# 17 Preparing for Global Transition: Implications of the Work of the International Resource Panel

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## Abstract

The International Resource Panel (IRP) was established as an expert scientific panel by UNEP in 2007. By using a material flow analysis perspective, the primary focus of the IRP is on global resource use and potential alternatives. The notion of a 'third great transformation' was deployed to suggest that the work of the IRP is documenting the endgame of the industrial socio-metabolic regime. Three clusters of reports were addressed: (a) global resource perspectives, with special reference to decoupling rates of economic growth from rates of resource use by focusing on the importance of resource productivity; (b) nexus themes, including cities, food, trade, and GHG mitigation technologies; and (c) specific resource challenges with respect to two clusters of issues, namely metals and ecosystem services .The conclusion reached is that a resource-use perspective adds to our understanding of the unsustainability of the current global system, complementing the outputs of climate science on the effects of anthropogenic carbon emissions and ecosystem science on the implications of biodiversity degradation. To this extent, the work of the IRP anticipates the possibility of a more resource efficient socio-metabolic order. However, the IRP has to date not addressed specifically the dynamics and modalities of transition from an institutional and macro-economic perspective.


**Keywords:** Decoupling, transformation, sustainable development, sustainability science, material flow analysis, long-wave theory.

## 17.1 Introduction

This chapter will analytically review the work of the *International Resource Panel* (IRP) from the perspective of global transition theory.[1] It will be argued that the IRP can be understood as a collaborative effort by a diverse group of researchers to document the metabolic case for why the industrial epoch has effectively reached the end of its 250-year historical cycle. Although this documentary evidence suggests that the necessary conditions are in place for a transition to a more sustainable long-term development cycle, this by no means implies that the IRP has developed a view on whether sufficient conditions exist for such a transition to happen. Now that the Sustainable Development Goals have been approved, this may provide the context for such a task. The IRP has yet to pay attention to the key factors that will determine the nature of such a transition, namely social actors, their networks and the highly complex dynamics of the institutions that embody the intentions of organized historic and current socio-economic interests.

The *International Resource Panel* (IRP) was established by the *United Nations Environment Programme* (UNEP) in 2007 (see <http://www.unep.org/resourcepanel/>). It is currently co-chaired by Dr. Ernst Ulrich von Weiszäcker and Dr. Ashok Khosla and has twenty-four members from twenty-six countries. It is not constituted like the *Intergovernmental Panel on Climate Change* (IPCC) as an inter-*governmental* expert panel. Instead, it is a panel of experts funded by governments and UNEP that also has a Steering Committee made up of government representatives who consider the scientific reports of the Panel members, but without the requirement that reports must first be approved by the Steering Committee before they are published. The Steering Com-

1 The arguments presented in this chapter have been developed exclusively by the author and do not in any way reflect the views of the IRP, UNEP or individual members of the IRP.



H.G. Brauch et al. (eds.), *Handbook on Sustainability Transition and Sustainable Peace*,
Hexagon Series on Human and Environmental Security and Peace 10, DOI 10.1007/978-3-319-43884-9_17

mittee, however, does have the power to approve the initiation of reports. The Panel members come from a wide range of scientific disciplines and intellectual traditions, with some closely allied to their respective governments while others are thoroughly independent and even oppositional within their domestic policy environments.

The objectives of the International Resource Panel are to:

- provide independent, coherent and authoritative scientific assessments of policy relevance on the sustainable use of natural resources and their environmental impacts over the full life cycle;
- contribute to a better understanding of how to decouple economic growth rates from the rate of resource use and environmental degradation.

## 17.2 Contextualizing the Work of IRP

There is growing acceptance across a wide range of audiences that 'modern society' is currently facing historically unprecedented challenges. The advent of the 'Anthropocene' comes with an all-pervasive sense that landscape pressures like climate change, resource depletion and ecosystem breakdown threaten the conditions of existence of human life as we know it (Crutzen 2002). The onset of the global economic crisis in 2007/8 has resulted in a realization that we may have come to the end of the post-World War II long-term development cycle (Gore 2010; Swilling 2013b), and there is little understanding of what will come next. Simultaneously, there are those who argue that we may have reached a metabolic turning point that marks the endgame of the industrial era (Fischer-Kowalski 2011; German Advisory Council on Global Change 2011: 81; Haberl/Fisher-Kowalski/Krausmann et al. 2011). The result of these converging industrial and metabolic crises is an interregnum Edgar Morin has usefully called a 'polycrisis' (Morin 1999: 73).

Reflecting the thought patterns and influence of Schumpeterian long-wave theory (Foxon 2011; Freeman & Louca 2001; Köhler 2012; Perez 2002; Swilling 2013b), the *German Advisory Council on Global Change* (GACGC or WBGU) has argued that we should anticipate the third 'great transformation' comparable in its historical significance to the first two 'great transformations': the Neolithic revolution some 13,000 years ago and the industrial revolution some 250 years ago (German Advisory Council on Global Change 2011). Both can be defined as great transformations because they both resulted in fundamental shifts in the metabolic foundations of society: for the Neolithic transformation this entailed a shift to permanently occupied land, cultivated soils, harvested biomass, animal power, clay, rocks and the basic implements of pre-industrial agriculture; and then 250 years ago a shift to fossil fuels, metals, construction minerals and massive increases in biomass use and water use with the onset of the industrial revolution (Fischer-Kowalski/ Haberl 2007). For the GACGC, the third great transformation must be about radical decarbonization and resource efficiency to "provide wealth, stability and democracy within the planetary boundaries" (German Advisory Council on Global Change 2011: 81). However, all those who use long-wave theory recognize that these transitions are by no means linear and therefore cannot be easily predicted: they are highly complex processes that manifest differently across geographical scales and historical time. Key events can coalesce unexpectedly with accumulated macro-level structural shifts and the dynamics of conjunctural realignments to open up hitherto unlikely future trajectories.

It has been argued elsewhere that the year 2009 might be such a tipping point (Swilling 2013b): the collapse of Lehman Brothers at the end of 2008 was the key event, the conjunctural realignment was the ending of the post-World War II long-term development cycle (represented by the fact that 2009 was the first year since 1945 that the global economy shrank) and the structural shifts were reflected in the gradual realization that we could be breaching planetary boundaries in dangerous ways for human survival (marked by events such as the G20 adoption of the 'green economy' concept in 2009, following on from the awarding of the Nobel Prize to the IPCC, shock events like hurricane Katrina, heatwaves and economic shifts such as the rapid acceleration of investments in renewable energy technologies that were no longer confined to innovation niches).

Following Geels (2002), it is preferable to use the notion of 'transition' to describe these major metabolic shifts rather than the notion of 'transformation', on the understanding that it is specific transformations along the way that drive an overall transition. We can thus refer to a sustainability-oriented just transition as an alternative to the notion of a 'third great transformation' (Swilling/Annecke 2012), although these notions will be used interchangeably in this chapter.

Three conditions make this transition unique, only one of which is given sufficient emphasis by the GACGC Report. The first, recognized by the GACGC, is the fact that it is probably going to depend on the collective intent of specific constellations of actors who will need to collaborate at global, national and local levels. It is for this reason that the GACGC Report argues as follows:

"The imminent transition must gain momentum on the basis of the scientific findings and knowledge regarding the risks of continuation along the resource intensive development path based on fossil fuels, and shaped by policy-making to avoid the historical norm of a change in direction in response to crises and shocks" (German Advisory Council on Global Change 2011: 84).

This statement clearly defines the historic role of anticipatory science as key driver of the next great transformation (Poli 2014). This is why the work of the IRP, the IPCC, Future Earth and many other global scientific initiatives is significant. If they can contribute to the translation of anticipatory science into an anticipatory culture, then accumulated evidence about the risks we face and the potentials that can be exploited might just tilt the balance in favour of human survival (Poli 2014).

However, what needs greater emphasis is the implications of the *information and communication technology* (ICT) revolution that has transformed our organizational capabilities for learning and knowing—what Perez calls the fifth developmental surge that has taken place since the start of the industrial era (Perez 2009). Following Castells, just as the technologies of the combustion engine, electricity, telephony and mass production made possible the industrial revolution and its associated organizational arrangements (nation state, joint stock company, etc), so has the ICT revolution resulted in a new mode of organization, namely the network (Castells 2009). This new package of technologies and organizational modes has resulted in 'self-managed mass communications' with major implications for knowledge dissemination, innovation and collective action. For Brynjolfsson and McAffee, this provides the basis for the 'second machine age'—a new era of highly networked mutually interdependent activities that will unleash extraordinary creativity and productive potential (Brynjolfsson/McAffee 2014).

The internal informational recomposition of the industrial age that has taken place since the early 1970s has major implications for the anticipated sustainability-oriented transition. Following earlier work to address this question (Swilling 2013b), there is sufficient evidence that innovations made possible through network organization powered by ICTs will be stimulated by the financial returns that can be made by repairing the future of the planet (see discussion of Decoupling 2 below). If the 'second machine age' makes possible low carbon and resource-intensive modes of consumption and production, then a key driver of the third great transformation begins to come into view.

The third condition that makes this transition unique is the fact that we are living in an *urbanized* Anthropocene. The majority of the world's population now lives in cities and the next 2–2.5 billion people who are expected to be living on the planet by 2050 when the population is expected to hit the 9–9.5 billion mark will land up in African and Asian cities. Demographic projections suggest that we will be constructing in cities over the four decades to 2050 more material infrastructures than what we have built over the past 400 years (Angel 2012). This harsh spatial reality has major implications for how networks coalesce to rapidly translate anticipatory science into fundamental changes in the geographies of everyday consuming and producing. What remains almost certain is that these networks will not only emerge from the networks of innovation-oriented cities that are flowering around the world, they will also be using the challenges faced by cities as the laboratories for testing the technologies that will be deployed during the next great transformation.

