scenario compared to the business-as-usual scenario, in 2020

	Per capita GDP (%)	Private consumption (%)	Vulnerability (%)	Poverty (%)
Middle East	-13	5	-	-23
China	-2	-5	51	17
India	-5	-8	36	22
Indonesia	-4	-3	-	8
Rest of Asia	-5	-6	22	14
Central Asia	-19	-6	-	19
North Africa	-9	0	-	-1
Sub-Saharan Africa	-6	5	-	-6
South Africa	-2	-4	36	5
Global	-3	-3	-	6

ing countries lose in terms of trade, as increasing import prices put upward pressure on total import expenditures, while export prices increase much less. This decreases their consumption more than their GDP. Asian regions in particular are projected to see their consumption decrease.

The oil vulnerability, that is the share of GDP devoted to oil imports, increases in all oil importing countries. China in particular is projected to spend more of its GDP on oil imports. These countries are thus confronted with higher import bills compared with their GDP, making it more difficult for governments to provide other public services. For exporters, the share of oil revenues in total GDP increases, which is already above 10% and sometimes more than 20% for major oil exporting countries. Their economies become thus more dependent on oil export and should therefore be wary of Dutch disease. Furthermore, it should be noted that poor people do not necessarily benefit from the increased oil revenues.

The GDP losses do not imply that there will be losses in every sector. As labour and capital can reallocate, macro losses due to decreasing energy production and production in energy intensive sectors can be offset by production increases in energy extensive sectors. Generally, the largest decapitalisation occurs in the oil producing sector (crude oil production and refinery), mostly driven by large production losses. Although energy intensive sectors are also impacted by the high energy prices, redundant capital from the oil producing sector might increase capital in these sectors, thereby substituting energy inputs for capital inputs and mitigating part of the price increases. The largest decreases in sectoral output for the energy producing and energy intensive sectors are expected in the regions with the highest oil intensity (the Middle East, North Africa and Central Asia), while regions with low oil intensities (mainly in sub-Saharan Africa but also in Asia) can to some extent offset increasing production costs by increasing capital inputs through reallocations. In oil and gas importing regions, the share of energy related sectors is small compared to oil and gas exporting regions. Therefore, the reallocation of capital will also be smaller, which reduces the effect of the mitigating mechanism. The projected gains for sub-Saharan Africa therefore mainly account for the oil exporting countries, while the many oil importers might see a deterioration on all fronts.

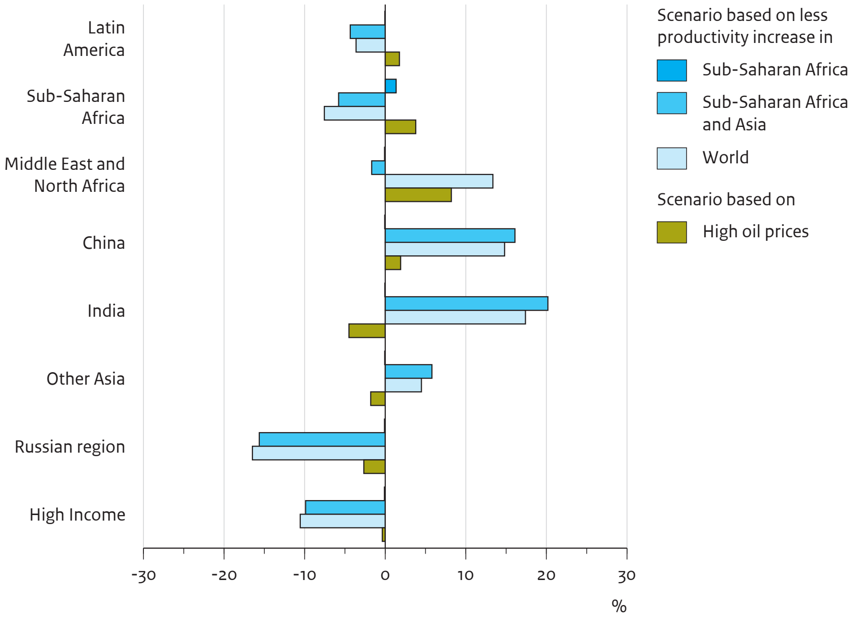
Changes in production structures and international trade also impact wages and thereby inequality. The analysis however does not include a thorough analysis of the distributional impacts. Taking only average consumption losses into account to project changes in poverty, an increase in global poverty is expected, with large increases in Asia and decreases in sub-Saharan Africa. Although China's poverty is projected to increase significantly, due to the very high poverty reduction in the business-as-usual scenario, their absolute increase is relatively low. According to the mechanism, decreasing poverty in sub-Saharan Africa decrease poverty only in the oil exporting countries, while importing countries are expected to more resemble India, where poverty increases significantly due to increasing oil prices.

The presented results should be interpreted with care as the reported regions are highly aggregated. As already discussed, sub-Saharan Africa in particular consists of both oil exporting and oil importing countries, which makes conclusions not generally applicable to all countries within the region. Furthermore, the flexibility of reallocation of capital between agricultural and non-

Figure 4.2

Change in import value relative to export value of primary agricultural commodities, 2020

Compared to baseline scenario



Change in import value relative to export value of primary agricultural commodities in 2020 compared to the baseline scenario. Negative values present a shift towards a higher value of export and/or a lower value of import of primary agricultural commodities.

agricultural sectors could be interpreted as optimistic, as this only applies to farmers that are integrated in the market and already have access to capital. Finally, the study does not address the impacts on traditional or modern energy use and thereby omits a major impact at the household level.

4.2.2 Impact of low productivity change on food scarcity

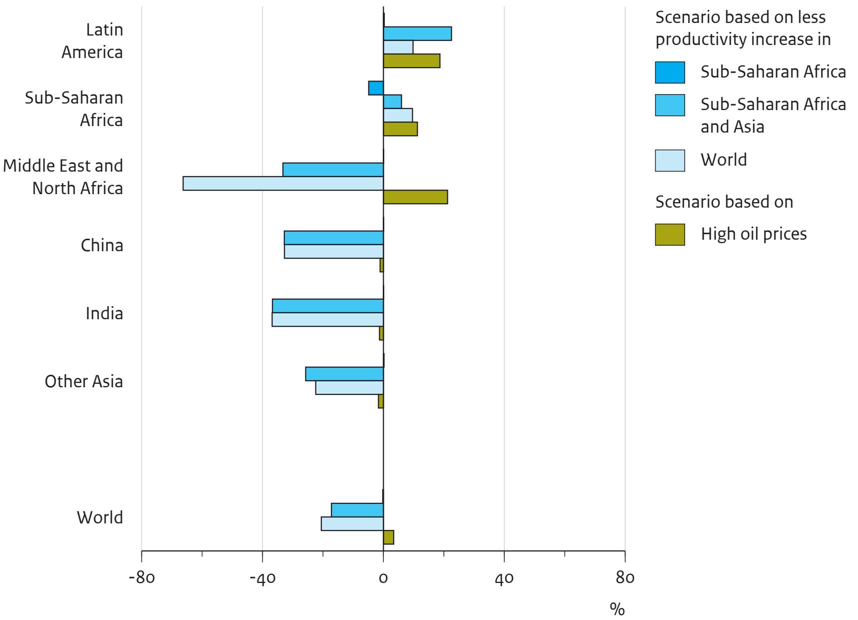
Increased food scarcity can be due to several developments (see Section 3.2). To assess impacts of food scarcity we use a general equilibrium analysis. The analysis addresses the impact of low productivity increase in primary agriculture; an example of a physical driver of scarcity (see Annex I). Towards 2020 a certain increase in the productivity of agricultural production systems is expected. As stated before, this future productivity increase is uncertain and may be hard to achieve in certain regions. In addition, impacts of climate change can have adverse effects, as can economic or social drivers that prevent farmers from increasing their productivity. The uncertainty in impacts differs between regions; therefore this case has been split up into three sub-cases. These sub-cases differ according to the regions in which the low productivity increase is expected: 1) in sub-Saharan Africa; 2) in sub-Saharan Africa and Asia; and 3) globally.

Trade can be a solution for consumers to deal with less domestic production. Consequently, commodity prices on the world market will increase. The impacts of the cases analyzed differ between countries that can profit (export more agricultural goods or the same amount at higher prices) and countries that need to import and that have to deal with increasing prices. Figure 4.2 shows the relative change with respect to the baseline in the value of imported agricultural commodities compared to the value of exported agricultural commodities, which combines changes in prices of traded goods and the physical volume. Countries and regions in which the balance shifts more to imports are China, India, Asia, the Middle East and North Africa. Latin America, the former Soviet Union, high income countries and, in certain cases, sub-Saharan Africa profit from the higher prices on the world market and the need for agricultural products in other regions. The impact of the shifts in agricultural import and export are negligible with respect to GDP. Figure 4.2 shows that especially less productivity growth in Asia has severe impacts. Sub-Saharan Africa can absorb less productivity growth by expanding its agricultural area (see also Section 4.1). The agricultural

Figure 4.3

Change in purchasing power of unskilled agricultural workers, 2020

Compared to baseline scenario



Change in purchasing power of unskilled agricultural workers in different scarcity scenarios in 2020 compared to the baseline, based on the difference in wages and cereal prices.

sector is too small with respect to the total economy to have any impact. Due to the higher prices the value added of the agricultural sector does not change substantially.

Although the impacts on GDP are very small, this does not imply that impacts on incomes are the same for all groups within a population. In many studies, the urban poor have been highlighted as the group most vulnerable to the high food prices in 2008 (World Bank, 2008; FAO, 2008b). However, lower agricultural productivity adds another vulnerable group: the unskilled agricultural worker. Although food prices are rising, the yield is less from the farmers' fields. Therefore, the landowners have a smaller budget to pay their employees than in the baseline. Since large sections of this group are unskilled or low-skilled, they are limited in finding work outside the agricultural sector. This makes their position even more difficult: they have to take lower wages. These developments could have major social impacts on an economy, depending on the proportion of the labour force that is active in the agricultural sector.

The other aspect is the impact on the purchasing power of this group. We assume the unskilled agricultural workers to be one of the lowest income groups. Besides lower wages, food prices are increasing. The expenditure on food in the lowest income group takes up an essential part of their income, in general ranging from 60–70% in Asia and sub-Saharan Africa (de Hoyos and Lessem, 2008). Figure 4.3 shows that, in Asia, North Africa and Middle East in particular, the impacts on purchasing power are substantial. Less productivity growth in sub-Saharan Africa has small impacts on the purchasing power of unskilled agricultural workers in that region. Impacts of high oil prices are positive or very little negative. The reason therefore is the increase in profit of farmers: they produce the same and earn more, because prices are higher. Besides, the prices of cereal commodities are less increasing than in the other scenarios, but the price of oil crops and sugar cane do.

4.2.3 Impacts of high oil prices on food scarcity

Oil scarcity impacts the agricultural sector or food prices in three different ways. In regions with a low energy-intensive agricultural sector it can be worthwhile to invest more capital in this sector than in others. Also the price of inputs in the agricultural sector will increase, resulting in higher food prices. Finally, biofuel crops will be more attractive to the energy sector in the case of high oil prices, also resulting in higher food prices.

Increasing oil prices could have a reallocation effect between sectors as capital flows tend to shift from high energy-intensive sectors to low energy-intensive sectors (see Section 4.2.1). The sectors that could profit from capital reallocation are the agricultural sectors in energy exporting regions in sub-Saharan Africa and Southeast Asia, which are in general relatively energy extensive and could increase agricultural productivity. However, many subsistence farmers in sub-Saharan Africa do not currently have access to capital, and this is not expected to change. Furthermore, this mechanism does not work in areas with high energy inputs in the agricultural sector, which is the case in arid areas in the Middle East, Central Asia and India, where agriculture depends highly on irrigation.

If oil production decreases compared to the baseline scenario (Section 4.2.1) higher oil price will affect food prices in two ways. First of all, the prices of inputs, for example fertiliser, will increase, resulting in higher production costs and therefore a higher food price. This process makes food crops less attractive to the energy sector. This effect especially impacts the rural poor. According to Ivo (2008), prices for DAP fertiliser more than trippled and prices of urea almost doubled between May 2006 and May 2008. Farmers forced to use organic fertilisers or no fertilisers have seen yields decrease and have been forced to reduce fallow periods and make use of degraded land. The decreasing yields have resulted in food supply constraints and in loss of income, which further increases poverty.

Secondly, energy from food crops will become more profitable at higher oil prices. This mechanism can result in higher food prices because the demand is higher and resources can become limited or more costly. In our analysis, this effect has more impact than the first one. This effect of oil scarcity will especially impact food prices on the world market and therefore food importing countries, and its net food buyers depending on imported food (more situated in urban areas).

Prices of staple food crops increase by 2–4% in the case of a 35% higher oil price. This is lower than the price increase in the case of lower productivity developments. Changes in poverty impacts are therefore small and in particular a result of the increasing grain prices in Africa. This result needs some refining, however. A lot of African farmers are barely connected to the market. The higher price of grain is a result of developments on the world market. For farmers, the higher fertiliser price will probably have more impact, resulting in lower yields or in less means to pay their workers.

4.3 Conclusions

People in developing countries are especially vulnerable to food and energy scarcities. Lack of food and clean energy sources are prominent signs. Currently, undernourishment and the use of traditional energy sources are especially high in sub-Saharan Africa and India and, to a lesser extent, also in the rest of Asia.

India and energy-importing countries in sub-Saharan Africa show the highest vulnerability to increasing oil prices. Population growth and economic development increases demand, while possibilities for substitution or increasing production are limited. Higher oil prices further increase their vulnerability. As a result of increasing oil prices, economic growth and consumption can decrease, exacerbating poverty. This is especially the case in India and Southeast Asia, and in oil-importing countries in sub-Saharan Africa. These are also the countries with the lowest levels of access to modern energy sources, such as electricity and oil-based fuels for cooking and heating, making the transition to such sources more difficult. Finally, high energy prices may also induce higher food prices, as fertiliser prices and the demand for biofuels increase.