The co-evolutionary dynamics of anticipatory science, the network mode of organization and learning made possible by the ICT revolution, and the reconfiguration of spaces of agglomeration caused by accelerated urbanization create conditions that make it possible to consider the end of the industrial epoch and how the long-term sustainability-oriented transition—or third great transformation—could emerge (Swilling/Annecke 2012). This provides the context for understanding the enormous significance of the rapidly expanding body of work that has been generated by the IRP since 2007. At the simplest level, the IRP is providing documented evidence across a range of fields that it is no longer possible to conceive of a future for modern society that rests on the assumption that there are unlimited resources available for ensuring the well-being of over nine billion people on a finite planet by 2050. In other words, the IRP is documenting the end of the industrial socio-metabolic era and by implication anticipates a more sustainable era in the future. However, the IRP has also put in place within the global policy community a way of thinking that is different to the two other mainstream bodies of sustainability science, namely climate science and ecosystem science. By thinking of sociotechnical and socio-economic systems as socio-metabolic systems that consume, transform and dispose of resources extracted from natural systems, the IRP has put in place a key conceptual framework for imagining the dimensions and modalities of a more sustainable epoch. The notion that we need to decouple economic development and well-being from the rising rate of resource consumption is potentially a very radical idea, especially if this implies massive reductions in resource use per capita for people living in rich countries and a redefinition of development for those policy-makers in poorer countries committed to poverty eradication. How we build a more equitable world of over nine billion people by 2050 without destroying the planet will not only depend on the mainstreaming of an appropriate political economy to replace neo-liberalism (Picketty 2014); it will also mean that a political economy that is appropriate for imagining the next great transformation will have to recognize that it will be necessary to fundamentally reconfigure the flow of non-renewable and renewable resources through our sociotechnical and socio-economic systems. When read together from the transition perspective outlined here, the research assessments generated by the IRP since 2007 provide a significant starting point and partial foundation for achieving such a synthesis.

## 17.3 Overview of the Work of the IRP

Unlike the IPCC, the IRP does not produce an integrated report at specific points in time. Instead, the IRP publishes reports as and when they have been produced by one or more members of the IRP and their respective research teams. This means there is no integrated synthesis of the IRP's body of knowledge. For the purposes of this chapter, the work of the panel has been divided into the following categories:[2]

- *global resource perspectives*, with special reference to decoupling rates of economic growth from rates of resource use by focusing on the importance of resource productivity (Decoupling 1 and Decoupling 2), the environmental impacts of products and materials, and the beginnings of scenario thinking;
- *nexus themes*, including cities, food, trade, and *greenhouse gas* (GHG) mitigation technologies;
- *specific resource challenges* with respect to two clusters of issues, namely metals (both stocks in use and recycling) and ecosystem services (including water and land-use/soils).[3]

The global resource perspectives define the IRP's commitment to focus on the resource inputs into the global economy, and therefore how future economic trajectories (whether growth-oriented or not) can be decoupled from the prevailing rising level of resource use over time. Without this kind of decoupling, a transition will be unlikely. Nexus themes are about specific spheres of action constituted by highly complex sociotechnical systems where the potential for decoupling exists. Specific resource challenges are about resource regimes that are both under threat from, for example, rising demand and prices, and can also be potential threats to larger systems that are dependent on them.

## 17.4 Global Resource Perspectives

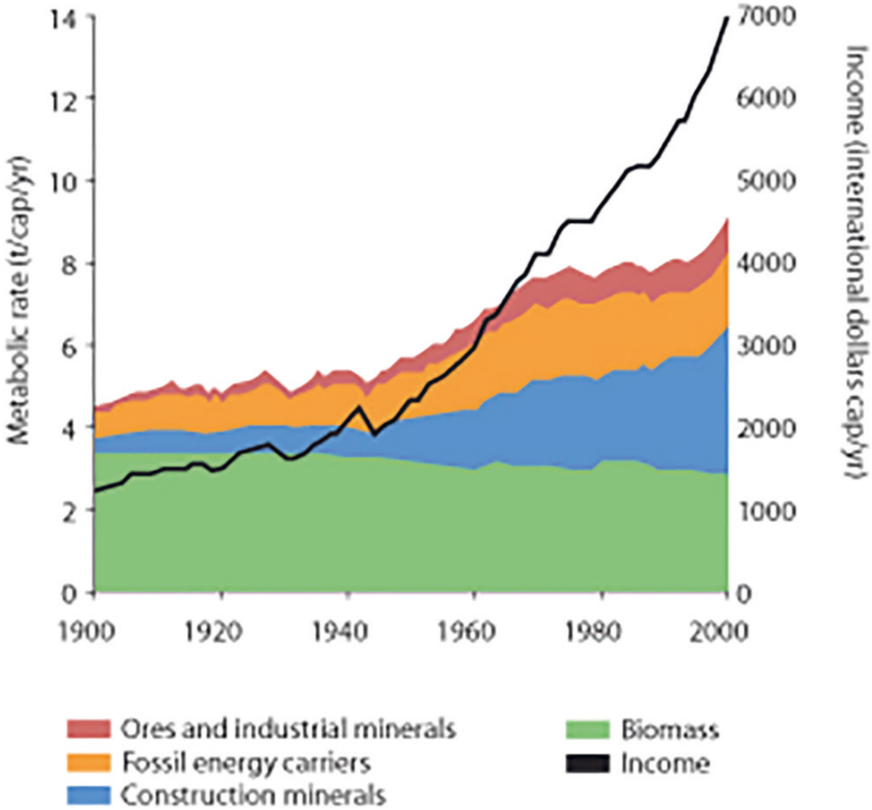
The environmental science of pollution, climate science and ecosystem science have traditionally been the three underlying bodies of science that have supported the claims of the environmental movement. In recent years material flow analysis has emerged as the fourth body of science, with roots in industrial ecology, resource economics and political economy (Fischer-Kowalski 1998, 1999). Major historical reinterpretations of agricultural and industrial economic transitions have now been written that are clearly extremely useful for anticipating the dynamics of future transitions (Fischer-Kowalski/Haberl 2007; Giampietro/Mayumi/Sorman 2012; Smil 2014). The focus has shifted from the negative environmental impacts of the outputs of industrial processes to the material inputs into a global economy that depends on a finite set of material resources. This is the discursive framework within which the work of the IRP should be located.

One of the first reports produced by the IRP (generally referred to as 'Decoupling 1') entitled *Decoupling Natural Resource Use and Environmental Impacts from Economic Growth* presented evidence on the use of four categories of resources: biomass (everything from agricultural products, to clothing

2 All completed reports referred to below are available on the IRP website at: <http://www.unep.org/ resourcepanel/>.

3 The IRP has also produced reports on biofuels and forests, but these have not been included in this analysis.

**Figure 17.1:** Global metabolic rates and incomes (1900–2005), and income. **Source:** Fischer-Kowalski and Swilling (2011: 12).




material like cotton, to forest products), fossil fuels (oil, coal and gas), construction minerals (cement, building sand, etc.) and ores and industrial minerals (Fischer-Kowalski/Swilling 2011). The Decoupling 1 Report shows that by the start of the twenty-first century the global economy consumed between 47 and 59 billion metric tons of resources (which is equal to half what is physically extracted from the crust of the earth). Between 1900 and 2005 total material extraction increased over this period by a factor of 8, while GDP increased by a factor of 23 for the same period. As reflected in figure 17.1, the result is relative decoupling between rates of resource use and global growth rates.

As the Decoupling 1 Report shows, rising global resource use during the course of the twentieth century (including the metabolic shift that took place from mid-century onwards as non-renewables grew and dependence on renewable biomass declined in relative terms) corresponded with declining real resource prices—a trend that came to an end in 2000–2002. Since 2000–2002, the macro-trend in real resource prices has been upwards (notwithstanding dips along the way).

The McKinsey Global Institute report (which was published after the IRP report) generally confirms the trends identified by the Decoupling 1 Report, demonstrating that resource prices have increased by 147 per cent in the decade since 2000. As a result investments in resource productivity over the long-term can generate returns of 10 per cent, more if the US$1.1 trillion "resource subsidies" are removed (McKinsey Global Institute 2011).

A key conclusion of the Decoupling 1 Report is that a transition to a more sustainable global economy will depend on absolute resource reduction in the developed world, and relative decoupling of economic growth rates from rates of resource use in the developing world. If this is not achieved, the Report argues, the result may well be an increase in total resource use from 60 *billion tonnes* (Bt) in 2005 to 140 Bt by 2050 if all nine billion people living on the planet by then consume the equivalent of the average European (i.e. 16 *tonnes per annum per capita* (t/cap), which is half what the average American con-

**Figure 17.2:** Composite resource price index (at constant prices, 1900–2000). **Source**: United States Geological Survey data cited in Fischer-Kowalski and Swilling (2011: 13).