India is also projected to have the highest increase in vulnerability to food scarcity. Population growth is expected to be large, in absolute numbers, food supplies will remain low, and possibilities for expanding domestic agricultural production depend mainly on increasing production per hectare. With the projected impacts of climate change in mind, this will be a major challenge. Countries in sub-Saharan Africa have more opportunities for increasing agricultural production. However, until now it has been very difficult to raise production in large parts of Africa. A lot of market and institutional barriers have to be overcome, if these regions wish to be less dependent on imports. With respect to food, China seems to be less vulnerable to scarcity than other countries in Asia and Africa.

In general, vulnerability to and impacts of resource scarcities can be reduced through decreased demand, increased production, or through substitution, including trade (see Chapter 3). Decreased demand is only possible to a certain extent, as hunger and a lack of modern energy sources is still widespread in many developing countries, especially in India and sub-Saharan Africa. Further, increasing trade increases a country's macroeconomic vulnerability to global commodity price increases. Households can be shielded from global price increases, for example, through subsidies or reduced taxation. However, when global prices increase, so do government expenditures, thereby transferring the vulnerability from households to governments. This could force governments to cut-down subsidies or expenses of other services, including health and education. Therefore, to successfully decrease vulnerability and increase access to food and energy, policies should manage oil subsidies, increase production, target efficiency improvements and address substitution where possible.

For energy at micro level, this includes supporting investments in more efficient stoves and modern fuels. However, as such technological developments may not produce significant results in the short term, a detailed analysis is needed to develop a subsidy system that targets those people most in need and avoids increasing a country's oil vulnerability. At macro level, strategic reserves can partly overcome oil price peaks, while exploration and refining should be increased. Furthermore, demand should be restrained through efficiency improvements and substitution (UNDP, 2007). Finally, the use of alternative energy, preferably sustainable sources, should be promoted.

For food, policies should include supporting investments in local knowledge to enhance agricultural productivity in a sustainable way. The technical options available to attain this depend on local physical, social and economic circumstances. Therefore, local knowledge is needed, also to develop technologies, for example, for the final cultivation of crops and for empowering poor people (Koning et al., 2008). Furthermore, when promoting alternatives to conventional energy that are linked to the agricultural sector, competition with food production should be avoided.

FIVE

Consequences of resource scarcities for the European Union and the Netherlands

The previous chapter discussed some possible consequences of increasing resource scarcities for developing countries. This chapter examines potential consequences for the European Union and the Netherlands.

5.1 Vulnerability of the European Union and the Netherlands

Europe and the Netherlands are to a large extent dependent on the import of resources. The dependence on foreign resources has caused concern about vulnerability to a disruption in these imports. There are significant differences with respect to how vulnerability is defined and framed. Here, vulnerability is aligned with the concepts of hazard, exposure or event risk. The dangers posed by import dependence are either that the supply will be interrupted or that a monopoly or cartel will manipulate prices and supplies to its advantage and at great cost to the economy. Table 5.1 gives an overview of the main dependencies of the European Union and the Netherlands. The main vulnerabilities for the European Union and the Netherlands due to high and increasing import rates relate to energy and minerals. Vulnerabilities to food and water scarcities are lower for the EU as a whole and for the Netherlands, as for food commodities the EU is a main exporter, and water scarcity is mainly a regional problem in Southern Europe.

5.1.1 Energy

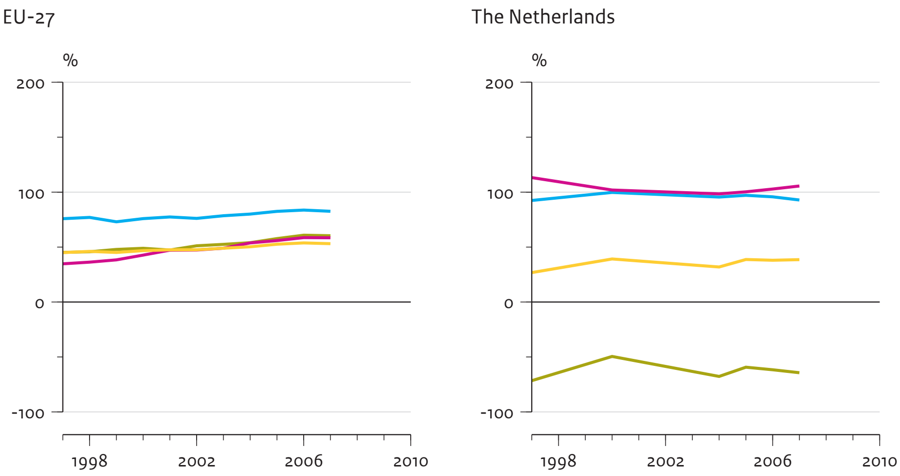
Due to the depletion of its domestic reserves over the last century, EU energy import dependency is increasing, resulting in an oil import dependency of over 80% and gas import dependency of some 60% in 2006 (Figure 5.1). This is high compared to for instance the United States, where oil and gas import dependency in 2008 amounted to 57% and 13% of demand respectively (EIA, 2010). Also, EU oil and gas imports originate from a limited number of countries (Figure 5.2); Russia plays a particularly important role. Due to the concentration of world oil and gas reserves in some of these countries and the expected depletion of world oil and gas reserves in other countries, a further restriction of the number of potential import countries is likely.

Contrary to the United States, where oil import dependency has the highest political priority, EU concerns are mainly directed at gas. EU import dependency on gas has increased in recent years, and EU vulnerability to gas scarcity is compounded by a large existing pipeline infrastructure and relatively rigid contract structures. Russia is by far the dominant gas supplier to the European Union (European Commission, 2008c) and some EU Member States are even 100% dependent on gas imports from Russia. Large reserves in this country mean that EU gas import dependency on Russia could further increase in the future. Due to its relatively large domestic reserves, gas import in the Netherlands is likely to remain limited in the short term but, like other EU Member States, the Netherlands will become increasingly dependent on imported gas in the middle term. These facts, combined with some recent political events, spark a growing feeling of unease in the EU about the dependency on Russian gas. Due to disputes about gas pricing, gas supplies between Russia and the Ukraine were interrupted for brief periods in the winter of 2006 and 2009. In 2009 in particular this caused major supply disruptions in many

Table 5.1
Main vulnerabilities of the European Union and the Netherlands to resource scarcities

	European Union	Netherlands	Remarks
Energy	High: major fossil fuel importer, tendency increasing	High: major fossil fuel importer, tendency increasing	Main focus on gas, less so on oil. Vulnerability of the Netherlands to gas scarcity lower due to domestic reserves
Food	Relatively low: major food commodities exporter	Relatively low: major exporter of high value food commodities	Soy beans receive particular attention
Minerals	High for certain minerals: major importer, tendency increasing	High for certain minerals: major importer, tendency increasing	High-tech metals and phosphate receive particular attention
Water	Relatively low: regional constraints particularly in Southern Europe, tendency increasing; issue of development cooperation	Relatively low: limited constraints; issue of development policies	

Figure 5.1
Import dependency



Oil
Natural gas
Hard coal and derivatives
All fuels

Positive values over 100 % indicate stocks build up during the reference year.
Negative dependency rate indicates a net exporter country.

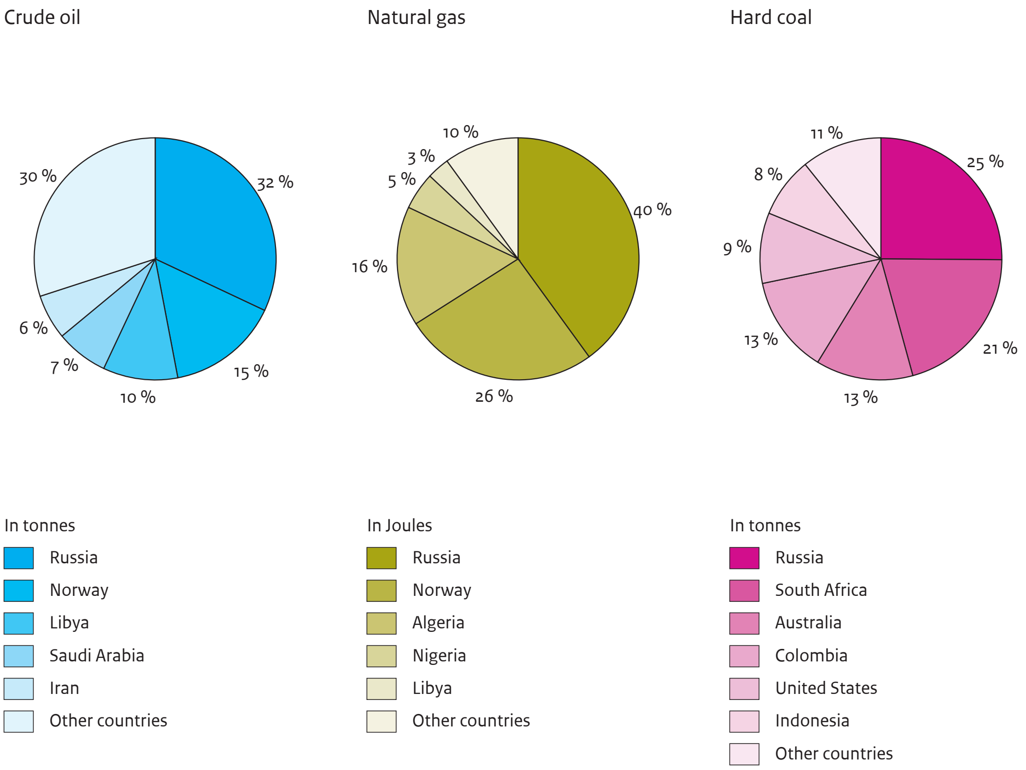
Source: Eurostat (2010)

Eastern European countries. Earlier, a gas conflict between Russia and Belarus had already resulted in some minor supply disruptions in Europe.

5.1.2 Minerals

A similar picture to energy applies to the EU situation regarding minerals: up to 100% of certain critical minerals, some of which are in increasing demand for high-tech and green applications, have to be imported by the European Union's Member States (Figure 5.3). Also, the number of countries producing these minerals is small. A recent analysis concluded therefore that, 'from a European point of view, increasing mineral scarcity is particularly worrisome, because only very few metallic mineral deposits worth exploiting are found on the continent. For a large number of metallic minerals, Europe is overwhelmingly dependent on foreign supplies to satisfy its industry's demand, including many

Figure 5.2
Import origins of energy commodities EU-27, 2007



Source: Eurostat (2009)

doping agents that are vital to products and production processes in the continent's extensive high-tech sector' (HCSS, 2010).

In the case of minerals, EU dependency on imports of rare earth metals from China has received particular political attention. An overwhelming proportion of world production (95%) is presently concentrated in China and, over the past three years, China steadily cut export quotas for rare earth elements, arguing that it needed additional supplies in order to develop its domestic clean energy and high-tech sectors. This fed suspicions that China planned global domination of rare earths, not in the least because of a much quoted phrase by former Chinese leader Deng Xiaoping that 'while the Middle East had oil, China had rare earths' (Financial Times, 2010). However, in 2010 China eased its export quotas, boosting the allowance for the first half of the year to 16,300 tons of rare earth elements, up by more than 8% compared with the same period in 2009.

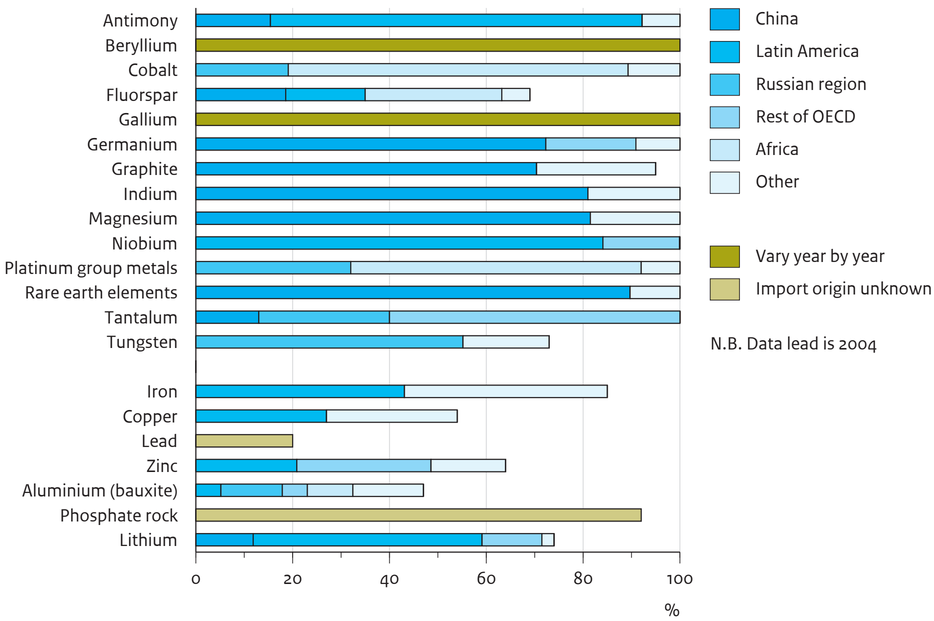
Phosphate, an essential mineral for increasing future food production, has also received political attention recently. In the Netherlands, an advisory committee to the Ministry of Agriculture warned of a future phosphate shortage (STA, 2009). Although an absolute shortage of phosphorus in the near future does not seem likely, reserves are concentrated in a few countries, in particular in Africa (van Vuuren et al., 2010). This could lead to market distortions in the future, either due to the monopoly behaviour of producers, or due to richer economies exerting market power at the cost of developing countries in order to ensure continuous phosphorus flows.

EU import dependencies on some metal concentrates and ores – net imports as a % of apparent consumption.

5.1.3 Water

Although the EU is generally considered a water-abundant region, dry periods have occurred more frequently in recent years in European Member States. Since water is a locally used resource, import dependency is not relevant in this case, but changes in local supply due to climatic circumstances and local water use are. Nine European countries are currently considered water stressed: Bulgaria, Cyprus, Germany, Italy, the former Yugoslav Republic of Macedonia, Malta, Spain, and the United Kingdom (England and Wales) (EEA, 2009). Hence, water scarcity is mostly, but not exclusively, a problem in Southern European Countries.

Figure 5.3
Import dependency and import origins of minerals EU-27, 2006



Source: European Commission (2008b), import dependency for lead is based on ILZSG (2006)

Whereas in Western and Central EU countries cooling for electricity generation is the main purpose of water abstraction (e.g. 56%), in Southern EU countries agricultural irrigation is the major user of water, accounting for 50% of water use. In the electricity sector, only a small amount of water does not return to the water body (around 5%), while the agricultural sector consumes 80% of the water abstracted. The expectation is that water demand for cooling purposes will decrease in the coming decades as older power plants are replaced by more efficient new plants. However, climate change might well lead to an aggravation of scarcity of water in the coming decades, due to decreasing precipitation and increasing abstraction for agriculture in Southern Member States. In Spain, regional water scarcity has already given rise to a much disputed and costly plan for investment in water infrastructures to transport water from the River Ebro in the north of Spain to the south (Albiac et al., 2006).
Over the period 1976 to 2006, the number of areas and people affected by droughts went up by almost 20%. At least 11% of the European population and 17% of its territory have been affected by water scarcity to date. Recent trends show a significant extension of water scarcity across Europe (European Commission, 2007).

5.1.4 Food

The vulnerability of the European Union and the Netherlands to food scarcity is limited. In a recent report (PRI, 2008) it was concluded that 'the current degree of self-sufficiency in the EU-27 is high and is likely to remain high in the near future. For the most basic food items, 95–100% and even over 100% of the European consumption is produced on its own territory. Extra EU trade volumes generally do not exceed 10% of the production volumes, with net trade volumes below 5%. Of all cereals produced, about a quarter is consumed directly, and about 60% is destined to animal feed. Although not all cereals fed to animals can easily be used for human consumption (like bread or pasta), this suggests some flexibility in overall food availability by modifying diets. Primarily processed foods and dairy products are exported. Europe imports about a quarter of its fruits and less than 10% of its vegetables, with total per capita supply doubling amounts strictly needed for an affluent diet.'

The only agricultural products with relatively high import rates in the EU are soy and vegetable oils. Even so, short-term scarcities of these products appear limited, as sudden supply disruptions are not considered probable, and even if they did occur could be relatively easily countered by changes to less meat-intensive diets (PRI, 2008): 'The only vulnerable area of significance [to food scarcity] appears to be the import of soybeans for fodder and vegetable oil, almost exclusively from South America. Soybean is a basic commodity to the oil and feed sector that is imported for almost 70% from Latin American countries and the remainder from the USA. In addition, 98% of soybean meal is imported from Latin America'. With the Rotterdam harbour as focal point, the Netherlands is by far the largest transit country for soy bean in Europe. Furthermore, Europe is heavily dependent on imported vegetable oils and fats, amounting to 32% of its consumption. If oil production from imported soy bean in the EU is included, this figure increases to nearly 43% for 2005 (PRI, 2008). However, 'even a total collapse of that import, while causing heavy price shocks, would not jeopardise the nutritional needs of the European population.'

5.1.5 Political risks and perceptions

While political risks of increasing scarcities are often stressed, less attention is generally given to the fact that in many cases substitution options exist for scarce resources, albeit at higher economic costs. While demand for lithium has risen steeply in recent years, mainly as a result of higher demand for electric transport, and the number of countries where lithium reserves are found is limited, alternatives for this power source with an even higher storage capacity have already been discovered (Ministry of Foreign Affairs and Ministry of Spatial Planning and Housing, 2009). Also, if lithium demand does indeed rise as expected, it is already technically possible to extract this element from sea water. South Korea is the first country to have announced that it will start doing so in 2015 (FT, 2010b).

Finally, fears about scarcities are also linked to the perception that certain countries might misuse control over scarce commodities for political purposes. Rather than one-sided dependencies, however, mutual dependencies often exist on a macroeconomic scale that are beneficial to both parties. These might limit the potential for unilateral action. Despite fears about the rise of China as an economic power, the Netherlands, for instance, seems to have profited rather than suffered from Chinese economic growth in recent years: relatively cheap imports from China reduced inflation in the Netherlands and strengthened the role of the Netherlands as a transit country. Negative effects of Chinese growth on the Netherlands in terms of economic restructuring, higher unemployment or higher income disparity have so far been absent or very limited. Chinese export products hardly overlap with Dutch export products. Large competitive effects and resulting sectoral changes are therefore not expected in the future (Suyker and de Groot, 2006). On the European scale, China is now the EU's second trading partner after the USA and the biggest source of imports. The EU is China's biggest trading partner (European Commission, 2010b).

5.2 Impacts on the European Union and the Netherlands

Whereas impacts of resource scarcities on developing countries can include hunger or lack of access to energy for the poor, the impacts are not likely to be found at such a fundamental subsistence level in large parts of the EU and the Netherlands. Nevertheless, impacts might be substantial. For energy and minerals, these are to be found particularly in the political dimension of scarcity: increasing dependency on a limited number of countries for imports, and hence rising fears of political blackmailing that might result in supply constraints due to export restrictions or to increasing competition for supply with other countries. Such constraints might fundamentally affect daily life in Europe, as was illustrated for instance by the impacts of the oil crisis on the Netherlands in the 1970s or those of the more recent gas crisis on Eastern Europe. Impacts might also consist of hampering technological innovation, as some metals are essential for high-tech applications in the energy sector. For food and water, impacts of resource scarcities on the European Union and the Netherlands are likely to be less pronounced than those due to energy and mineral scarcities. A sudden decline in soy bean imports, if it did occur, might require some changes in European and Dutch diets in the long term, but is unlikely to lead to food shortages as such. Water scarcity might have large impacts, particularly regarding regional agricultural yields, but is unlikely to seriously affect drinking water supplies. That the impacts of resource scarcities in the European Union and the Netherlands are so far limited is also suggested by assessments of the impacts of the 2008 energy and food price spikes. These were generally considered to have been less severe than the impacts of earlier price shocks.

5.2.1 Energy

The impacts of the 2008 oil price shock on the European Union were relatively limited. In the Netherlands, it was concluded that the Dutch economy hardly reacted to the oil price shock. This in contrast to the economic recession following the oil price shocks in the 1970s. According to the Dutch energy report (EZ, 2008), the Dutch economy first of all benefits from high economic growth in emerging economies, one of the main causes of recent high oil prices. Secondly, the importance of oil to economic growth in the Netherlands has decreased due to improved energy efficiency and a shift from energy intensive industries to a less energy intensive services sector. Thirdly, a reduced indexation of other commodity prices to oil prices has limited the risk of a wage spiral, in which higher prices for consumption would lead to higher wages, which would lead to higher prices for consumption, and so on. Due to the link between gas and oil prices, a high oil price even has a limited positive effect on the government's budget as long as economic growth in the Netherlands is not hampered by high oil prices. By contrast, the impacts of the 2009 gas price crisis on European consumers were more pronounced, as in several Eastern European countries consumers were cut off from gas supplies for several days during mid-winter (Kovasevic, 2009).

5.2.2 Food

Concerning food, only part of the observed food price increases at retail level in the EU in 2008 could be attributed to agricultural commodity price increases (European Commission, 2008d. The impact of the rise in food prices on the standard of living of consumers was further limited by the gradually declining share of total household income spent on food: 'This share currently stands on average at 14% in the EU and, indeed, is much lower for many countries of northern Europe. Therefore, in the case where higher commodity prices were fully transmitted to consumers, the overall increase in consumer food expenditure of 5% would lead to a more moderate decrease of around 0.7% in the purchasing power of an average EU-27 household' (European Commission, 2010c).

5.2.3 Minerals

Raw materials such as metals and minerals account for 40% of the production costs of industry; energy for only 1.6%. It is here, in particular, that industry bears a high cost risk if supply problems were to occur (Fraunhofer, 2009). The metals and minerals considered in this study are generally used as inputs in the high-technology or strategic sectors. Emerging technologies will lead to a large increase in demand for these minerals in the coming decades (Fraunhofer, 2009).

The critical metals and minerals share the characteristic that their potential mining and export are concentrated in a few countries. Countries producing these raw materials may influence their prices and the quantities made available on world markets. Export restrictions are applied to many of the metals and minerals under examination. Export restrictions for specific minerals are driving up world prices. China's export taxes and export quota for rare earth minerals have raised particular concern. World prices are now typically 20–40% higher than Chinese domestic prices (Korinek, 2010).

5.2.4 Water

The economic impact of water scarcity has until now been difficult to estimate. Scarcity results in higher water supply costs for the end-users, sometimes due to other technologies such as desalinisation plants, but also to secure supply. Other sectors are also affected: the agricultural sector has reconverted irrigated agricultural areas in regions in Spain, and in the UK the energy, industry and agricultural sectors were obliged to invest in water-efficient technologies. These developments result in increasing production costs and therefore decreasing employment in those sectors or even the migration of high water-intensive sectors. Environmentally, the scarcity of water affects the quality of wetlands and water bodies around the EU.

Some data on the economic impacts of droughts are available (Kraemer, 2007). These data concern alternative ways of securing domestic water supplies, loss of industrial, energy, agricultural and fishery production, and reduced water transport possibilities. In 5-year averages, the economic impacts ranged from 720 million euros a year to 5.3 billion euros a year for the EU in total. Environmental impacts of droughts are comparable to those of water scarcity: the quality of water and wetlands has been affected in particular in the past.

5.3 Differences in impacts between the EU and the Netherlands

While in many cases the impacts of resource scarcities on the European Union are similar to those on the Netherlands, this is not necessarily so in all situations. For instance, the gas situation in the Netherlands is quite different from that of the EU-27. In contrast to the EU as a whole, the Netherlands has a relatively low gas import dependency (Figure 5.1). Large domestic gas reserves mean that the Netherlands is a major European gas exporter. Hence, the impacts of increasing gas import dependencies are likely to be smaller in the Netherlands than elsewhere in the EU-27. In contrast to Eastern Europe, the 2009 Russian gas crisis had hardly any effect on the Netherlands. This might change, however, in future decades as the Netherlands' gas reserves are exhausted.

Similarly, regarding the import of soy beans, the Netherlands has a special position. Through its harbours, the Netherlands is by far the largest EU transit country for this commodity. In 2008, the Netherlands was responsible for 27% of the EU import of soy beans, and 22% of the import of soy flour, whereas the Netherlands' share in EU soy bean consumption was only 9% (TFDS, 2010). Dependency on the import of soy beans from South America, while at a European scale considered a potential security risk and negative impact, therefore economically benefits the Netherlands.

5.4 Conclusions

Europe is facing tighter global markets for energy and minerals. Scarcity will result from the growing demand from emerging economies rather than from factual disruptions in supply, although fear of supply disruptions will continue to play a role in future resource policies. Except for 'high-tech' minerals, growth in global demand for energy and bulk materials can be expected to slow down in the coming decades. The world is unlikely to run out of oil, metals and minerals, in the foreseeable future. Current resource estimates suggest ample reserves still remain. However, it takes time for supply to adjust to demand fluctuations, since the development and exploration of resources is capital-intensive. As a result, short-term scarcities of energy and minerals will remain a common feature. The long-term supply prospects for agricultural commodities are uncertain. Climate change and water scarcity could have significant impacts on yields. Vulnerability to water scarcity is mainly an issue of concern in southern European Member States. EU and Dutch vulnerability to food scarcity is, apart from an exceptional case such as soy, also relatively low due to a relatively high food production and comfortable export position of the European Union and the existence of the internal EU market.

Increasing resource scarcity will result in higher and more volatile prices. Higher prices will exert a downward pressure on economic growth. Volatile prices will discourage investment in resource exploration and depress capacity. Consumer trust in general will be undermined. Compared to developing countries, however, the economic impact of scarcity on the EU and the Netherlands is small, as resource intensity is relatively small in developed countries. Furthermore, the impact of price shocks can be expected to decline in the future. Energy intensity has fallen considerably in the past and is projected to improve in the future. The declining trend in metal intensity can be expected to continue in the future. Modern goods make less intensive use of commodities and economic growth will imply a further shift from resource-intensive manufacturing towards services. For food, impacts might show in terms of required dietary changes, if soy bean imports decrease substantially, although the food supply as such is not likely to be endangered. Water scarcity might result in regional impacts on agriculture in southern Europe, but the drinking water supply is unlikely to be fundamentally affected. If increasing scarcities are mainly expressed in price peaks, these might well have limited impacts on the EU, as suggested by the analyses of the 2008 oil and food price peaks.

For energy and minerals, Europe is largely dependent on the import of resources. Production is concentrated in a few countries. Fear is warranted that exporting countries will use their market power for economic or political reasons. Export restrictions for specific minerals are driving up world prices. China's export taxes and export quota for rare earth minerals have raised particular concern. World prices are now typically 20 to 40% higher than Chinese domestic prices (Korinek, 2010).

The political impact of scarcity is harder to interpret. Europe and other OECD countries face fiercer competition from emerging economies. Growing import dependencies also add to the feeling of vulnerability. Fears exist that revenues might be used to boost terrorism or conflict; market power might be used for political and strategic reasons. A boycott or failing infrastructure may lead to severe supply disruptions. The social turmoil of such events will be much worse than a mere price increase. Vulnerability to resource scarcities is dependent on political judgments. Fears of becoming dependent on some countries for the supply of strategic resources might be overrated, as one-sided dependencies often at closer inspection can also be regarded as mutual interdependencies at a macroeconomic level. In other cases, options to substitute resources, although at higher costs, already exist. These options can be used to decrease the political vulnerability to resource scarcity, albeit at the cost of higher end-user prices.