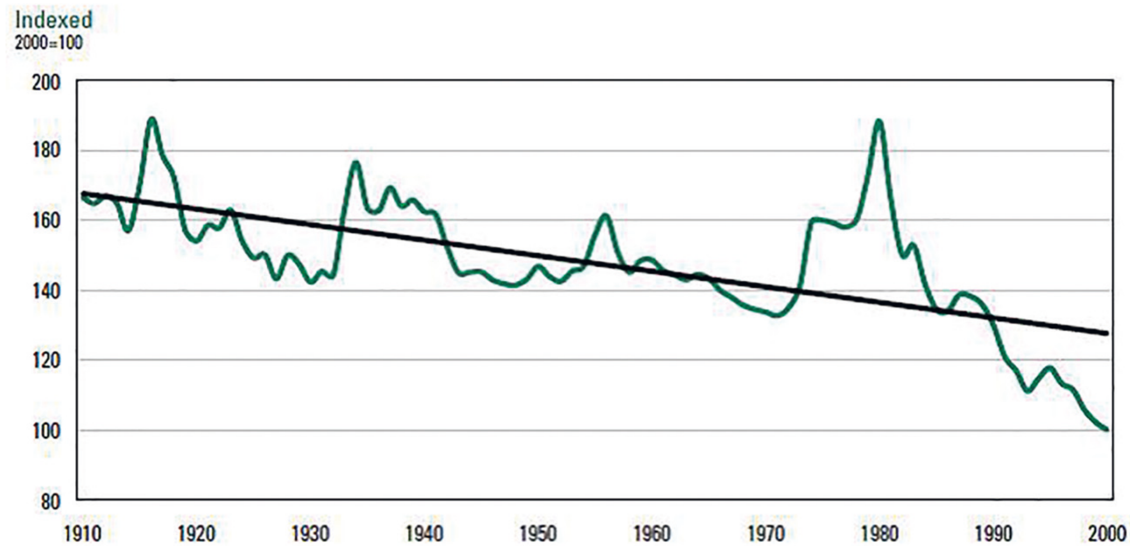
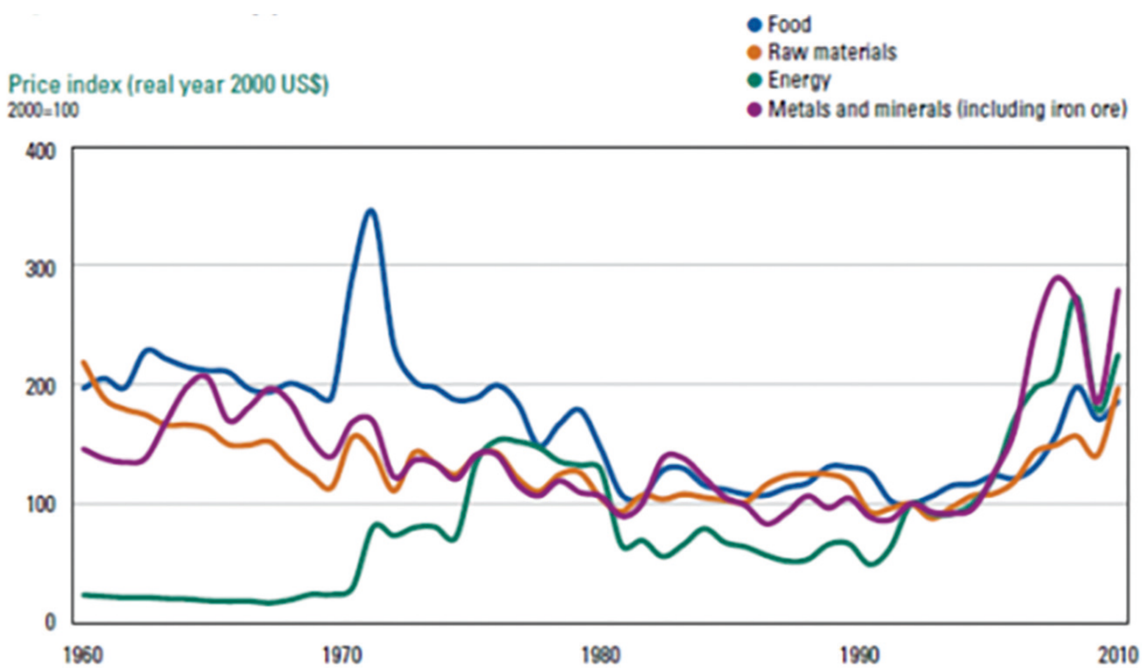



**Figure 17.3:** Commodity price indices. **Source**: Fischer-Kowalski and Swilling (2011: 13).




sumes). However, if the convergence point is 8 t/cap, the total material requirement would be 70 Bt by 2050 on a planet of nine billion people. The Decoupling 1 Report suggests that the material equivalent of living in ways that will result in the emission of 2 tonnes of $CO_2$ per annum per capita by 2050 on a planet of nine billion people (as recommended by the IPCC) may well be 60 Bt or 6 t/cap for everyone. Although the latter is the logical consequence of the science of the IPCC that all countries approved, it implies a 'great transformation' equal in significance to the metabolic transformations that resulted in the Neolithic and Industrial Revolutions.

Reinforcing the argument of the Decoupling 1 Report, another early IRP report entitled *Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials* (referred to as the Priority Materials Report) addressed key ques-

**Figure 17.4:** Major contributors to global GHG emissions, including land use and land cover change (measures in CO2 eqivalents using a 100 year global warming potential).**Source**: UNEP (2010).

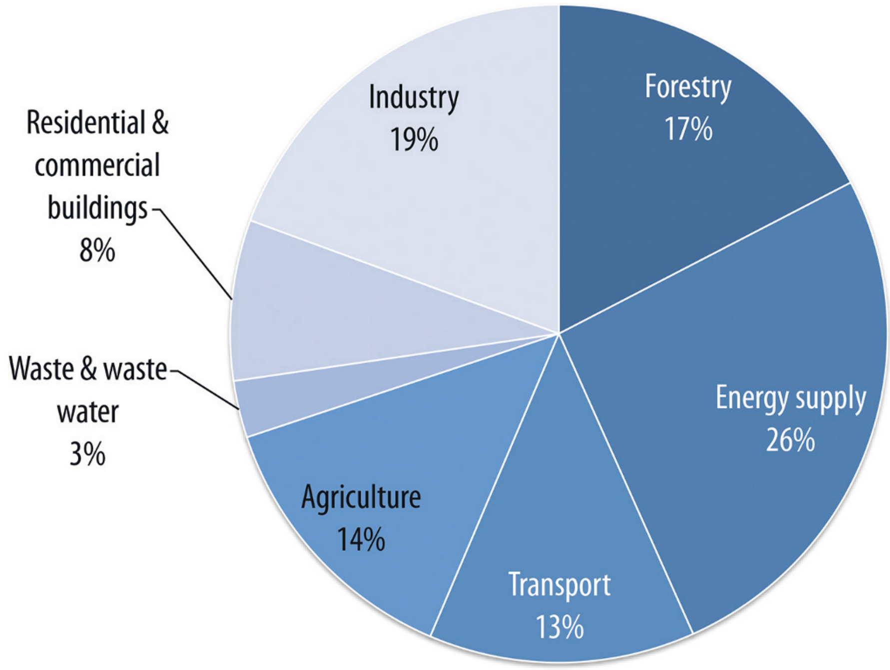
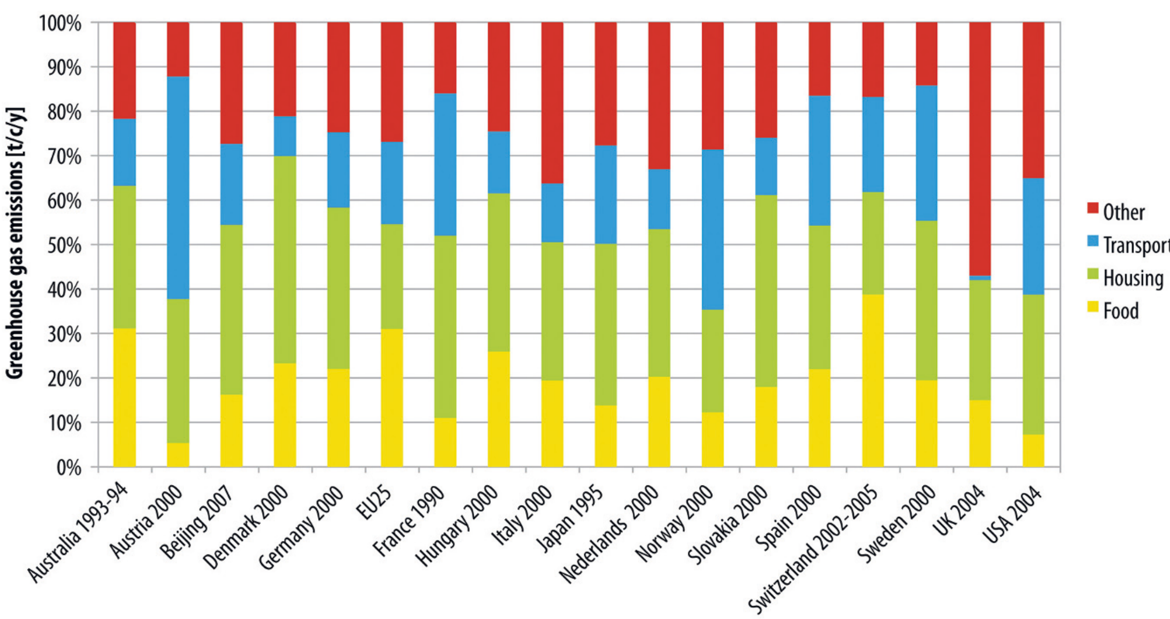


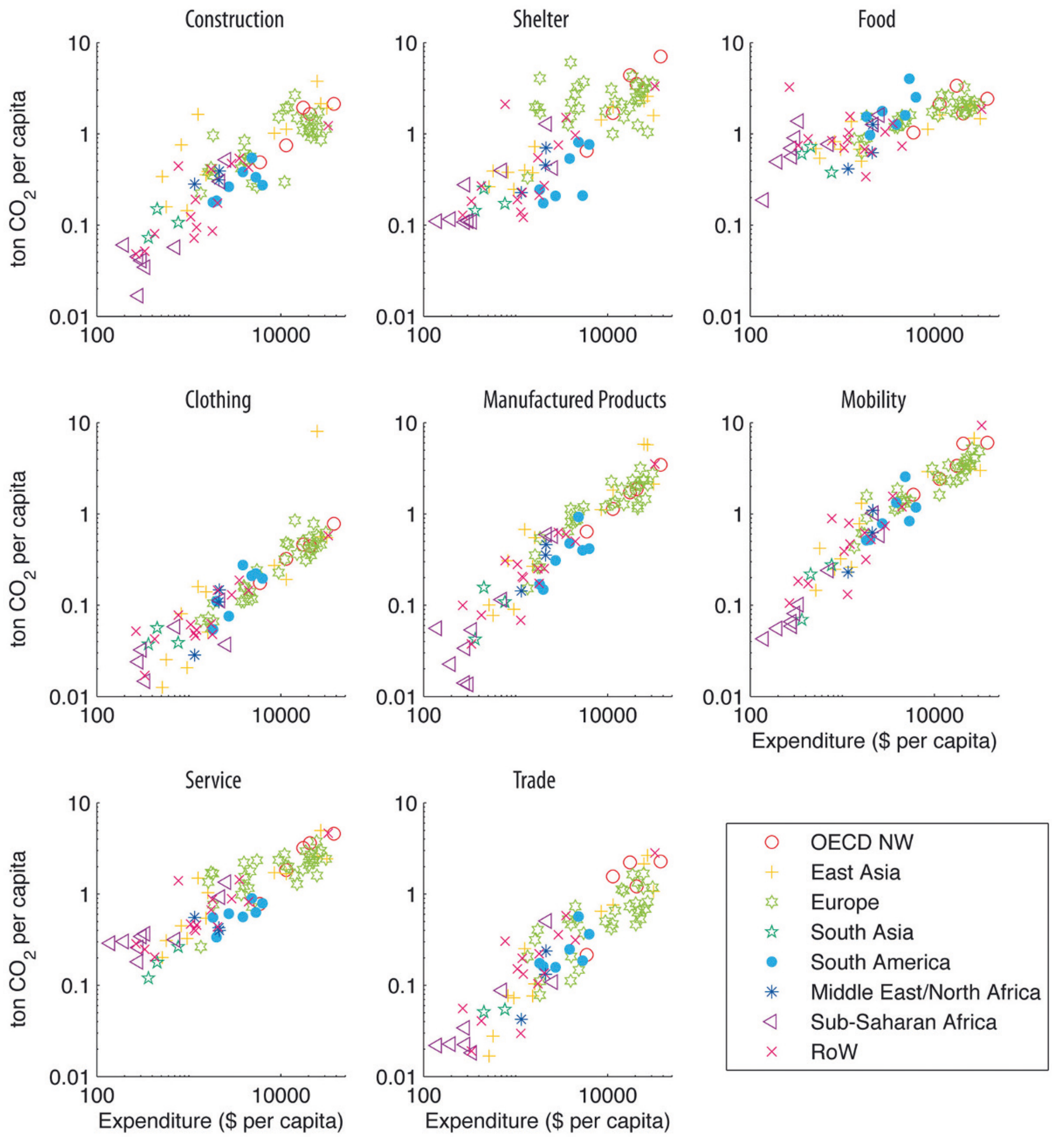

**Figure 17.5:** Distribution of energy use across consumption categories, as identified in different studies, and total energy use measures in kW per capita. **Source**: UNEP (2010).




tions of relevance to this review, only three of which are addressed here: Which industries are the most responsible for contributing to environmental and resource pressures? What products and services have the greatest environmental impacts? Which materials have the greatest environmental impacts across their respective life cycles? (UNEP 2010)

As indicated in figure 17.4 and related information in the Priority Materials Report, the energy industry, followed by industry and forestry (through deforesta-

**Figure 17.6:** Carbon Footprint of different consumption categories (tonnes of CO2 Equivalents per capita in 2001) in 87 countries/regions as a function of expenditure ($ per capita). **Source**: UNEP (2010).




tion), are the greatest contributors to climate change, abiotic resource depletion, and sometimes eutrophication, acidification and toxicity.

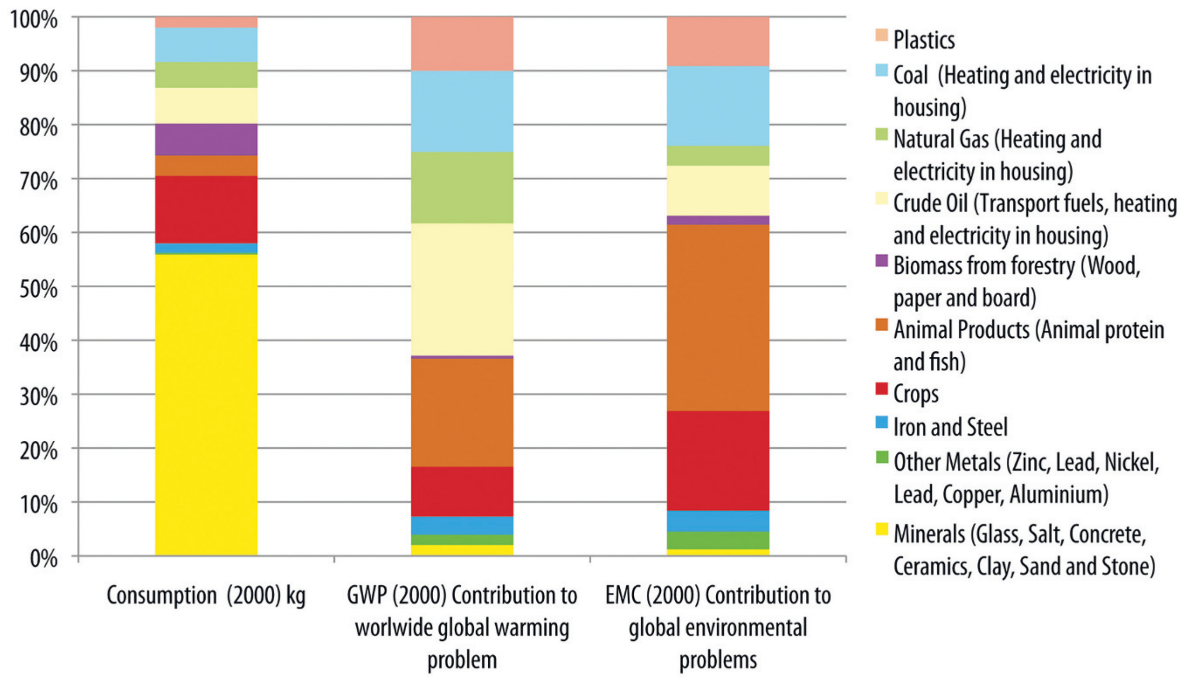
As far as consumption is concerned, the Report shows that transport, housing and food are responsible for 60 per cent of all impacts (see figure 17.5). Given that these are overwhelmingly configured by urban systems, this prioritization reinforces the argument of the City-Level Decoupling Report (discussed later) that interventions that address these priorities will have to take into account their spatial contextuality.

However, even more important is the unsurprising fact that as incomes go up so do the enviromental impacts. Figure 17.6 clearly shows that there is no decoupling when it comes to rising incomes and related environmental impacts.

As far as the environmental impacts of materials are concerned, the Priority Materials Report shows that animal products, fossil fuels and key metals (iron, steel and aluminium) have the greatest impacts. However, only integrated data for Europe exists.

The first bar in figure 17.7 shows resource use in kilograms per capita, while the second and third show the environmental impacts weighted according to their environmental impacts over the life cycle (the so-called *environmentally-weighted material consumption*, EMC). The second gives the EMC for the *global*

**Figure 17.7:** Normalized global warming potential of material flows and *Environmentally weighted Material Consumption* (EMC) for EU-27+1 region. **Source**: UNEP (2010).




*warming potential* (GWP), while the third adds up a large number of environmental impact categories such as global warming, acidification, land use competition plus others with equal weightings.

The *Priority Materials Report* concludes that future economic growth and development on a business-as-usual basis will exacerbate these trends. The impact of fossil fuels and agricultural activities are seen as the top two priorities that must be addressed if a transition to a more sustainable order is to be achieved.

In a follow-up to the Decoupling 1 Report, the IRP report entitled *Decoupling 2: Technologies Opportunities and Policy Options* (launched at Green Week, Brussels, in June 2014) argued that there are three types of decoupling (UNEP 2014):

- decoupling through maturation: found mainly in developed countries, this is a natural process caused by saturated demand, levelling off or even decline of populations, minimal new construction and a shift towards services;
- decoupling through burden shifting to other countries: by off-shoring the resource extraction and related impacts to other countries and then excluding this reality from material use calculations, it is possible for many countries to create the appearance of decoupling–in reality, as recent research has shown, if the ecological rucksacks are attributed to the consumer and not producer, this apparent decoupling disappears (Wiedman/Schandl/Lenzen et al. 2013);
- decoupling by intentionally improving resource productivity: as a "paradigm shift", this type of decoupling "requires technological and institutional innovations, resource-efficient infrastructure, low-material-intensity manufacturing, public awareness and appropriate attitudes and behaviours" (UNEP 2014:5).

The Decoupling 2 Report demonstrated that since 2000 metal prices have risen by 176%, rubber by 350%, energy by 260% and food by 22.4% (with some projecting an increase for food of 120–180% by 2030). Demand for water by 2030 is expected to have risen by 40%, exceeding existing capacity by 60%. Possibly even more important than price increases is price volatility and related supply shocks (UNEP 2014). The Decoupling 2 Report documents a wide range of emerging alternatives that are made possible by these price increases and argues the case for replicating radical resource productivity improvement on a global scale. Many examples are provided, including the potential to reduce energy and water demand in developed economies by 50–80% using existing energy and water efficiency technologies; how developing countries investing in new energy infrastructure could reduce energy demand by half over the next twelve years if energy efficiency and renewable energy technologies were adopted now rather than later; and that decoupling technologies could result in resource savings equal to US$2.9 to 3.7 trillion each year until 2030 if the policy, regulatory and technological innovations are put in place (UNEP 2014).