Finally, this chapter concludes that vulnerabilities of the European Union and the Netherlands to resource scarcities are substantial for energy (gas) and 14 critical minerals. Although the resource positions for the European Union as a whole, and for the Netherlands as a single country, in most cases run parallel, some interests, for example relating to gas and soy, may differ due to specific national circumstances in the Netherlands. There is sufficient scope for EU and Dutch policy responses in the field of resource policies. However, vulnerabilities and impacts vary substantially per resource. Although in some cases everyday life in the European Union may be affected, increasing resource scarcities in the near future are unlikely to have any impact on a subsistence level, for European and Dutch citizens – in contrast to expected impacts in developing countries.

Resource policies in the European Union and the Netherlands

In previous chapters it was shown that the precise meaning of 'scarcity' differs substantially, depending on the resource. Although the basis for all resource scarcities lies in a growing demand for resources due to population growth and economic growth, the reasons for current policy discussions vary per resource and country. However, generally, physical exhaustion is not the main concern in current policy discussions. Rather, sometimes economic aspects are prevalent, at other times strategic and political considerations.

It was also noted that several complex interactions exist that make an integrated approach to resource scarcities necessary: both the use of the various resources and the policy options intended to mitigate the scarcity of individual resources are mutually interdependent. To complicate things even further, resource use interacts in several ways with global environmental problems of climate change and biodiversity loss.

Furthermore, the analysis has shown that, although there are serious reasons for concern in both Europe and the Netherlands, the consequences of resource scarcities are likely to be far more severe for certain groups of people in developing countries, particularly those that rely on the import of food and energy.

Building on these conclusions, this chapter analyses, in more detail, the actual resource policies in the European Union and the Netherlands. Section 6.1 outlines the lessons that can be drawn from the previous chapters for the organisation of future resource policies. Sections 6.2 and 6.3 analyse to what extent present EU and Dutch resource policies conform with this picture, and Section 6.4 provides a comparison between EU and Dutch policies, as well as some overall conclusions.

6.1 Key components for the organisation of future resource policies

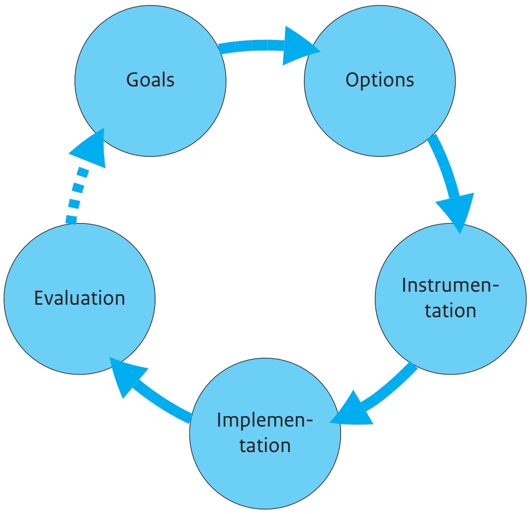
Policies are in the most general sense subject to a constant process of formulation, implementation and evaluation. Ideally, this 'policy cycle' (Figure 6.1) starts, once a problem has been recognised, with the formulation of goals, after which broad policy directions or 'policy options' are identified. With the help of policy instruments, the options are implemented in order to realise the goals set. A while after implementation, realisation of the goals is evaluated, after which the process starts anew.

Resource policies are no exception to this process. However, the previous chapters of this report show that some particular features have to be taken into account when organising future resource policies. This section takes a closer look at these features.

6.1.1 Trade-offs between resource policy objectives

As outlined in Chapter 2, two key policy objectives are relevant when looking at resource scarcities: a secure and uninterrupted supply of resources to end-users and a supply of resources at affordable prices to end-users. However, these are embedded in a broader web of resource policy objectives. Two policy objectives can be distinguished that generally accompany the other two objectives: the resource supply to end-users should take

Figure 6.1
Policy cycle



place in the most environmentally friendly way possible, and this supply should preferably not cause negative effects in parts of the supply chain outside Europe. In particular, negative impacts on the poorest in developing countries should be prevented or mitigated in line with development policy objectives (Table 6.1).

The table clearly shows that realisation of each of the individual objectives is subject to trade-offs:

- Maximising *security of resource supply* can for instance be stimulated by establishing or increasing emergency stocks. However, such emergency stocks can inflate prices. Likewise, for a secure energy supply, coal use could be stimulated in electricity generation, which without carbon capture and storage will lead to higher CO_2 emissions. Security of supply, although it generally aims to reduce resource imports and stimulate domestic production, might also lead to a more intense relationship with some developing countries. Neither import reduction by developing countries nor an increase in imports by other developing countries automatically leads to benefits for the poor.
- Maximising *affordability of resource supply* might lead to the selection of lowest cost resources which could be detrimental to security of supply. Neither would this stimulate the introduction of environmentally friendly options or innovative solutions, which generally come at a price that is initially higher than the options already on the market, nor would a lowest cost approach be beneficial to the poorest in developing countries, who would benefit from the higher prices paid for resources.
- Maximising *an environmentally friendly supply* of resources could introduce new dependencies if this leads to the substitution of one resource for another, which in turn introduces new dependencies. This objective could also lead to higher end-user prices as new technologies are often more expensive than those already on the market. Neither does their introduction always fit in with the economic and social structures in developing countries as their implementation sometimes requires high-tech knowledge or infrastructures.
- Maximising *a resource supply that is also fair to the poorest in developing countries* might imply stimulating domestic production and consumption in developing countries, which could negatively affect the export of these resources to the European Union and the Netherlands, hence the security of supply in importing countries. Higher prices paid to developing countries could also interfere with low prices to end-users in importing countries, and stimulating demand for resources in developing countries might increase the environmental pressure of these resources.

In addition to trade-offs between individual objectives, also rebound effects of actions with respect to resources have to be taken into account. Further, interactions also exist between the short- and long-term components of single objectives. For instance, security of supply is necessary in the years to come, but also in 20 years' time. The same holds for affordability, an environmentally friendly supply of resources and a fair supply of resources. In addition to the interactions between the four objectives, there are also interactions between the realisation of the short- and long-term components of each of the objectives. For example, policy interventions directed at reducing a short-term price spike might lead to higher

Table 6.1
Some examples of trade-offs between resource policy objectives

		Resource scarcity		Wider resource policy objectives	
		Secure	**Affordable**	**Environmentally friendly**	**Fair**
Resource scarcity	**Secure**		Maximising security of supply can imply high end-user prices (for example in case of emergency stocks)	Diversification of energy sources (e.g. coal and biofuels) might cause higher greenhouse gas emissions or biodiversity loss	Changes in resource imports from developing countries do not automatically lead to benefits for the poorest in developing countries
	Affordable	Lowest cost supply interferes with diversification		Lowest cost supply is not necessarily environmentally friendly and might prevent introduction of new options	Lowest cost supply does not take into account interests of poorest in developing countries
Wider resource policy objectives	**Environmentally friendly**	Some environmentally friendly options can cause new dependencies (high-tech metals for energy)	Prescribing environmentally friendly options might increase overall price levels		Environmentally friendly options not always easy to implement in developing countries (high-tech knowledge sometimes required)
	Fair	Stimulating domestic consumption in developing countries can interfere with export of resources to the EU and the Netherlands	Fair/ higher prices for resources from developing countries might increase costs	Fair/ higher supply of resources to developing countries and stimulating demand in developing countries might increase environmental pressure	

demand for a resource in the long term if they result in a structurally lower price. Emergency food supplies to developing countries in the case of drought might lead to temporary oversupply and could in this way induce longer-term structurally negative effects on local food markets. Such interactions should also be noted for the effective and efficient realisation of resource policy objectives.

Hence, not all objectives of resource policies can be maximised at the same time. The trade-offs between resource policy objectives make setting priorities within these objectives inevitable. This priority setting will differ by country and resource and depends on the perspective a government takes regarding for example political dependencies on other countries and confidence in international market mechanisms as a solution to resource conflicts. Sections 6.2 and 6.3 discuss to what extent present EU and Dutch resource policies pay attention to the interaction of policy objectives.

6.1.2 Trade-offs between resource policy options

Ideally, once resource policy objectives and their respective priorities are clear, the next step is to choose the policy options to achieve these objectives. However, the selection of one policy option to deal with the scarcity of one resource might well have repercussions for other resources, or for climate change and biodiversity loss.

In Chapter 3, policy options were categorised based on the scarcity dimension these options primarily aim to address: physical, economic or political. Regarding policy options intended to address the physical dimension of scarcity, four fundamentally different categories of policies were distinguished: 'Expansion of the resource base', 'Demand reduction', 'Efficiency improvement', and 'Substitution of resources by other resources'. For the economic dimension, 'Institutional functioning of markets' and 'Investment in physical infrastructure' were distinguished as different categories of policy options. For the political dimension, Prevention, Deterrence, Containment and Crisis management were identified as four different policy option directions. It was also noted that many individual policy options have effects in two or more scarcity dimensions. Changing the energy mix in a country towards more renewables for instance can improve security of supply and reduce physical scarcity of fossil fuels in the longer term, but might meanwhile lead

Table 6.2

Examples of resource policy options applied in practice and their potential side-effects

Scarcity dimension	Policy option (examples)	Main resource policy objective	Potential adverse side-effects	Potential positive side-effects
Political – Prevention	Improve foreign relations (bilateral, multilateral)	Secure supply	Reduce supply of resources to other countries or to global poor	New bilateral contacts based on resource supply can also encompass wider economic and cultural relations
Political – Deterrence	Refer to the UN Security Council	Secure supply	Conflict	
Political – Containment	Diversification of resources	Secure supply	Other resources might create new dependencies	
Political – Crisis management	Emergency stocks	Secure supply	Higher end-user prices	
Economic – Investment in infrastructure	Link transport infrastructures	Affordable supply, secure supply		Optimisation over larger areas might increase efficiency of resource use
Economic – Institutional functioning of markets	Introduce water pricing	Fair supply	Limited access to poor	
Physical -Expansion of the resource base	Increase domestic exploration of fossil reserves	Secure supply	Increasing fossil reserves could imply prolonged emission of CO_2 from fossil fuels	
Physical - Demand reduction	Stimulate reduction of meat consumption	Environmentally friendly supply		Reduced energy, minerals and water use
Physical -Efficiency improvement	Stimulate more efficient machinery and equipment in industrial and agricultural sectors	Environmentally friendly supply		Reduced inputs in food, minerals and water chains
Physical - Substitution of resources by other resources	Biofuels	Environmentally friendly supply; Secure supply	Fertile lands used for energy production instead of for food production	

to higher end-user prices. Table 6.2 gives some examples of policy options directed at resource scarcities and their potential negative and positive trade-offs. Sections 6.2 and 6.3 address to what extent present EU and Dutch resource policies pay attention to the interaction of policy options.

6.1.3 Monitoring and coordination

Interactions between individual resource policy objectives and between policy options require close monitoring that goes beyond the monitoring of individual resource scarcities. Rather, a careful ex-ante evaluation of the possible effects of intended policy objectives and options is needed to avoid trade-offs on other resources and on climate change or biodiversity. Interactions between short-term and long-term effects should also be made explicit, and data flows should come together in a organisational body that is able to analyse these data adequately so that an appropriate policy reaction not only in the long term, but also in the case of a short-term crisis, can be formulated – either by the entity itself or by a competent delegated policy body.

Sections 6.2 and 6.3 therefore take a look at the way in which the monitoring and coordination of resource policies in the EU and the Netherlands are organised.

6.2 Current European resource policies

European resource policies have already existed for many years for some individual resources. The European Common Agricultural Policy, for instance, was set up in the 1960s to prevent food shortages for consumers and to provide income stability for farmers. European energy policies, focusing on coal, were even at the heart

Table 6.3
Outline of the EU 2020 strategy

Europe 2020 Strategy		
Headline targets – Raise employment rate from 69% to 75%; – Invest 3% of GDP by raising private sector investments, and develop a new indicator to track innovation; – Reduce greenhouse gas emissions by at least 20%, or by 30% in the case of a global agreement, increase the share of renewables to 20% and achieve a 20% increase in energy efficiency; – Reduce the share of early school leavers from 15% to 10% and increase the share of the population aged 30-34 having completed tertiary education from 31% to at least 40%; – Reduce the number of Europeans living below national poverty lines by 25%, lifting 20 million people out of poverty.		
Smart Growth	**Sustainable Growth**	**Inclusive Growth**
Innovation Flagship Initiative 'Innovation Union'	**Climate, energy and mobility** Flagship Initiative 'Resource Efficient Europe'	**Employment and skills** Flagship Initiative 'An Agenda for New Skills and Jobs'
Education Flagship Initiative 'Youth on the Move'		
Digital Society Flagship Initiative 'Digital Society'	**Competitiveness** Flagship Initiative 'An Industrial Policy for the Globalisation Era'	**Fighting poverty** Flagship Initiative 'European Platform against Poverty'

Source: European Commission (2010)

of the foundation of the European Community in the 1950s. However, it is only recently that policies have been initiated for 'raw materials' in the form of a 'Raw Materials Initiative' (European Commission, 2008b). An integrated resources strategy was initiated in 2005, when the European Commission released a communication presenting a 'thematic strategy on the sustainable use of natural resources' (European Commission, 2005). The main focus of this strategy was 'to reduce the negative environmental impacts generated by the use of natural resources in a growing economy.'

The present overarching framework for EU resource policies is defined in the Europe 2020 strategy on 'Smart, Sustainable and Inclusive Growth', published by the Commission in March 2010. In this strategy, a 'Resource Efficient Europe' is outlined as one of the seven flagship activities (Table 6.3), in addition to innovation, education, digital society, competitiveness, employment and skills, and fighting poverty. The main aim of this flagship activity (European Commission, 2010) is to 'decouple economic growth from resource and energy use, reduce CO_2 emissions, enhance competitiveness and promote greater energy security'. For that purpose, the Commission aims to establish a 'consistent funding strategy, an enhanced use of market-based instruments like emissions trading, energy taxation, a state-aid framework and green public procurement'.