The most significant contribution of the Decoupling 2 Report is the suggestion that radical resource productivity can be achieved by introducing a resource tax system that is used to gradually and incrementally increase real resource prices over the long term. This tax could be used to ameliorate rising prices when these occur, and to counteract declining resource prices when these occur, thus providing the market with a level of certainty over the long term. This is crucial for counteracting what is inevitably going to happen if nothing of this kind is done, namely increasing price volatility that will tend to reinforce short-term investment perspectives with limited investment in innovation. Long-term innovation-driven investments will not thrive if prices remain volatile.

Informed by the thinking reflected in the above Reports and what has emerged in the nexus and specific resource challenge reports, during the course of 2013 and 2014 IRP member Professor Tom Graedel led a group that has started to consider the formulation of future scenarios. The group has decided to adopt the GEO 4 scenarios that will be used to frame future resource use storylines. These scenarios are as follows:

- markets first—a "business-as-usual" scenario;
- policy first—a "make the world greener" scenario;
- security first—an isolationist scenario of rising social, environmental, and economic tension;
- sustainability first—a new environment and development paradigm with more equitable outcomes and institutions that is, in effect, consistent with GACGC's 'third great transformation'.

If the IRP succeeds in integrating the various strands of its work into some credible scenarios using the GEO4 (or similarly well-accepted) storylines, this will contribute a new perspective to the already cluttered scenario-building scene. More importantly, it will help to bring the IRP's research firmly into the realm of the emerging science of anticipation (Poli 2014).

## 17.5 Nexus Themes

Each nexus theme can be defined as a complex of interrelated resource use and environmental impact issues that can be analysed by reference to a particular cross-cutting process. Cities concentrate in space in particular context-specific ways all the resource use and environmental impact issues addressed by the general global reports discussed in the previous section. Food systems are globally, regionally and locally constituted in ways that connect incredibly complex flows of nutrients, energy, water, wastes and materials. Trade is about the global flows of resources and their associated ecological rucksacks that can be attributed to the producing or consuming countries with drastically differing results. And GHG mitigation technologies are massive composites that require energy and resource inputs that are intended to produce lower carbon and more resource-efficient outputs. Although the IRP's work on these nexus themes is discussed below, only the report on cities had been published at the time of writing. This may mean the other nexus themes are dealt with more superficially.

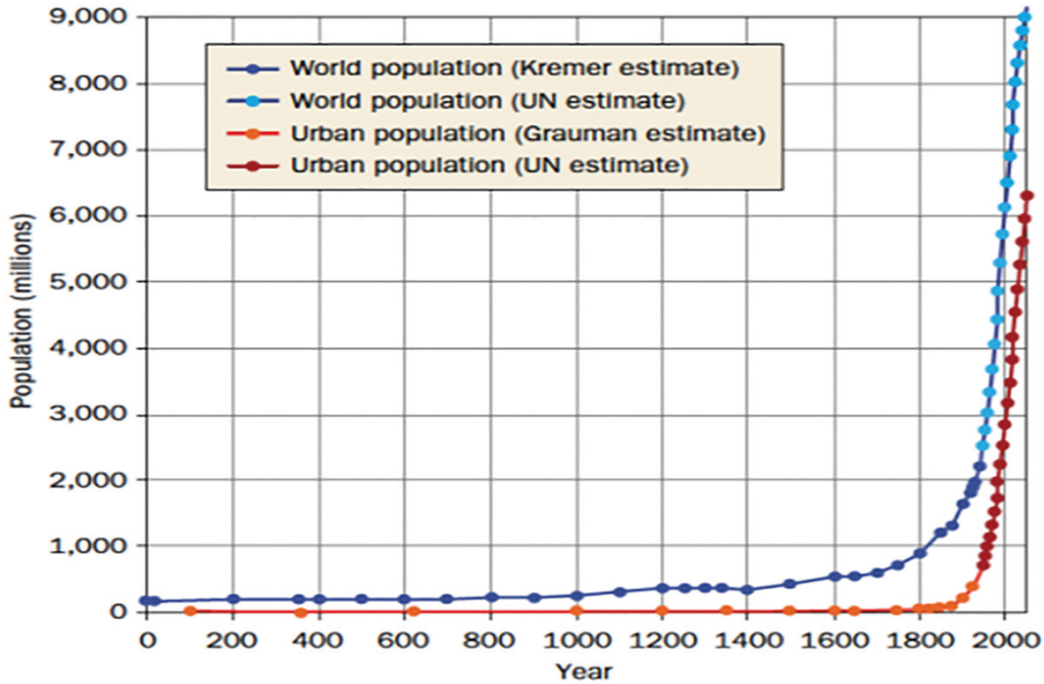
### 17.5.1 City-Level Decoupling

The main aim of the Cities Working Group of the IRP is to apply the insights generated by the new literature on urban metabolism (Barles 2009; Barles 2010; Costa/Marchettini/Facchini, 2004; Farrao/Fernandez 2013; Heynen/Kaika/Swyngedouw 2006; Kennedy/Pincetl/ Bunje 2011; Ramaswami/Weible/Main et al. 2012; for the most comprehensive overview of the literature see Robinson/Musango/Swilling et al. 2013; Swilling/Robinson/ Marvin et al. 2013; Swyngedouw 2006; Weisz/Steinberger 2010) to the challenge of designing, building and operating more sustainable urban infrastructures.

The first urbanization wave took place between 1750 and 1950, and resulted in the urbanization of about 400 million people in what is now the developed world. The second urbanization wave between 1950 and 2030 is expected to result in the urbanization of close to four billion people in the developing world in less than a century. By 2007 just over fifty per cent of the global population lived in cities. Hence we should be talking about the 'urban Anthropocene'.

Based on UN population data for 1950–2050 (Department of Economic and Social Affairs, United Nations 2012), the total global urban population is expected to increase from 3.5 billion in 2010 (of which 73 per cent were in cities in developing countries) to 7.3 billion in 2050 (by which time 83 per cent will be living in cities in developing countries). This means that by 2010 the global process of urbanization that began in earnest in 1800 (see figure 17.8) had only

**Figure 17.8:** World Population and Urban Growth Trends (0-2010). **Source**: Angel (2012).




resulted in the urbanization of 48 per cent of households that are expected to live in cities by 2050.

Furthermore, according to the groundbreaking UN Habitat report *Challenge of Slums* (United Nations Centre for Human Settlements 2003), of the 3.5 billion who were living in cities by 2010, one billion lived in slums. In other words, 210 years of urbanization had created a decent quality of life for only two-thirds of all urban dwellers. Resolving this problem must, therefore, be seen as integral to a just urban transition by 2050.

It follows, therefore, that 52 per cent of the urban fabric that is expected to exist by 2050 must still happen over the four decades to 2050. The significant proportion of the additional urban population of nearly four billion people will end up in developing country cities, in particular Asian and African cities. If we include the one billion people who live in slums, then it follows that material infrastructures of one kind or another will need to be assembled for an additional five billion new urban dwellers by 2050.

This raises an obvious and vitally important question: what will the resource requirements of future urbanization be if business-as-usual sociotechnical systems are deployed to assemble built environments? What are the resource implications of more sustainable sociotechnical systems? Unfortunately, no one has attempted to answer these questions yet, which is why the IRP decided at its meeting Santiago in May 2014 to approve a study by its Cities Working Group that aims to address these questions.

This new study will build on the first IRP Report on cities entitled *City-Level Decoupling: Urban Resource Flows and the Governance of Infrastructure Transitions* (referred to as the City Decoupling Report) (Swilling/Robinson/Marvin et al. 2013). Noting the proliferation of reports on sustainability in cities, the core argument of this Report was that insufficient attention was paid in these reports and in the academic literature to the strategic importance of urban infrastructures. It was noted that urban infrastructures conduct resource flows (e.g. energy, waste, water and sanitation) through urban systems. It follows, therefore, that in order to transition from linear unsustainable urban metabolisms to more circular sustainable urban metabolisms it will be necessary to reconfigure urban infrastructures.

Thirty case studies of urban infrastructure transitions across all world regions were documented in order to demonstrate that there is plenty of evidence that various initiatives are under way. Furthermore, it was noted that intermediaries play a crucial role as facilitators of change. *Global technology companies* (GTCs) have emerged as new major players within the urban policy space. Companies like IBM, Siemens, Cisco, Altech and others have all mounted 'smart city' programmes, with Songdo city in South Korea the poster child for what this means in practice

(Kuecker 2013). The last time public discourse was inundated with visions of grand city-wide transformations was in the late 1800s with respect to sanitation infrastructure and in the post-World War I period during the lead-up to the highway construction programme that transformed cities around the world (Hajer/Dassen 2014). The result today is the promotion of massive global escalations in investments in urban infrastructures in cities in both developed and developing countries, sometimes but not always within a 'smart city' framework (Airoldi/Biscarini/Saracina 2010; Doshi/Schulam/Gabaldon 2007; Siemens/PWC/Berwin Leighton Paisne 2014; World Business Council for Sustainable Development 2014). The algorithmic urbanism promoted by the GTCs holds many dangers, including the consolidation of new wealth-based digital divides and greenwashing (Hajer 2014; Luque/ Marvin/ McFarlane 2013).