The Commission has furthermore launched proposals to modernise and decarbonise the transport sector and several energy-related activities, such as completion of the internal energy market, the SET plan, Trans European Energy Networks and an Energy Efficiency Action Plan. A 'Vision of structural and technological changes required to move to a low carbon, resource efficient and climate resilient economy by 2050' is to be published under this flagship activity to further specify these plans. The Commission also urges action from Member States. These need, inter alia, to 'phase out environmentally harmful subsidies, deploy market-based instruments to adapt production and consumption methods, to develop transport, energy and ICT infrastructures and to invest in energy efficiency and in more efficient recycling'.

6.2.1 Attention to interaction between resource policy objectives

When analysing the attention paid to trade-offs between resource policy objectives at the European Union level, several observations can be made. First of all, the focus of policies seems to have shifted from mainly environmental to more economic and political, as suggested by the inclusion of 'enhancement of competitiveness' and 'promoting greater energy security' as explicit objectives of the current strategy. This is in contrast to the 2005 strategy, which seemed to have been inspired in particular for environmental reasons. However, the relationships and trade-offs between the present objectives are not discussed explicitly. Neither is it made clear what a 'greater energy security' entails exactly.

Secondly, the 'Resource Efficient Europe' flagship activity comes on top of a whole range of existing policies, including the 2005 thematic strategy on natural resources, that are either cross-cutting or that focus on the individual resources of energy, food, minerals or water. Links between objectives of the flagship activity and those of other cross-cutting or sectoral strategies are diffuse (Schaik et al., 2010). There have been ideas to merge the existing EU Sustainable Development Strategy and the Lisbon Strategy into the new EU2020 strategy, as all three claim to present an overarching framework, but these have not yet led to decisions as to which strategy precedes over the others in the case of conflicting objectives. Hence, the position of Resource Efficient Europe regarding other key European strategies is unclear.

Thirdly, both in 'Resource Efficient Europe' and strategies focusing on individual resources, the development component, that is the consequences for developing countries and especially impacts on the poorest, seems to be largely absent. Whereas in the 2005 resource strategy 'the global dimension' of resource policies was still explicitly addressed and as a result an international panel on the sustainable use of natural resources was established, the 'fair' objective of current resource policies and of individual resources is largely left to EU development policies. This even though 'Policy Coherence for Development', first introduced in the 1993 Maastricht Treaty, has been reconfirmed and strengthened in the 2009 Lisbon Treaty. This Policy Coherence commits the Union and its Member States to take account of development policies when formulating any EU policies that are likely to affect developing countries (ECDPM, 2010).

6.2.2 Attention to interaction between resource policy options

At the level of individual policy options, quite a lot of attention is paid to trade-offs between policies directed at the individual resources. For biofuels in particular, indirect land-use changes resulting from the use of fertile lands for biofuels instead of food production have been extensively examined (cf. van Oorschot et al., 2010). As a result of concerns about these indirect land-use changes, the original Biofuels Directive, which required 10% of transport fuels to be obtained from biomass by 2020, was changed in 2008. It now includes a wider target of 10% of transport fuel needs from renewable sources, including biofuels, hydrogen and green electricity. Sustainability criteria for biofuels were also introduced, making clear which types of land cannot be used to produce biofuels and which are set to promote only biofuels with high greenhouse gas savings (European Commission, 2010d). However, a systematic examination of interactions between resource policy options is still missing.

6.2.3 Attention to monitoring and coordination

Resource policies have a high profile at EU level, not only because of their designation as one of the seven flagship activities of the new overarching EU2020 strategy, but also because they are meant to be the new integrating element of the recently split DG Environment, which has lost its former responsibilities for climate action to a newly created DG. Integrated resource policies therefore seem to be heading rapidly to an implementation phase, with a strong role for the DG Environment as a coordinating body. Policy attention for integrated resource policies seems to be guaranteed as a whole Directorate-General of the European Commission is assigned with the task of realising a 'Resource Efficient Europe'.

A relatively strong coordinating body like the DG Environment means that many lines relating to integrated resource policies come together in this DG, which has announced its intention to cooperate closely with DGs in which responsibilities for the individual resources are to be found, such as the DG Energy and the DG Agriculture. However, the subsidiarity principle means that several responsibilities regarding policy objectives for the individual resources are designated to individual Member States. Realisation of the security of supply objective, for instance, is hampered by the fact that the overall energy mix is the responsibility of individual Member States. It therefore remains to be seen whether the coordination of information flows can be translated into effective policies.

The monitoring of potential impacts of resource policies seems to be quite well organised at the European level. Since 2002 it has been obligatory to conduct an integrated impact assessment should the Commission propose new legislation. In their current form, the Commission's impact assessment procedure guidelines (2009) offer various checks and balances. Objectives have to be set that 'correspond to the problem and its root causes, are identified at a number of levels going from general to more specific, and are coherent with existing EU policies and strategies'. Subsequently, main policy options have to be investigated and classified in terms of effectiveness, efficiency and coherence. Direct and indirect economic, social and environmental effects of the policy options have to be assessed against a baseline and the main risks and uncertainties have to be considered. In principle therefore, sufficient checks and balances seem to be identified in the Commission's procedures to ensure that resource policy objectives and policy options are carefully formulated.

However, the examination of in particular trade-offs between objectives and options is left to the individual policymakers carrying out the assessment. Neither the 'fair' objective nor the assessment of EU-external effects is mentioned explicitly in the European impact assessment guidelines. This also shows in the development of indicators for this flagship activity, which is the next step in the implementation of intended policies. A formal adoption of resource efficiency criteria by the Commission still has to take place, but indicators developed so far cover four different resource-use categories appropriated for production or product use: materials – both biotic and abiotic, such as fossil fuels – water, land use and greenhouse gas (GHG) emissions (SERI, 2009). These indicators seem to offer a broad overview of various resources, although food and biodiversity are not included. EU-external effects are also not mentioned explicitly.

6.3 Current Dutch resource policies

Scarcity policies were put on the political agenda in the Netherlands by Dutch Government as a response to the energy and food crises, and reconfirmed by a Dutch parliament resolution of November 2008 asking government 'to initiate, nationally and internationally, the development of scenarios for integrated policy responses to the multiple crises the world population is presently facing' (Eerste Kamer, 2008). An inter-departmental working group was formed to address the topic that came up with a response in March 2010. In a letter to parliament, it stated that the exploration carried out had given some idea of relations between scarcities, and the role of world views herein, but that further research by knowledge institutes in the coming years was required. A brochure was produced with research questions for future policy (VROM, 2010) and a conference organised in which several high-ranking Dutch and European policymakers participated.

An account was also given of the activities of the working group in a final document published in 2010 (Passenier, Lak and Koutstaal, 2010). This document stated that many new contacts and cross-links between departments had been formed as a result of the group's activities, that the working group had succeeded in raising interest in the topic at the national and international level, but also that implementation of knowledge in organisations took much longer than the working group had expected'. As a main conclusion, it was stated that 'the project has had more results than expected, but will need sufficient international strength and a strong coordinating role within national government for a good and structural landing in policies'. Future actions regarding Dutch resource policies will depend on a new government to be formed in autumn 2010.

6.3.1 Attention to interaction between resource policy objectives

The Dutch Working Group on Scarcity and Transitions was asked to come up with questions for future research regarding resource scarcity. In the resulting booklet, several main questions were formulated. Given the limited scope of the assignment of the working group, in the booklet no attention was paid to the general objectives of resource policies and their potential interactions at a strategic level. Neither was the question of potential interactions at the level of policy objectives raised in the questions formulated for further research (VROM, 2010).

At the level of individual resources, limited attention is also paid to the interaction of policy objectives in resource policies. The main policy goals in the energy field, for instance, are a 'clean, reliable and affordable' energy supply in the Netherlands (EZ, 2008). Although the exact meaning of this at the objectives level is described in some detail (see Box 6.1), trade-offs between the three goals are not explicitly discussed – although it is noted that energy policy is part of wider, integral governmental policies, which in particular also comprise consumer policies, industrial policies and innovation policies.

Box 6.1 What does a 'clean, reliable and affordable' energy supply in the Netherlands mean?

In the Energy Report 2008, the Ministry of Economic Affairs gives a detailed account of Dutch energy policy objectives. It states that the objective 'reliable' comprises the long-term availability of energy sources, the degree to which an uninterrupted supply to end-users in normal circumstances can be guaranteed, and the degree to which international and national crises can be prevented or contained. The objective 'affordable' refers to the competitiveness of companies as well as the purchasing power of consumers. 'Clean' comprises greenhouse gas emissions, further emissions from energy (NO_x, SO_2, fine particulate matter and nuclear waste) and other environmental aspects such as loss of biodiversity and soil subsidence.

6.3.2 Attention to interaction between resource policy options

Much attention was paid by the Working Group on Scarcity and Transitions to integrated resource policies at the individual policy option level. This is expressed in particular in the establishment of new contacts with networks and platforms dealing with specific resource policy issues, in order to disseminate its 'insights and research questions'. Due to the increased attention paid to resource policies in the Netherlands, several such new networks and platforms were formed in which the working group participated. Links were for instance established with a 'Materials Scarcity Platform', originally an initiative of research institutes and businesses addressing minerals, and a governmental 'Nutrient flow task group', with a specific focus on phosphate.

Within government, the working group also established contacts with several programmes, which are temporary units of policymakers from one or more departments focusing on specific policy problems. The 'Sustainable Food Systems' and 'Biodiversity' programmes, as well as the 'Interdepartmental Vision Group on Sustainable Materials Management', were mentioned specifically by the working group as relevant to the resource policy work. The working group also claims to have given 'a new impulse' to the discussion about Global Public Goods at the Department of Development Cooperation of the Ministry of Foreign Affairs by linking this discussion to geopolitics (Passenier, Lak and Koutstaal, 2010).

6.3.3 Attention to monitoring and coordination

Two things are particularly notable regarding the Dutch approach to resource policy monitoring and coordination. In the first place, compared to the EU approach, the Dutch government seems to have chosen a particularly prudent and step-wise approach towards resource policies, with a large focus on research rather than on the direct implementation of new policies. This is for instance expressed in the goal formulated for the working group. Rather than providing recommendations for the implementation of resource policies, the working group had to conduct a meta-assessment of the developing scarcities of food, water, energy and minerals in the world, with the aim to formulate 'key questions for further research'.

Secondly, and coming largely forth from this cautious approach, a relatively 'light' form of coordination was chosen, with temporary interdepartmental working groups reporting to government, in comparison with a whole Directorate-General that was assigned with the task of 'Resource Efficiency' policies at the European level. Due to the nature of the task and the responsibilities given to the working group, the question regarding the monitoring of relevant data for resource policies and their translation into effective policies has not yet been addressed.

6.4 Geopolitics and consequences for EU and Dutch resource policies

The geopolitics of resource policies particularly come into play regarding the policy objective 'security of supply'. Much attention has been given to this policy objective both at a European and a Dutch level. This particularly holds true for energy and minerals. Whereas at an EU level this objective is often used to support claims for the further integration of policies, in the Netherlands it has resulted in a split approach: fortifying EU and multilateral integration on the one hand, and attempts to strengthen bilateral relations on the other.

The international policy landscape regarding resources seems to have changed in recent years. WTO efforts to harmonise international trade, highly important to global resource markets, have still not had any results and agreement seems far off. Neither have international environmental agreements shown much progress in recent years. Most prominently, the 2009 Copenhagen climate summit failed to deliver a global agreement. Similarly, little progress has been made recently regarding the international protection of endangered species (cf. Potocnik, 2010). Meanwhile, much has been written about land grabbing in Africa (e.g. FAO, IIED and IFAD, 2009), about the presumed power politics of Russia in the 2006 and 2009 gas crises (e.g. Euractiv, 2009) and about Chinese export bans on rare earth metals (e.g. McClearn, 2009). All these developments point to the greater importance of the political dimension in international resource policies, and seem to suggest that the defence of national interests rather than that of the global community as a whole, also regarding resources, is gaining weight. The traditional US view on energy security as a leading principle in energy policies, or the Chinese attempts to ensure access to energy in African countries could also be interpreted in this way. However, the general conclusion that security of supply is becoming the most prominent policy objective in resource policies would be too easy to draw, as recent political developments can also be interpreted otherwise (see Box 6.2).

Whether or not concerns regarding security of supply are gaining pace, many policy actions of the European Union and the Netherlands in recent years seem to have been guided by this perspective, as they were aimed particularly at strengthening security of supply. The recent attention to for instance diversification of energy sup-

Box 6.2 Security of supply above all?

Several incidents in recent years have spurred concerns in the EU and the Netherlands about the political abuse of resource concentrations and about resource competition with emerging economies. In most of these cases, however, allegations are contested by the respective counterparts.

Gas crisis

The 2009 Russian–Ukrainian gas crisis led to gas supply disruptions in the European Union. Russia claims that the conflict was purely economic and that contractual long-term supply obligations to the European Union will not be endangered. Medvedev: 'For more than 40 years we've provided gas to Europe and we have everything necessary to ensure that the 21st century is the century of natural gas. And we will fulfil our obligations.' (Euronews, 2009).

Land grabbing

During and after the 2008 food crisis, several import-dependent countries, including China, Saudi Arabia and South Korea, acquired large areas of farmland from poorer, resource rich nations such as Brazil, Cambodia and various African countries. These deals received much attention in Western news media under the headings 'land grabbing' and 'neo colonialism'. A particularly contested deal was made in 2008 by the South Korean company Daewoo in Madagascar, leasing a large part of the country's agricultural lands for 99 years. The deal was defended by Daewoo, stating that the land involved was totally undeveloped so far, and that the deal would provide jobs and investments in roads, irrigation and grain storage facilities for Madagascar (Financial Times, 2008). However, the Daewoo deal was repealed by a new Madagascan leadership in 2009.

Rare earth metals

China has imposed a 'rapid diminution of export quotas' on a number of rare metals needed for several high-tech applications since 2005. The country is planning a full export ban as of 2015. To stress the political content of this move, a statement of former Chinese leader Deng Xiaoping is often quoted in this context, saying that 'the Middle East has oil, China has rare earths' (Euractiv, 2010). China however claims to have imposed export quotas on rare earth metals because 'domestic tapping of those metals has been almost out of control, often damaging the environment in rare earth areas. The low prices, meanwhile, cannot match the value of the product.' (China Daily, 2010).

plies, energy crisis management policies and intensified bilateral energy relations can all be attributed to such an engagement. For minerals, the recent Raw Materials Initiative also appears to be guided by security thinking. On the other hand, security aspects are not at the top of the agenda for food and water.