Unfortunately, very little data were available about the metabolic flows before and after a given intervention. The City Decoupling Report therefore concluded that in order to assess whether urban infrastructure innovations do, indeed, result in more sustainable outcomes it would be necessary in future to use the tools of urban metabolic flow analysis in combination with systems dynamics modelling. These tools will make it possible to evaluate and, therefore, model the effect of a given set of sociotechnical innovations at two levels: at the level of design with respect to a given sectorial intervention (e.g. a public transit system or sewage treatment plant) and at the level of city-wide planning with respect to the overall resource productivity of the entire urban system.

Given that over fifty per cent of the global population now lives in cities and given the extent of future urban growth, retrofitting and building new urban infrastructures that reproduce sustainable urban metabolisms may well be the single most important driver of the third great transformation.

### 17.5.2 GHG Mitigation Technologies

Given that the energy transition is going to be the most important driver of the third great transformation, it follows that more needs to be known about the environmental implications of the suite of renewable energy technologies that are regarded as the cornerstone of this transition. In a draft highly-detailed 500-page report entitled *Green Energy Choices: The Benefits, Risks and Trade-offs of Low-Carbon Technologies for Electricity Production* (referred to as the Green Energy Report) the following technologies were assessed using Life Cycle Assessment: wind power, hydropower, *photovoltaics* (PV), *concentrated solar power* (CSP), geothermal power, *natural gas combined cycle power* (GCCP) with and without CO2 *capture and storage* (CCS), and coal-fired power with and without CCS (Hertwich/Gibon/Arveson et al. 2015).[4] Bioenergy, nuclear energy, oil-fired power plants and ocean energy were not assessed.

The Green Energy Report found that wind, PV, CSP, hydro and geothermal power generate GHG emissions over the life cycle of less than 50gCO2e/kWh. This compares favourably to coal-fired power plants that generate 800–1,000gCO2e/kWh over the life cycle and GCCP (without CCS) that generates 500–600gCO2e/kWh over the life cycle. CCS can reduce emissions of fossil power plants by only 200–300gCO2e/kWh. As far as pollution and related health impacts are concerned, renewables reduce impacts by seventy to ninety per cent. Similarly, impacts of renewables on ecosystems are a factor of three to ten lower than fossil power plants (Hertwich/Gibon/Arveson et al. 2015).

By contrast, the Report shows, a global transition to renewables (with some GCCP for peak loading and some coal power plants) would require an increased use of steel, cement and copper in comparison to the continuation of the business-as-usual fossil-fuel-based system. Furthermore, renewables depend on various rare earth metals like indium and tellurium, as well as silver (Hertwich/Gibon/Arveson et al. 2015). There is no consensus in the literature on the security of supply of these materials. However, their concentration in China is well known.

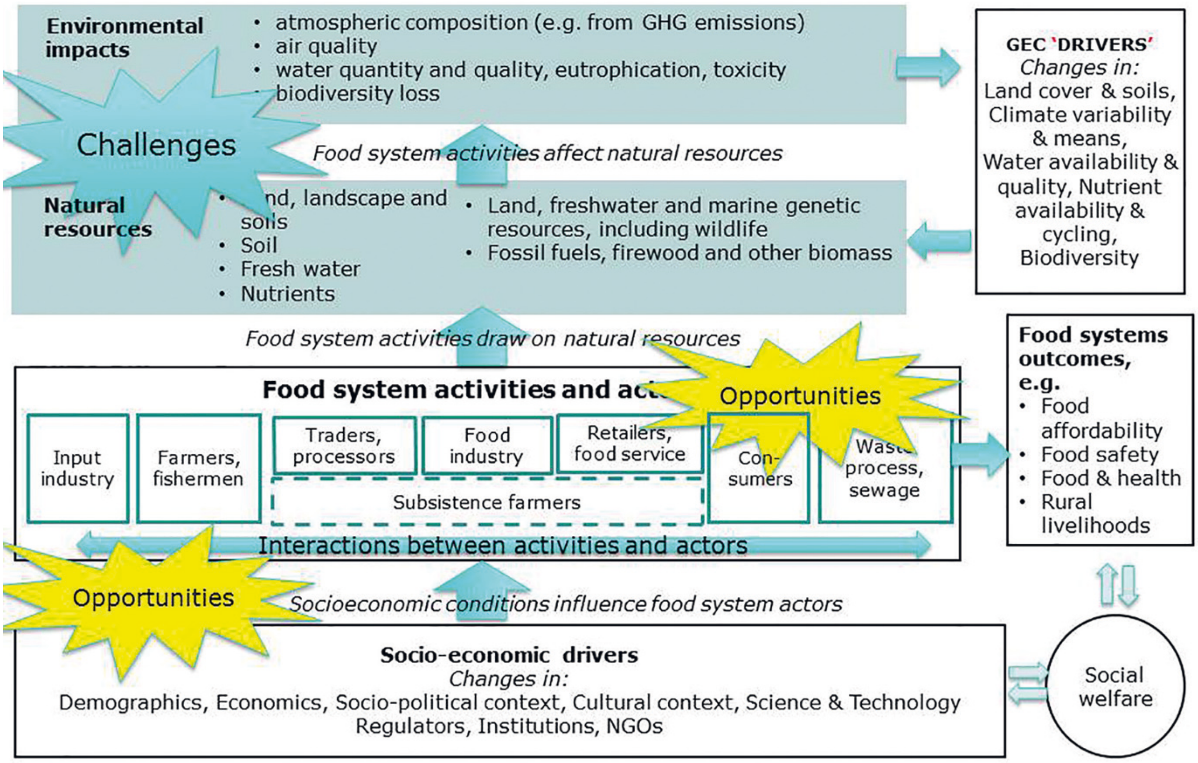
In short, from a purely technical perspective (which of course ignores institutional change, financing and learning) the environmental impacts of renewables are substantially reduced compared to fossil-fuel-based energy supply. However, the resource inputs with respect to steel, cement and copper may be greater if alternative technologies for these aspects of the clean energy infrastructure are not found. Increased requirements of bulk materials such as steel, cement and copper can easily be met with current production rates.

### 17.5.3 Food Systems

As argued by the *Priority Materials* Report, the food system is a major user of resources and a major con-

4 Note that at the time of writing this report had not gone through the UNEP peer-review process.

**Figure 17.9:** Conceptual Framework: Food Systems and Natural Resources. **Source**: Hajer, Westhoek, Ozay et al. (2015: 12.




tributor to negative environmental impacts. Food systems are highly complex global-local systems that are currently in deep crisis as several long-term megatrends accumulate into a perfect storm. Breaking from the dominant tendency to see food insecurity as a problem of production, the Food Working Group of the IRP adopts a food system perspective that, in turn, makes it possible to see food insecurity as a direct and persistent symptom of a flawed global food system (Hajer/Westhoek/Ozay et al. 2015). Food security is defined as a situation where all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life (Food and Agriculture Organization 1996). Considered in terms of the distribution of dietary energy supply, 868 million people around the world were considered chronically undernourished in 2013 (FAO 2013: ix). In addition, a further two billion people experienced the negative health consequences of micronutrient deficiencies (FAO et al. 2012: 4). About 850 million of the people estimated to be undernourished live in developing countries (FAO A/B et al. 2012: 8). Food insecurity is one of the key indicators of a system incapable of responding to the pressures that it faces. The capacity of the food system to ensure food availability and thus food security is shaped by a wide variety of factors, but the increase in population, urbanization and improved welfare are the most important (Food and Agriculture Organization 2013: ix) drivers of food system change. The conceptual framework captured in figure 17.9 represents this complex set of actors and networks.

The IRP's report on the food system essentially mounts the following argument (Hajer/Westhoek/Ozay et al. 2015). The global food system is now dominated by large-scale modern systems that have replaced localized family-farm-based food economies with large-scale globalized processing and retail activities, long value chains, regulatory standards and transnational companies. One result of neo-liberalization since the 1980s has been the shift in food governance from largely localized upstream governance systems to the big global downstream players, in particular the food processors and retailers. The result is that the food system is now primarily configured for short-term profit rather than the long-term continuity of farming systems and the ecosystems they used to depend on. Global and national governance systems tend to reinforce this orientation because it is perceived to be more 'efficient'. As a result concentration in the off-farm sectors of the food value chain are high and rising: the three largest seed companies control 50 per cent of the market; the top ten agro-processors have 28 per cent of market share; and the top ten food retailers control 10 per cent of the market. It is this shift in power that is contested by the agro-ecological movements who want a return to local food bio-economies where sufficiency ensures the long-term sustainability of the underlying ecosystems.

The Food System Report goes on to argue that population growth, urbanization and improved welfare imply a ten per cent increase in food demand by 2025, with the fastest growth in demand taking place where logistical infrastructures are weakest. Given that urbanization and economic growth in developing countries implies an expanding middle class, a nutrition transition is under way from calorie-rich diets (cereals) to energy-rich diets (meat, vegetable oils and sugars). Energy-rich food requires far greater natural resource inputs, including the fact that instead of being consumed directly by humans grains are used as inputs for livestock production. This, in turn, increases the demand for land for cereal production and grazing. Furthermore, now that supermarkets have become the dominant food delivery systems in all regions where middle-class consumers are significant, energy-rich food is transported over longer distances, requires more packaging and depends on vast globally structured networks of interconnected specialized companies and value chains. The combined impact of these processes includes soil degradation as land is overexploited, depletion of acquifers and fish stocks, eutrophication due to nutrient losses (rising by twenty per cent over the next forty years) and diminished biodiversity. Climate change is expected to reduce crop production in key regions of the world (Hajer/Westhoek/Ozay et al. 2015).