Although mentioning individual countries in policy documents is often carefully avoided, fears of the European Union, the Netherlands and other OECD countries seem to point in two main directions. On the demand side, concerns appear to be directed particularly at competition with emerging economies such as China and India for the import of resources from third countries. On the supply-side, several countries are scrutinised (depending on the resource), including for instance Russia (gas / EU), the Middle East (oil), Venezuela (oil / US), China (rare earth metals), Morocco (phosphate) and several South American countries (e.g. lithium).

With a primary focus on multilateral governance in the Netherlands as well as in the European Union, and few opportunities for the European Union at this moment to enact a strong, coordinated foreign and defence policy, a fractioned world in which main geopolitical parties each try to maximise their own national resource interests would probably be one of the least desired geopolitical tendencies for the years to come. 'Robust' resource policies for the EU and the Netherlands would therefore be directed at preventing and mitigating this tendency where possible, and simultaneously preparing for a worst case in which these tendencies to national resource competition would indeed become dominant.

Externally, such robust policies would mean that political resource scarcities and concentrations of resources should also be regarded from the viewpoint of the supplying party: what could be the main motives of the exporting party to continue with, or alternatively disrupt, supplies? And how could demand competition with emerging economies be avoided without also interfering in the legitimate resource needs of these countries? Internally, reducing demand for resources or substitution could be appropriate policy responses, as they would reduce overall import dependency and thus reduce risks. However, substitution without taking into account interactions with other resources could also lead to new dependencies. Strengthening innovation capacities by stepping up research and development into new technologies would only be robust to any changes in dominant world views if the accompanying new resource needs are previously assessed.

6.5 Conclusions

This chapter has discussed the fact that, although policies for individual resources already have existed for many years, the increasing recognition in recent years of the complex interactions between individual resource policies and their relations to climate change and biodiversity loss, have resulted in the initiation of several new policies in the European Union, and in institutional changes, both on EU level and in the Netherlands.

Policy developments in the EU and in the Netherlands were assessed against three requirements for future resource policies based on the analysis made in this report: 1) Attention to trade-offs between policy objectives at a more strategic policy level, 2) attention to trade-offs between policy options at a more practical level, and 3) attention to coordination and monitoring, making sure that a coordinating body receives sufficient information in time to address both short-term crises and long-term policies, and that it has the legal and practical competences to act regarding all policy objectives formulated. The geopolitical aspects of resource policies for the EU and the Netherlands were also discussed.

It was concluded that:

1) The focus of integrated resource policies is shifting from purely environmental to more economic and political. In particular, resource policies are now more closely linked to innovation and to security of supply. However, a clear definition of objectives and translation into measurable indicators are still missing, particularly regarding security of supply.
2) Attention to interactions and trade-offs between policy objectives is largely absent, as well as a link to development policies ('fair' objective), despite aired intentions to integrate development policies into other policies.
3) Attention to trade-offs largely takes place at the level of individual policy options. Many policy developments can be seen at this level, with the examination of trade-offs related to biofuel development perhaps the furthest developed. However, a systematic evaluation of trade-offs of policy options is lacking, also because much information about interactions is still not available.
4) Monitoring and coordination mechanisms have been put in place, both in the European Union and the Netherlands, but their embedding into the policy organisation as a whole differs substantially. However, it is too early to say what would be more preferable: a more research-oriented approach with a relatively weak coordinating body, as in the Netherlands, or a more centrally organised and policy-implementation directed approach, as in the EU, – as policies at both levels are still in an initial phase.
5) A geopolitical situation in which national interests in resource policies would become dominant would be the least desirable outcome for the EU and the Netherlands, as their ability to act in such a situation might be limited compared to other main geopolitical players. Hence, robust resource policies of the EU and the Netherlands should in the first place be directed at preventing such a situation, and only in the second place at adaptation, should such a situation occur.

References

Chapter 1

Eerste Kamer (2008) Resolutie Schuurman, Netherlands First Chamber of Parliament, EK 2008-2009, 31 700 B, 4 November 2008.
European Commission (2010) Europe 2020: A strategy for smart, sustainable and inclusive growth. COM(2010), Brussels, 3 March 2010.
FAO (2008) The state of food insecurity in the world: High food prices and food security - threaths and opportunities. Rome, Food and Agricultural Organization of the United Nations.
Schaik, L. van, Jan Rood, Kees Homan and Barend van Wonderen (2010) Enriching the Planet – Empowering Europe. Optimising the Use of Natural Resources for a More Sustainable Economy. Conference Paper, 26/27 April 2010, Clingendael Institute, The Hague.
OECD (2008) OECD Environmental Outlook to 2030, Organisation for Economic Co-operation and Development, Paris, available at www.oecd.org/environment/outlookto2030.
VROM (2010) Dutch Ministry of Environment, Scarcity and Transitions – Questions for future policies. Letter to Parliament, 2010009239, 30 March 2010.

Chapter 2

Barnett, H.J. and C. Morse (1963) Scarcity and growth Johns Hopkins Univ. Press.
Calleo, D.P. (2009) How to govern a multipolar world. Current History, 108(721), 361-367.
Fukuyama, F. (1992) The end of history and the last man, Free Press, New York.
IEA (2005) International Energy Agency, World Energy Outlook 2005. Paris.
Krautkraemer, Jeffrey A (2005) Economics of Natural Resource Scarcity: The State of the Debate, Resources for the Future Discussion Paper 05–14, Washington. http://www.rff.org/rff/documents/rff-dp-05-14.pdf.
Malthus, T.R. (1798) An Essay on the Principle of Population, As It Affects the Future Improvement of Society, with Remarks on the Speculations of Mr. Godwin M. Condorcet, and Other Writers. London: J. Johnson.
Meadows, D.H., Dennis L. Meadows, Jorgen Randers, and William W. Behrens III (1972) The Limits to Growth. New York: Universe Books.
Ruijven, B. van (2008) Energy and Development: A Modelling Apporach. Copernicus Insitute for Sustainable Development and Innovation, department of Science, Technology and Society. Utrecht, Utrecht University. Doctor: 267.
Pingali,, P. (2004) Westernization of Asian Diets and the transformation of food systems: implications for research and policy. ESA working paper no 04-17. FAO, Rome.
Rogner, H.H. (1997) An assessment of world hydrocarbon resources. Annual. Reviews Energy Envrionment 22: 217-62.
Simpson, D., M.A. Toman and R.U Ayers, editors (2005) Resources for the Future, Scarcity and growth revisited: natural resources and the environment in the new millennium, Resources for the Future, Washington, DC, USA.
Subacchi, P. (2008) New power centres and new power brokers: Are they shaping a new economic order? International Affairs, 84(3), 485-498+8-9.
Tainter, J.A. (1990) The collapse of complex societies. Cambridge University Press.
UNEP (2010) Metals Stocks in Society –Scientific Analysis, Editor: International Panel for Sustainable Resource Management, Working Group on the Global Metal Flows, Lead author: T. E. Graedel lead author T.A.E. Graedel. http://www.unep.fr/shared/publications/pdf/DTIx1264xPA-Metal%20stocks%20in%20society.pdf.
United Nations (2008) World Population Prospects: the 2008 revision. United Nations, Department for Economic and Social Information and Policy Analysis, New York.
United Nations (2009) United Nations International Framework - Classification for Reserves / Resources. Available at http://www.samcode.co.za/downloads/UNFC/20090310_Draft%20UNFC-2009.doc.
United Nations (2010) World urbanization prospects. The 2009 revision. UN Department of economic and Social Affairs, New York.
USDA (2008) United States Development Agency, Real projected Gross Domestic Production for baseline countries/regions updated 12/16/2008. USDA Economic Research Service. Accessible online: http://www.ers.usda.gov/Data/macroeconomics/.
World Bank (2008) Global Economic Prospects 2009: Commodities at the Crossroads, The World Bank, Washington DC.

World Bank (2010a) Global Economic Prospects 2010: Fiscal headwinds and recovery. The World Bank, Washington.
WorldBank (2010b) Global Commodity Markets: Review and Price forecast. A companion to Global Economic Prospects 2010. Washington, World Bank: 36.
World Bank (2010c) Global Monitoring Report: the MDGs after the crisis, The World Bank, Washington DC.
World Bank (2010d) World Development Indicators, Databank World Bank.

Chapter 3

Ayres, Robert, U. (2001) Resources, Scarcity, Growth And The Environment, Center for the Management of Environmental Resources, INSEAD, France. http://ec.europa.eu/environment/enveco/waste/pdf/ayres.pdf.
Bakker, M.H.N. (2009) Transboundary river floods: Examining countries, international river basins and continents. Water Policy 11, 269 – 288.
Banse, M., P. Nowicki and H. van Meijl (2008) Why are current world food prices so high. LEI Wageningen UR, The Hague.
BP (2009) Statistical review of World energy, June 2009. Available at www.bp.com/statisticalreview.
Campbell, C. and J.H. Laherrère (1998) The end of cheap oil, Scientific American Magazine, March.
Cotula, L., S. Vermeulen, R. Leonard and J. Keeley (2009) Land Grab or Development Opportunity? Agricultural investment and international land deals in Africa. FAO, IIED and IFAD, London/Rome.
Diederen, A.M. (2009) Metal minerals scarcity: A call for managed austerity and the elements of hope. http://www.hcss.nl/en/publication/1051/Metal-minerals-scarcity:-A-call-for-managed-auster.html.
EIA, United States Energy Information Administration (2009) U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Proved Reserves, 2008, October 29, 2009.
European Commission (2008) Facing the Challenge of Higher Oil Prices, COM(2008)321, 11 June 2008.
FAO (2008b) Soaring Food Prices: Facts, Perspectives, Impacts and Actions Required. High-Level Conference on World Food Security: The Challenges of Climate Change and Bioenergy. Rome, FAO: 50.
FAO (2009a) The State of Food Insecurity in the World - Economic Crisis: impacts and lessons learned. Food and Agriculture Organisation of the United Nations, Rome, Italy.
FAO (2009b) The State of Food and Agriculture 2009. Livestock in the Balance. Food and Agriculture Organisation of the United Nations, Rome, Italy.
Fraunhofer (2009) Raw materials for Emerging Technologies, Final Report – Abridged, from G . Angerer et al. Rohstoffe für Zukunftstechnologien (Schlussbericht) Einfluss des branchenspezifischen Rohstoffbedarfs in rohstoffintensiven Zukunftstechnologien auf die zukünftige Rohstoffnachfrage.
Grebmer, K, B. Von, Nestorova, A. Quisumbing, R. Fertziger, H. Fritschel, R. Pandya-Lorch, and Y. Yohannes (2009) Global Hunger Index. The challenge of hunger: focus on financial crisis and gender inequality. Welt Hunger Hilfe, IFPRI, Concern Worldwide. Bonn, Washington D.C., Dublin.
HCSS (2010) The Hague Centre for Strategic Studies, Scarcity of Minerals – A Strategic Security Issue, The Hague.
IEA, International Energy Agency (2008) World Energy Outlook 2008. Paris.
IEA, International Energy Agency (2009) World Energy Outlook 2009. Paris.
ITF, Interagency Task Force on Commodity Markets (2008) Interim report on crude oil. Washington D.C. July 2008. Available at http://www.cftc.gov/ucm/groups/public/@newsroom/documents/file/itfinterimreportoncrudeoil0708.pdf.
IWMI, International Water Management Institute (2007) Water for Food, Water for Life – An comprehensive assessment of water management in agriculture, Earthscan.
Klare, M. (2008) Rising Powers, Shrinking Planet, One World Publications.
Lynch, M. (2009) Peak oil is a waste of energy, New York Times, 24 August 2009.
Mitchell, D. (2008) A note on Rising food prices. The World Bank, Development Prospects Group, Washington.
National Research Council (2008) Minerals, Critical Minerals and the U.S. Economy. The National Academies Press, Washington D.C.
OECD (2008b) Rising food prices. Causes and consequences. OECD, Paris.
Percival, B. et al. (2009) Gambling in Sub-Saharan Africa: Energy Security through the Prism of Sino-African Relations, Bas Percival, Benjamin Valk and Lucia van Geuns, CIEP Energy Paper, July 2009.
Rijsberman, F.R. (2006) Water Scarcity: Fact or Fiction? Agricultural Water Management 80, 5-22.
Simon, Julian L., Guenter Weinrauch, and Stephen Moore (1994) The Reserves of Extracted Resources: Historical Data, Natural Resources Research, Vol 3, Number 4, 327-340, Springer Verlag. http://www.springerlink.com/content/y0613wt350661w73/fulltext.pdf.
Trostle, R. (2008) Fluctuating food commodity prices. A complex issue with no easy answers. Amber Waves Vol 6, Issue 5. Economic Research Service USDA.
UNEP (2010) Metal Stocks in Society - Scientific Synthesis, Editor: International Panel for Sustainable Resource

Management, Working Group on the Global Metal Flows, Lead author: T. E. Graedel. http://www.unep.fr/shared/publications/pdf/DTIx1264xPA-Metal%20stocks%20in%20society.pdf.
UNESCO (2003) Water for People, Water for Life, United Nations World Water Development Report. Paris.
USGS (2006) Recycled Cell Phones—A Treasure Trove of Valuable Metals, by Daniel E. Sullivan, U.S. Geological Survey Fact Sheet 2006-3097. http://pubs.usgs.gov/fs/2006/3097/fs2006-3097.pdf.
USGS, United States Geological Service (2009) Minerals yearbook 2007 Available at http://minerals.usgs.gov/minerals/pubs/commodity/recycle/myb1-2007-recyc.pdf.
Van Vuuren, D.P., A.F. Bouwman, A.H.W. Beusen (2010) Phosphorus demand for the 1970-2100 period: A scenario analysis of resource depletion. Global Environmental Change 20 (2010) 428-439.
Worldbank (2009) Global Economic Prospects 2009, Commodities at the Crossroads, Worldbank, Washington. http://siteresources.worldbank.org/INTGEP2009/Resources/10363_WebPDF-w47.pdf.
WHO/UNICEF (2004) Meeting the MDG Drinking Water and Sanitation Target: A Mid-Term Assessment of Progress. Geneva and New York. Available at www.wssinfo.org/pdf/JMP_04_text.pdf.
WWI (2009) The Rationale for Sustainable Resource Management, A Report To the Government of the Netherlands (VROM), The Worldwatch Institute, Washington.
UN (2007) World Urbanization Prospects: The 2007 Revision Population Database. Online database available at http://esa.un.org/unup/.
UN Millennium Project (2005) Health, dignity and development: what will it take? Task Force on Water and Sanitation. UNDP.
Zeitoun, M. and J. Warner (2006) Hydro-hegemony – a framework for analysis of trans-boundary water conflicts, Water Policy 8, 435-460.