The Food System Report concludes that there are significant opportunities to increase resource use efficiency in the food system, while simultaneously reducing environmental impacts. On the supply side, important options include increasing yields in certain low-yield regions with higher potential using a more balanced mixed of natural resources (including agro-ecological systems and higher input of minerals), leading to an increase in the output per unit of land, water and human labour; increased nutrient use efficiency in the food chain, and consequent reduction of nutrient losses to the environment; development of resource efficient aquaculture systems; and sustainable land and water management using agro-ecological approaches. On the demand side, the two key strategies would be reduction of food losses and wastes, and a shift to less resource-intensive diets, especially in regions with 'western' diets, by lowering the consumption of meat, dairy and eggs (Hajer/Westhoek/Ozay et al. 2015).

### 17.5.4 Trade

The core question of the *International Trade in Resources* report (referred to as the Trade Report) (Fischer-Kowalski/Dittrich/ Eisenmenger et al. 2015) is whether or not the global trading system contributes to greater resource efficiency and diminished environmental impacts.

The Trade Report clearly shows that although trade in volume increased by a factor of 2.5 between 1980 and 2010, trade measured in monetary terms increased dramatically to twenty-eight per cent of global GDP in 2010. Fifteen per cent of all extracted materials are traded internationally. The Report argues that while incentivizing increased extraction, one key result was increased financial revenues for poor resource-rich countries that rapidly became major exporters. In theory this should have positive developmental consequences that would need to be weighed against the environmental costs; however, as Collier has argued, in reality the more dependent on resource rents economies become the less likely they are to have the governance mechanisms to translate resource rents into developmental benefits—a dynamic known as the resource curse (Collier 2010).

The Trade Report goes on to argue that a closer look at physical trade (see figure 17.10) reveals that the total volume of materials traded between 1980 and 2010 more than doubled, with fossil fuels making up around fifty per cent of the total volume traded. However, reflecting the levelling-off of oil production and trade globally since 2005 (Murray/King 2012), growth rates in trade in oil have declined since 2005.

Figure 17.11, sourced from the Trade Report, reflects who the largest exporters and importers were in 2010. Representing a shift from twentieth-century trends, by 2010 only thirty per cent of all countries were net material suppliers while seventy per cent of all countries had become net importers—and now this was not neatly split along North-South lines. South American countries, Scandinavia, and west and central Asian countries, together with Canada, Australia and the south-east Asian islands, have become the largest suppliers of materials. The largest importers were the US, Japan and Western Europe.

**Figure 17.10:** Physical trade according to material composition (1980-2010). **Source**: Fischer-Kowalski, Dittrich, Eisenmenger et al. (2015).

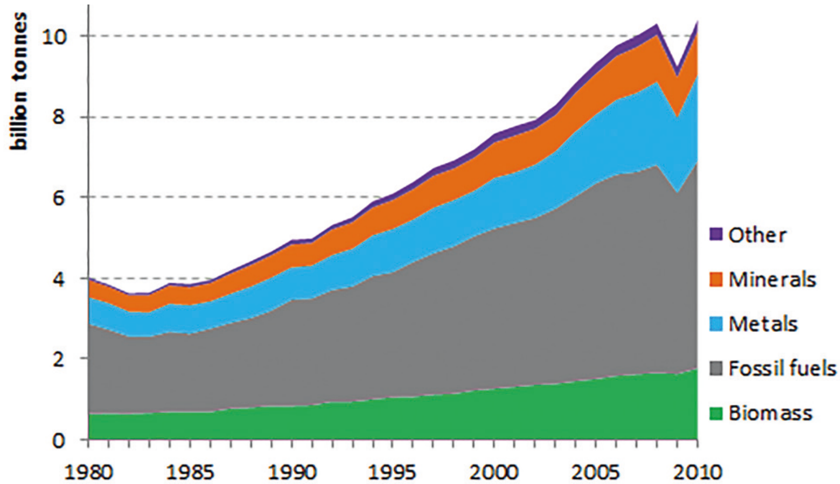
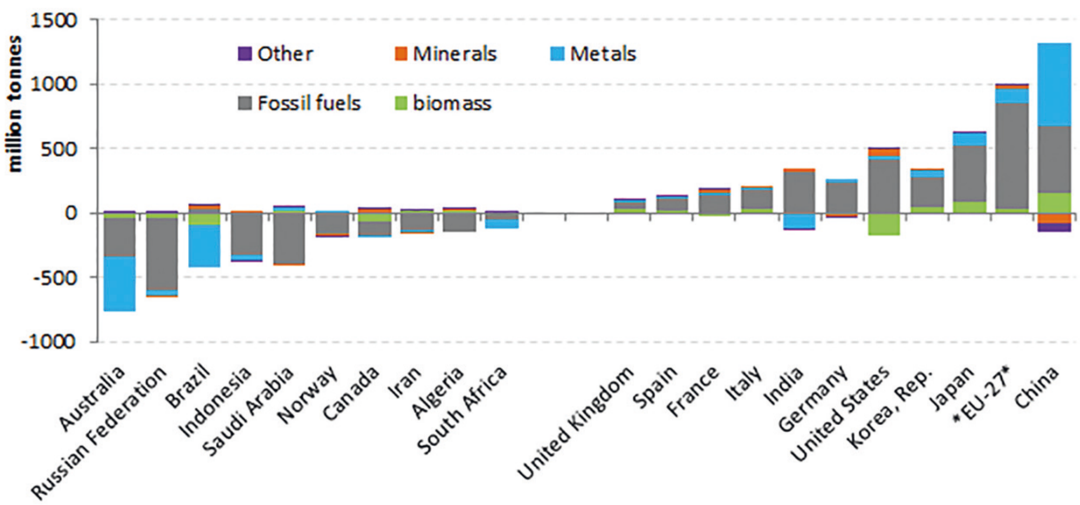



**Figure 17.11:** Largest net exporters and importers by material composition of net trade in 2010. **Source**: Fischer-Kowalski, Dittrich,Eisenmenger et al. (2015).




The strategic significance of the mode of analysis in the Trade Report is that it adds another perspective to the assumptions made in the Decoupling 1 Report. Using calculations of 'domestic material extraction' (domestic extraction minus exports plus imports), Decoupling 1 effectively employed a producer perspective that allocated the ecological rucksack (i.e. materials used to produce exports) of imported goods to the exporting country. If, however, the ecological rucksack is attributed to the importing country, apparent decoupling by burden shifting is no longer possible (Wiedman/Schandl/Lenzen et al. 2013). Indeed, Wiedman, Schandl, Lenzen et al. (2013) calculated that forty per cent of the resources extracted were used to enable the exports of goods and services to other countries (Wiedman/Schandl/Lenzen et al. 2013). The map below reflects the material footprint of nations (in t/cap) where ecological rucksacks are attributed to the consumer and not the producer. This new perspective has become the basis for the *International Trade in Resources* report.

The Trade Report argues that the twentieth-century international division of labour was characterized by declining resource prices that in general made it possible for Northern industrialized countries to act as importers of primary resources and exporters of manufactured goods, with Southern countries as the exporters of primary resources and importers of manufactured goods. The Trade Report confirms that this picture is rapidly changing in the twenty-first century. In a context of rising resource prices, some fast industrializers in the global South have become both importers of primary resources and exporters of manufactured goods, and some industrialized countries like Canada and Australia have become increasingly important exporters of primary resources. In general, there are an increasing number of countries dependent on resource imports and a declining number of countries that are providing an ever-greater proportion of resource exports (Fischer-Kowalski/Dittrich/Eisenmenger et al. 2015). Trade makes physical burden-shifting possible, but this is unmasked if ecological rucksacks are attributed to the consumer and not the producer.

The Trade Report ends by saying that a conclusive answer to the core question about the role of trade in resource use and environmental impacts is not possible at this stage, especially if a balanced view of environmental and developmental factors is taken into account. This, however, is not the question that guides the primary concerns of this chapter—this chapter is interested in the dynamics of transformation. From this perspective, the declining number of countries providing more and more primary resources within the context of a long-term super-cycle of rising resource prices is clearly the most important limiting factor. The rise of 'resource nationalism' in Africa (together with rising labour costs in China which makes manufacturing through beneficiation increasingly viable in Africa (Swilling 2013a)) suggests that the rising state of resource prices is unlikely to be reversed in the near future, and the adoption by the EU of a Resource Efficiency strategy suggests that rich resource-importing countries will start to find ways of reducing their dependence on resource imports (European Commission 2011). Both signal new directions of change with potentially transformative implications.

## 17.6 Specific Resource Challenges

The series of IRP reports that deal with specific resource challenges have addressed metals (four reports), water (two reports), land-use and soils, and forests.[5] They all recognize that these resources will in one way or another be required by society irrespective of whether there is a sustainability-oriented transition or not. It therefore follows that it is necessary to understand the complex dynamics that will shape the availability of these resources over time and what actions will be required to ensure that these resources are managed and used in more sustainable ways as part of a wider 'great transformation' process.

### 17.6.1 Metals

The Metals Working Group has published four peer-reviewed reports and one working paper:[6]

- Report 1: Metal Stocks in Society (2010);
- Report 2a: Recycling Rates of Metals (2011);
- Report 2b: Metal Recycling: Opportunities, Limits, Infrastructure;
- Report 3: Environmental Risks and Challenges of Anthropogenic Metals Flows and Cycles (2013);
- Working Paper: Estimating Long-Term Geological Stocks of Metals.
- Future reports include:
- Report 4: Future Demand Scenarios for Metals;
- Report 5: Critical Metals and Policy Options.