Chapter 4

African Union (2006) Concept paper, First African Union conference of ministers responsibel for hydrocarbons (oil and gas), Cairo, Egypt.
Bakker, S., Beursken, L., Grafakos, S., Jansen, J., van Ruijven, B.J. and van Vuuren, D.P. (2009) Oil price and climate mitigation, Netherlands Environmental Assessment Agency (PBL), Bilthoven.
Badri Narayanan, G. and Walmsley, T.L. (editors) (2008) Global Trade, Assistance, and Production: The GTAP 7 Data Base. Center for Global Trade Analysis, Purdue University.
Collier, Paul (2010) The plundered planet : why we must, and how we can, manage nature for global prosperity. Oxford University Press, Oxford; New York.
Cotula, L, Vermeulen, S, Leonard, R and Keeley, J (2009) Land Grab or Development Opportunity? Agricultural investment and international land deals in Africa, FAO, IIED, IFAD, London/Rome.
EIA (2010) International Energy Statistics. United States Energy Information Administration.Accessed on July 2010.
FAOSTAT (2010) Food security statistics. Food and Agriculture Organisation of the United Nations. http://www.fao.org/economic/ess/food-security-statistics/en/.
de Hoyos, R. and Lessem, R. (2008) Food shares in consumption: new evidence using engel curves for developing countries, World Bank, Washington D.C.
IEA (2004) Analysis of the impact of high oil prices on the global economy, International Energy Agency.
Ivo, A.M. (2008) Food and fertilizer price hypes in Sub-Saharan Africa. It never rains but it pours; Cameroon a caricature of the broader picture, African Centre for Community and Development, Limbe, Cameroon.
Kilian, L. (2008) The economic effects of energy price shocks. Journal of Economic Literature, 46(4): 871-909.
Koning, N.B.J., Van Ittersum, M.K., Becx, G.A., Van Boekel, M.A.J.S., Brandenburg, W.A., Van Den Broek, J.A., Goudriaan, J., Van Hofwegen, G., Jongeneel, R.A., Schiere, J.B. and Smies, M. (2008) Long-term global availability of food: continued abundance or new scarcity? NJAS - Wageningen Journal of Life Sciences, 55(3): 229-292.
Lucas, P.L., Bollen, J.C.B. and Manders, T. (2010) Impacts of increasing oil prices on poverty and hunger, Thirteenth Annual Conference on Global Economic Analysis, Penang, Malaysia.
Modi, V., McDade, S., Lallement, D. and Saghir, J. (2005) Energy services for the Millennium Development Goals: Achieving the Millennium Development Goals, Energy Sector Management Assistance Programme, United Nations Development Programme, UN Millennium Project, and World Bank, New York.
van Ruijven, B. and van Vuuren, D. (2009) Oil and natural gas prices and greenhouse gas emission mitigation. Energy Policy, 37: 4797–4808.
UNDP (2007) Overcoming vulnerability to rising oil prices: Options for Asia and the Pacific, United Nations Development Programme, Bangkok, Thailand. http://www.ers.usda.gov/Data/Macroeconomics/#BaselineMacroTables. Accessed on September 9, 2010.
UNDP-WHO (2010) The energy access situation in developing countries: a review focused on the least developed countries and Sub-Saharan Africa, United Nations Development Programme and the World Health Institute.

Saghir, J. (2006) Global Energy Security Perspectives, e7 Summit, Evian, May 30, 2006.
UNDP (2007) Overcoming Vulnerability to Rising Oil Prices: Options for Asia and the Pacific United Nations Development Programme, Bangkok.
USDA (2010) International Macroeconomic Data Set. United States Department of Agriculture, Economic Research Service. http://www.ers.usda.gov/Data/Macroeconomics/. Accessed on August 1, 2010.
WHO (2006) Indoor air pollution and health, Retrieved April 4, 3006, from http://www.who.int/mediacentre/factsheets/fs292/en/index.html.

Chapter 5

Albiac, J. (2006) The case of the water framework directive and irrigation in mediterranean agriculture. Occasional Paper of the Human Development Report Office. http://hdr.undp.org/en/reports/global/hdr2006/papers/albiac%20jose.pdf.
EEA (2009) European Environmental Agency. Water Exploitation Index. Published 9 January 2009. http://www.eea.europa.eu/data-and-maps/figures/water-exploitation-index-wei-2.
EIA (2010) Energy Information Administration website, http://tonto.eia.doe.gov/ Retrieved October 2010.
European Commission (2007) Addressing the challenge of water scarcity and droughts in the European Union Communication from the Commission to the European Parliament and the Council COM/2007/0414 final.
European Commission (2008b) The Raw Materials Initiative – Meeting our Critical Needs for Growth and Jobs in Europe, Working Document, COM(2008)699, Brussels.
European Commission (2008c) An EU energy security and solidarity action plan COM(2008) 781 final, Brussels, 13.11.2008.
European Commission (2008d) Issues paper on high food prices, Staff working paper, D(2008), Brussels, May 06, 2008. http://ec.europa.eu/agriculture/analysis/tradepol/foodprices_en.pdf.
European Commission (2010b) European Commission website, Trade, Bilateral relations, China. Retrieved October 2010. http://ec.europa.eu/trade/creating-opportunities/bilateral-relations/countries/china/.
European Commission (2010c) European Commission website, Agriculture and Rural Development, Food Prices. Retrieved October 2010. http://ec.europa.eu/agriculture/foodprices/index_en.htm.
EZ, Dutch Ministry of Economic Affairs (2008) Energierapport 2008, The Hague.
Financial Times (2010a) China ups rare earth reserve. February 11, 2010.
Financial Times (2010b) Seoul turns to seawater as battery makers hunt for lithium, March 9, 2010.
IZLSG (2006) Lead And Zinc Statistics, Monthly bulletin of the International Lead and Zinc Study Group, Vol 46 No 2, February 2006.
Korinek, J. and J. Kim (2010) Export Restrictions On Strategic Raw Materials And Their Impact On Trade, OECD Trade Policy Working Papers, No. 95, OECD.
Kovasevic (2009) The impact of the Russia – Ukraine gas crisis in South-Eastern Europe. Oxford Institute for Energy Studies. NG 29. March 2009. http://www.oxfordenergy.org/pdfs/NG29.pdf.
Kraemer, R. Andreas (2007) Economic Impact of Droughts: Challenges for Water & Environmental Policies. Water Scarcity and Drought - a Priority of the Portuguese Presidency, Jg. 1, 61-88.
PRI Plant Research International (2008) Resilience of the European Food System to Calamities, Report for the Steering Committee Technology Assessment of the Ministry of Agriculture, Nature and Food Quality, the Netherlands, Wageningen University, November 2008.
STA (2009) Stuurgroep Technology Assessment van het Ministerie van LNV, 2009, Fosfaat – van te veel naar tekort. http://www.nrc.nl/multimedia/archive/00254/fosfaatnotitie_254680a.pdf.
TFDS (2010) Task Force Duurzame Soja. Retrieved from website of the Taskforce for Sustainable Soy Beans, October 2010. http://www.taskforceduurzamesoja.nl/index.php?option=com_content&task=view&id=29&Itemid.

Chapter 6

China Daily (2010) What is the rare earth war all about, 28/4/10.
ECDPM (2010) European Development Cooperation: Brokering Environmental Knowledge beyond Lisbon, ECDPM Discussion Paper, No 102, August 2010.
Euractiv (2009) Pipeline Politics? Russia and the EU's battle for energy, 20 August 2009, http://www.euractiv.com/en/energy/pipeline-politics-russia-eu-battle-energy/article-177579.
Euractiv (2010) Worries mount over China's rare earth export ban, 9 June 2010.
Euronews (2009) Gazprom's Medvedev on Ukraine gas crisis, 3/2/09.
European Commission (2005) Thematic strategy on the sustainable use of natural resources, SEC (2005) 1683, 1684.
European Commission (2009) EU Impact Assessment Guidelines SEC (2009) 92

European Commission (2010) Commission sets up system for certifying sustainable biofuels, memo/10/247, 10 June 2010.
EZ (2008) Energierapport 2008. http://www.rijksoverheid.nl/documenten-en-publicaties/rapporten/2008/06/18/energierapport-2008.html.
FAO, IIED and IFAD (2009) Land grab or development opportunity – Agricultural investment and international land deals in Africa, http://www.fao.org/docrep/011/ak241e/ak241e00.htm.
Financial Times (2008) Daewoo to cultivate Madagascar land for free, 19/11/08.
McClearn (2009) Rare-earth metals – The new China syndrome, Canadian Business Magazine, 9 October 2009.
Passenier, A., Lak, M. and Koutstaal, H. (2010) Project Schaarste en Transitie – Eindverantwoording, The Hague 2010.
Potocnik, J. (2010) Statement by Janez Potočnik, on the Outcome of the meeting of the Conference of the Parties to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in Doha26 March 2010, Brussels, http://www.europa-eu-un.org/articles/es/article_9621_es.htm.
SERI (2009) How to measure Europe's resource use, Vienna, June 2009.
STPG, Scarcity and Transition Project Group (2010) Scarcity and Transition – Research Questions for Future Policy, The Hague.
VROM (2010) Scarcity and Transition: research questions for future policy, joint project by the mininstries of Foreign Affairs and Husing, Spatial planning and te Environment. http://international.vrom.nl/DOcs/internationaal/Scarcity and transition.pdf.
Oorschot, M. van, J. Ros and J. Notenboom (2010) Evaluation of the indirect effects of biofuel production on biodiversity: assessment across spatial and temporal scales. Netherlands Environmental Assessment Agency, Bilthoven, May 2010.

Appendices

Badri Narayanan, G. and Walmsley, T.L. (editors) (2008) Global Trade, Assistance, and Production: The GTAP 7 Data Base. Center for Global Trade Analysis, Purdue University.
Chen, S. and Ravallion, M. (2008) The Developing World Is Poorer Than We Thought, But No Less Successful in the Fight against Poverty. World Bank Policy Research Working Paper 4703.
Cypher, J.M. and Dietz, J.L. (1997) The process of economic development. Routledge, London.
Hilderink, H.B.M. (2000) World population in transition: an integrated regional modelling framework. Thela Thesis / Rozenberg, Amsterdam, 256 pp.
Hilderink, H.B.M. and Lucas, P.L. (editors) (2008) Towards a Global Integrated Sustainability Model: GISMO 1.0 status report. Netherlands Environmental Assessment Agency (PBL), Bilthoven, the Netherlands.
IEA (2008) World Energy Outlook 2008, OEDC, International Energy Agency, Paris.
Lejour, A., Veenendaal, P., Verweij, G. and van Leeuwen, N. (2006) WorldScan: a Model for International Economic Policy Analysis. CPB Document No 111, Netherlands Bureau for Economic Policy Analysis (CPB), The Hague, the Netherlands.
OECD (2008) OECD Environmental Outlook to 2030, Organisation for Economic Co-operation and Development, www.oecd.org/environment/outlookto2030.
van Ruijven, B. J. (2008) Energy and Development - A Modelling Approach, Utrecht University, Utrecht, 271 pp.
van Ruijven, B. and van Vuuren, D. (2009) Oil and natural gas prices and greenhouse gas emission mitigation. Energy Policy, 37: 4797–4808.

Appendices

Appendix 1: Background to the food scarcity scenarios of chapter 4

This section provides an overview of the implementation of the scenarios used for the food scarcity analysis in Chapter 4. In addition, it includes a description of the baseline and a brief discussion of some of the most important scenario results.

The LEITAP model

The analysis uses the LEITAP model which is based on GTAP (Woltjer, 2009; Hertel, 1997). The standard LEITAP model is a multi-region, multi-sector, computable general equilibrium model which assumes perfect competition and constant returns to scale. It is built on a database consisting of data collected from around the world, including bilateral trade flows, production, consumption and intermediate uses of commodities and services. The LEITAP model provides the additional capacity to analyze policies specific to Europe and the ability to run scenarios relating to global biofuels and land use. EU-policies, including first and second pillar measures, have been modeled and are important in simulating the economy as it is expected to exist in the near future. A very important addition is land supply and substitution, based on biophysical model outcomes from the IMAGE model (MNP, 2006). Finally, dynamic mobility of capital and labor between agricultural and non-agricultural sectors has been modeled. Analyses in this report are based on version 6 of the GTAP database which uses data from 2001 as the base year. The database contains detailed bilateral trade, transport and protection data characterizing economic linkages among regions, and mathematically consistent individual country input-output data which account for inter-sectoral linkages. The regional disaggregation includes most EU member states as individual countries and all important countries and regions outside the EU from an agricultural production and demand point of view.

Implementation of Scenarios

The following sections describe the implementation of the scenarios run for PBL. The general idea of running the scenarios is to model the effects that potential economic changes may have on measures of scarcity and poverty. All scenarios are divided into two periods, 2010-2013 and 2013-2020, results are presented for the combined period **2010-2020**. In accordance with the themes of the Scarcity and Transition project (PBL, 2009), each scenario was analyzed with reference to its impacts on the following general indicators: land productivity (output per hectare), the price of production and consumption, consumption volumes, wages and imports and exports.

1. Base Scenario

A base scenario was selected which reflects, at a fundamental level, the economic situation as it existed in 2010 and is expected to exist in the near future. The LEITAP model is changed via shocks. The shocks implemented for the scenarios under consideration are adjustments to data used in the model. For instance, a simple computable general equilibrium model will consist of a database and behavioral assumptions about the relationships between the components of the database, e.g., production and consumption relationships. A shock is a way to experiment with the impacts of changing one or more of these relationships. Therefore, a good way to understand a scenario is to examine its shocks.

Important macro-shocks include:

a. Land augmenting technical change for the primary agricultural products. Provided by the IMAGE model (MNP, 2006).
b. Capital, labor, and natural resource enhancing technological change. Provided by the Central Planning Bureau (CPB).
c. Factor supply endowments, linked to GDP (USDA).
d. Population growth, linked to employment (USDA).
e. World price index of primary factors linked to inflation (USDA).
f. A budget for biofuels which is initially set at the difference in value of domestic traded commodities for use in production commodities at agent prices and the value of domestic traded commodities for use in production commodities at market prices.

2. Scenarios which shock productivity in the agriculture sector

The purpose of these experiments was to assess the impact of an expected decrease in the growth of productivity in the agriculture sector. In particular, scenarios were run to examine the effects of:

1. A twenty-five percent decrease in global agricultural productivity growth
2. A twenty-five percent decrease in agricultural productivity growth in West Africa

3. A twenty-five percent decrease in agricultural productivity growth in Africa and Asia

The scenarios were implemented by reducing the rate of technical change from what it would have been in the base scenario by certain percent, and doing so for each of the scenario periods. For instance, if, according to the GTAP database, the productivity of paddy rice was expected to increase by 5%, a shock reduces of 25% reduces that value to 3.75%. As a general rule, when interpreting the results, it is important to keep in mind that the shock is applied to the expected growth in productivity. Therefore, if a country was expected to experience a large increase in productivity (e.g., India and China) it will "suffer" more relative to a country that is not expected to experience large technological improvements.

2a. A twenty-five percent decrease in global agricultural productivity growth

Predictably, the price of production increases significantly in the primary agricultural sector when compared to the other sectors, particularly in the Middle East and North Africa, China, and India regions. The increase in the production price of agriculture is probably due in large part to the limited availability of land in these countries. These countries are therefore quite dependent on technologically driven improvements. The increase in the price of production leads to predictable decreases in the volume of private consumption per capita.

The story in regards to employment is mixed. While high income countries experience increases in employment, others, particularly China and India have reduced employment. Those two countries might be experiencing larger decreases as a result of the relatively large reduction in technological progress that they forgo in this scenario. Similarly, nominal wages for both skilled and unskilled workers in the primary agricultural regions fall significantly for China, India and the Middle East and North Africa.

The relative cost of production of primary products is higher for some countries, so resources shift to products for which there is a relative advantage.

Imports and exports are greatly affected by the reduction in productivity growth. Many countries increase exports while exports from China, India and the Middle East and North Africa fall. The shock changes the relative advantages of the regions, making some countries relatively better at producing primary products. High Inc countries appear to have benefited from the reduced increases in productivity, perhaps because they have already incorporated technical improvements into their production process; in other words, they are not expected to experience great increases in productivity. Similarly, Chinese, Indian, and Middle East and North African imports increase. Only high income countries become less dependent on imports.

2b. A twenty-five percent decrease in agricultural productivity growth in West Africa

In effect, it asks a much narrower question than the previous scenario. Specifically, it asks what would happen if productivity increases fell in West Africa while remaining the same as the base scenario for the rest of the world. The same regions and products will be examined as in the previous section and for reasons of parsimony I will use the same structure to analyze the results.

Again, the scenario yields, more or less, the expected results to productivity in that only SSA (sub-Saharan Africa) is influenced by the change in productivity. And, once again, there is great variation among the product categories. World productivity falls as a result of the fall in SSA, indicating the importance of this region in the world in terms of expected technological growth.

The price of production increases in SSA increases by a relatively large amount. Increases in the price of production for other countries might be a result of the fact that they are unable to import as much from SSA or that it is now profitable for them to export more because SSA is unable to (see exports and imports below). Both reasons would imply that production and therefore production prices increase slightly for countries other than SSA. While the volume of private consumption falls. Once again, higher prices lead to less consumption, but consumption doesn't fall by as by much as price, so the amount spent on primary agricultural products increases.

The increase in primary agricultural prices results in a decrease in private consumption as consumers are now less able to afford these relatively more expensive products. The rise in production costs results in less employment in the primary agricultural sector. An increase in the relative price of production should and does influence employment in the sector. The price of production is now relatively high in the primary agricultural sector, raising the relative attractiveness of the remaining sectors. As a result, employment falls in percentage, per capita terms in comparison to the base scenario. It is perhaps interesting to note that although productivity falls, by design, the increase in the price of production is relatively small. This is partly a result of new land being brought into production in West Africa. So, although land demand increases to account for the decreasing productivity, the price of land increases at a nearly corresponding rate.

The impacts on employment appear to be approximately equal amongst skilled labor and unskilled labor. In comparison to the previous scenario, most labor categories in both primary and processed sectors suffer in West Africa. Unskilled labor in the primary agricultural and processed sectors represents a large majority of the employment in both sectors. In addition, both types of labor experience a reduction in the value of their employment. In other words, the employees who remain in the primary agricultural sector earn less.

Export volumes of primary agricultural products fall from SSA as these products become relatively more expensive and exports from other regions increase as it becomes more profitable for them to do so relative to SSA.
By similar reasoning, imports increase significantly for SSA as the internal costs of production rise relative to the base scenario.

2c. A twenty-five percent decrease in agricultural productivity growth in Africa and Asia

The price of production in the primary sector increases significantly for Asia and Africa, but slightly less than in the first scenario. Differences between the scenarios are predictable given the assumptions of general equilibrium models. Since in this scenario only a subset of the regions of the world are shocked, those countries not experiencing the shock are able to adjust their production to the new economic reality. In other words, the non-shocked countries are free or freer to adjust their production, reducing the initial effects of the shock on countries in Asia and Africa.

The price of production is now relatively high in the primary agricultural sector, raising the relative attractiveness of the other sectors. Employment falls in percentage, per capita terms in comparison to the base scenario.

The rise in production costs results in less employment in the primary agricultural sector. An increase in the relative price of production should and does influence employment in the sector. The price of production is now relatively high in the primary agricultural sector, raising the relative attractiveness of the remaining sectors. As a result, in general employment falls in percentage, per capita, terms in comparison to the base scenario. In addition, wages fall significantly in both China and India (10%). This fits well with the idea that resources have shifted to other sectors as a result of the higher prices in the primary sector. As a result, demand for labor in the primary agricultural sector falls.
In contrast, employment in SSA, as in the first scenario, increases. This might be a result of relatively less expensive labor in SSA. Producers in SSA find that the relative cost of labor has fallen in comparison to other inputs. Although all inputs are influenced by the decrease in productivity growth, in SSA, labor is relatively less affected and relatively less expensive.

Just as with the West Africa scenario, both categories of primary agricultural labor suffer in this scenario.
Unskilled labor in the primary agricultural and processed sectors represents a large majority of the employment in both sectors. Although employment and wages in the primary sector fall, sectoral income increases. This is because the value (another way to think about it is the amount that is spent on the sector), of primary agricultural products represents a greater share of the value of the Asia and Africa's total output. Likewise, the share of primary consumption as a percentage of total consumption of agricultural products and processed agricultural products per capita increases dramatically. The fall is much greater than in the other two productivity scenarios. While the per capita volume of private consumption falls. Once again, higher prices lead to less consumption, but consumption doesn't fall by as by much as price, so the amount spent on primary agricultural products increases.

3. *Scenario in which the supply of oil is decreased*

The original proposal was to tax the price of oil and thereby raise its price for all users; however, taxes can have undesirable side effects in general equilibrium models. As an alternative, the endowment (supply) of crude oil was lowered using a technical parameter, which essentially makes it more difficult to extract oil. As a result, production changes from an expected increase of 5.5% over the period 2010-2020 to a worldwide contraction in production volume of around 13% and it becomes much more expensive.

Although crude oil is predominating used by the industrial sector, the percentage reduction in oil use is similar in all sectors. In other words, while most of the absolute reduction in crude oil occurs in the industrial sector, all sectors must adjust to the relatively more expensive input price of oil. Production volumes of all products decrease in most sectors in most countries. The exception is the primary agricultural sector, which experiences an increase in production in most regions. The apparent anomaly of the primary agricultural sector becomes less of an anomaly when the influence of the increase in products used in the production of biofuels is taken into account. Worldwide, the production of biodiesel and ethanol increase significantly. This, in turn, stimulates the production of primary agricultural products namely, vegetable oils and sugars, used in their production. The increase in the demand for those two products leads to a substantial increase in land prices which impacts nearly the entire land market. Employment, as an alternative input to crude oil, increases in the primary and processed agricultural sectors, but also increases because of the increased demand for vegetable oils and sugars. Worldwide GDP, even for oil exporting regions, falls, despite the increase in production of crops for biofuels, but by less than 1%.

Appendix 2: Background to the high oil prices scenario of chapter 4

To assess the macroeconomic and poverty impacts of increasing oil prices an integrated modelling framework is used, which consists of the WorldScan model (Lejour et al., 2006), and the Global Integrated Sustainability Model (GISMO) (Hilderink and Lucas, 2008). The World-Scan model is used to assess the macroeconomic and sectoral impacts of the high oil price shock. The GISMO model is linked to the WorldScan model and is subsequently used to assess the impacts the high oil price shock on the proportion of the population living with less than $1.25 per day.

The WorldScan model

The WorldScan model is a recursively dynamic Computable General Equilibrium (CGE) model (Lejour et al., 2006). It builds upon neoclassical theory, has strong micro-foundations and explicitly determines simultaneous equilibrium on a large number of markets. The structure of WorldScan's core version is similar to the GTAP model (Hertel, 1997) and uses the GTAP-7 database (see Badri Narayanan and Walmsley, 2008). WorldScan is used both as a tool to construct long-term scenarios and as an instrument for policy impact assessments, e.g. in the fields of climate change, economic integration and trade.
Each sector within a region produces a unique variety of a good. Factor demand is derived from cost minimisation, given production technology. The production technology is represented by a production function which relates output to factor inputs and intermediate inputs. The main factor inputs are labour and capital. Only capital is mobile across regions. Intermediate inputs are goods, services and energy, which are to some extent substitutable. The relevance of each of these inputs for production and their substitutability is represented by a nested structure of constant elasticities of substitution (CES) functions. The values of the substitution parameters reflect the substitution possibilities between inputs, which may differ across sectors reflecting the different substitution possibilities of (factor) inputs within the producing sectors. Consumers decide how to spend their earned income in three stages; distribution over consumption (private and government) and savings, allocating consumption income to consumer goods and services, and international trade. On the basis of their preferences consumers decide how to spend their budget on consumer goods and services, using a Linear Expenditure System (LES). The energy part distinguishes three fossil energy carriers: coal, oil and gas. The production and demand structures of these fossil energy carriers (fixed factors) follow the functional specification of the other goods and services sectors.

The GISMO model

The GISMO model addresses sustainable development by focussing on the two-way relationship between global environmental change and human development. It allows to asses human development by specifically addressing changes in Quality of Life as a consequence of changes in the three sustainability domains (social, economic and environmental). The model is system dynamic in nature and builds on the long history of Integrated Assessment modelling, including the PHOENIX model (Hilderink, 2000) describing human/social dynamics and the IMAGE model addressing global change from and environmental perspective. Quality of life is modeled focusing on income, education and health and their underlying dynamics. Here, we only describe the poverty calculations. For an in-debt description of the full model see Hilderink and Lucas (2008).
Poverty headcount, people below the poverty line (here $1.25 per day at 2005 Purchasing Power Parity), is dependent on total income and its distribution over a population. Most commonly, distribution is expressed using the GINI coefficient, a statistical summary of the Lorenz curve (Cypher and Dietz, 1997). Using a lognormal distribution, the income distribution can be fully specified with only two parameters: mean expenditures per capita and the GINI coefficient (see Figure 1 and van Ruijven, 2008). The model is calibrated towards historic regional poverty and GINI coefficients, taken from the Povcal*Net* database (Chen and Ravallion, 2008). Developments in regional expenditures per capita are taken from the WorldScan model, while the GINI coefficients are kept constant in time.

Business as usual and the high oil and gas variant

The business as usual macroeconomic projection is based on the projection of the OECD Environmental Outlook OECD (2008). In this projection, oil and gas prices drop from approximately $38 per barrel in 2004 to $25 per barrel in 2020 (2004$US). For the high oil and gas price variant, oil and gas prices are exogenously shocked according to the high variant of van Ruijven et al (2009), which is based on IEA (2008). In this variant the price of oil triples compared to 2004 levels, i.e. from 38$ per barrel to slightly more than 100 US$ per barrel in 2020 (both 2004US$). The higher prices of oil and gas are simulated in the WorldScan model by uniformly reducing world oil reserves across regions, i.e. regional percentage adjustment of the fixed factors (oil and gas) are the same to match the prescribed global prices of oil and gas.

Resource scarcity features prominent on the agendas of policymakers worldwide. Concerns are triggered by high prices of energy, food and commodities, as well as by fears about supply security of resources. Scarcity is a complex issue with physical, economic and geopolitical dimensions. This study explores a number of questions: What scarcities should we worry about? What is driving scarcity? What are the impacts? And, finally, which policies are conceivable for the European Union and the Netherlands to deal with resource scarcities?

This study is a publication by:

PBL Netherlands Environmental Assessment Agency

Mailing address
PO Box 30314
2500 GH The Hague
The Netherlands

Visiting address
Oranjebuitensingel 6
2511 VE The Hague
T +31 (0)70 3288700

www.pbl.nl/en

February 2011