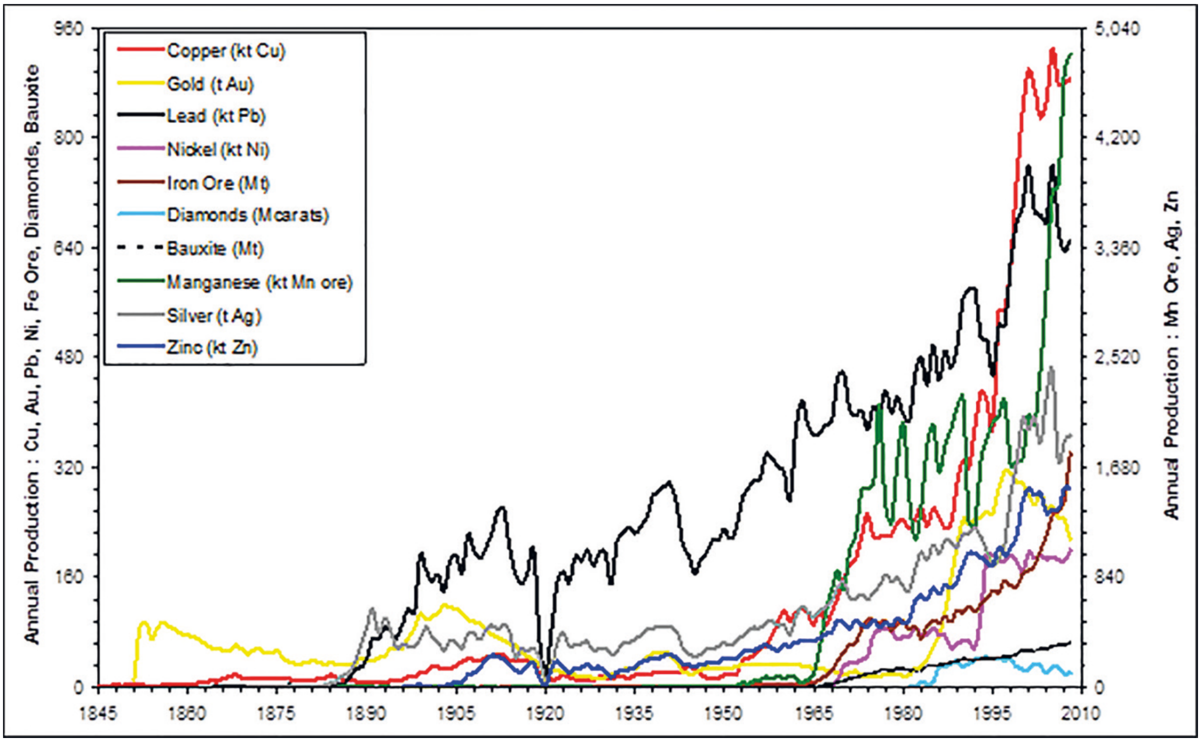
All economies, no matter their level of development, depend on metals of various kinds. The rise of the information age and related increased demand for hi-tech electronic goods has resulted in rapid increases in demand for speciality (or rare earth) metals like lithium and indium. Simultaneously, the accelerated growth and rapid urbanization in the BRICS (Brazil, Russia, India, China, South Africa) -plus countries (e.g. Turkey, Mexico, Nigeria and Indonesia)—especially China—has resulted in massive increases in demand for base metals. Figure 17.12 depicts the growth in demand in recent decades. In combination, these two driving forces of demand have deepened the criticality of a wide range of metals. For example, as the Metals e-Book makes clear, the future demand for zinc, copper, nickel and aluminium just for the expansion of the global energy system are in each case several magnitudes greater than current demand (e.g. demand for aluminium is expected to grow from 500 *gigagrams per year* (Gg/y) to over 5,500 Gg/y by 2050 just for non-fossil fuel infrastructure).

The increasing complexity of electronic goods is a major driver of demand for a wide range of metals to

5 The Reports on biofuels and forests have not been included, partly because the implications of biofuels is incorporated into the land and soil group, and the forests report was compiled in a way that does not quite fit into the overall orientation of the IRP.

6 A summary is contained in an e-book available on the IRP website at <http://www.unep.org/resourcepanel>. Unless alternative sources are specified, the data referred to in this section is taken from this e-book (International Resource Panel Working Group on Global Metal Flows 2013).

**Figure 17.12:** Growth in production of minerals, 1845–2010. **Source**: Mudd (2009), cited in International Resource Panel Working Group on Global Metal Flows (2013).




produce the compounds required by these goods. Figure 17.13 reveals the growth in the number of elements needed to make a microchip.

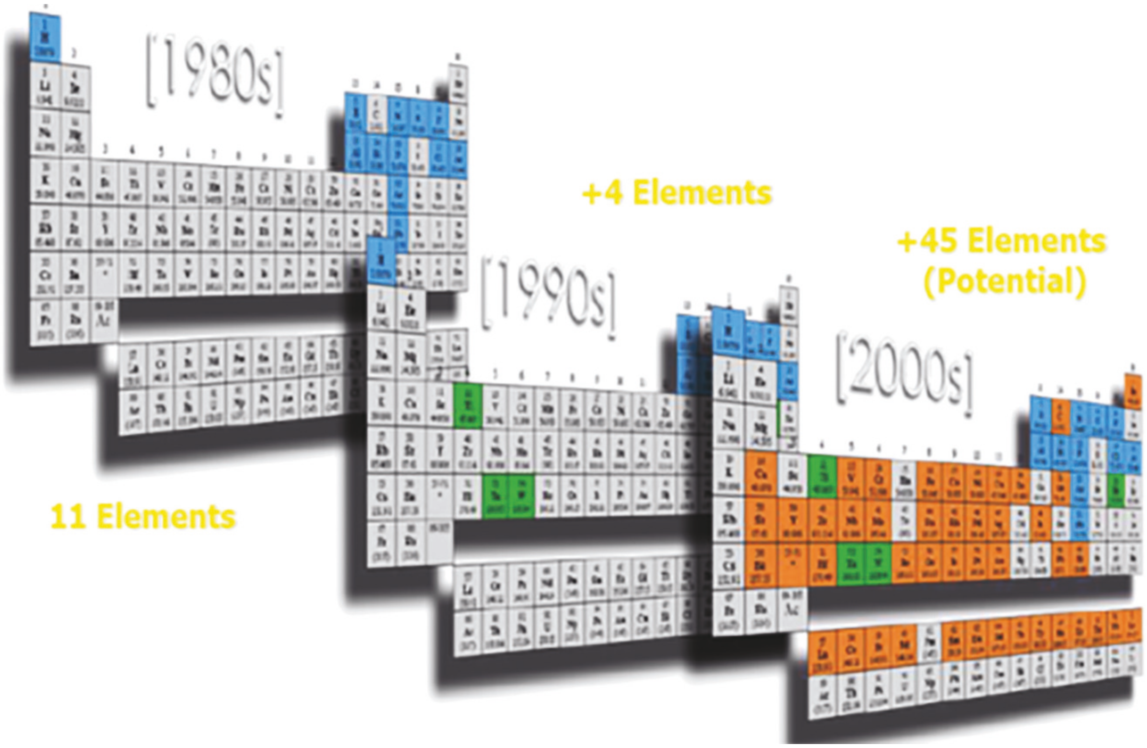
Although a lack of information prevents high-confidence estimations about resource depletion (Smil 2014), what is clear from the work of the Metals Working Group is that there are also other factors that increase supply risks. These include, according to reports of this Working Group, challenging technological conditions (depth, composition of ore as ore grades decline), economic variables (adequacy of infrastructure, size of deposit), environmental constrains (natural habitats, ecosystem services), and geopolitical dynamics (trade barriers, political instability, weak states) (International Resource Panel Working Group on Global Metal Flows 2013).

Global metals production is a major contributor to environmental pollution and energy demand. The Working Group's reports shows that no less than seven to eight per cent of global energy use and therefore energy-related GHG emissions can be attributed to metals production. Whereas 20 MJ of energy is needed to make a kilogram of steel, 200,000 MJ is needed to make a kilogram of platinum (International Resource Panel Working Group on Global Metal Flows 2013). A major driver of increased future energy demand of metals production is the decline in ore quality—three times more material must be moved today to extract a kilogram of ore compared to a century ago.

Report 1 estimated the quantity of metals being used by society for the period 2000-2006. The average for aluminium was 80 kg per capita, with a range of 350–500 kg/cap for developed economies and 35 kg/cap for the least developed economies. Similarly for copper: 35-55 kg/cap is the global average, ranging from 140-300 kg/cap to 30-40kg/cap; and 2200kg/cap for iron, ranging from 7,000–14,000kg/cap to 2,000kg/cap. Obviously, the same pattern replicates itself for each metal (International Resource Panel Working Group on Global Metal Flows 2013), the implication being that global development targets aimed at eradicating poverty and achieving greater equity will entail significant increases in metals consumption in developing countries.

To diminish the environmental impact and energy requirements of metal production it will be necessary to increase the recycling rates of metals. Report 2a demonstrated that the *end of life-recycling rates* (EoL-RR) for metals are very low: EoLRR of above fifty per cent can be found for only eighteen metals.

**Figure 17.13:** Computer Chip Elemental Contents. **Source**: Quoted in a Powerpoint presentation by Tom Graedel, November 2013, Stellenbosch University.




The Report shows that part of the explanation for low EoLRRs is rising demand and the long in-use life of metals. However, another more important explanation is that the design of products has not hitherto taken into account the need for end-of-life recovery and reuse. Disassembly and metals recovery is not what designers have been required to do. To increase EoLRRs to fifty per cent or more for all metals as part of a wider sustainability-oriented transition, it will be necessary, the Report argues, to radically change the way products are designed (i.e. design for disassembly) and substantial investments in new collection infrastructures will be necessary (International Resource Panel Working Group on Global Metal Flows 2013). As resource prices continue to rise as demand continues to grow, driven mainly by the requirements of the information age and urbanization, the financial viability of design for disassembly will more than likely improve. This will be a crucial driver of a more fundamental transformation.

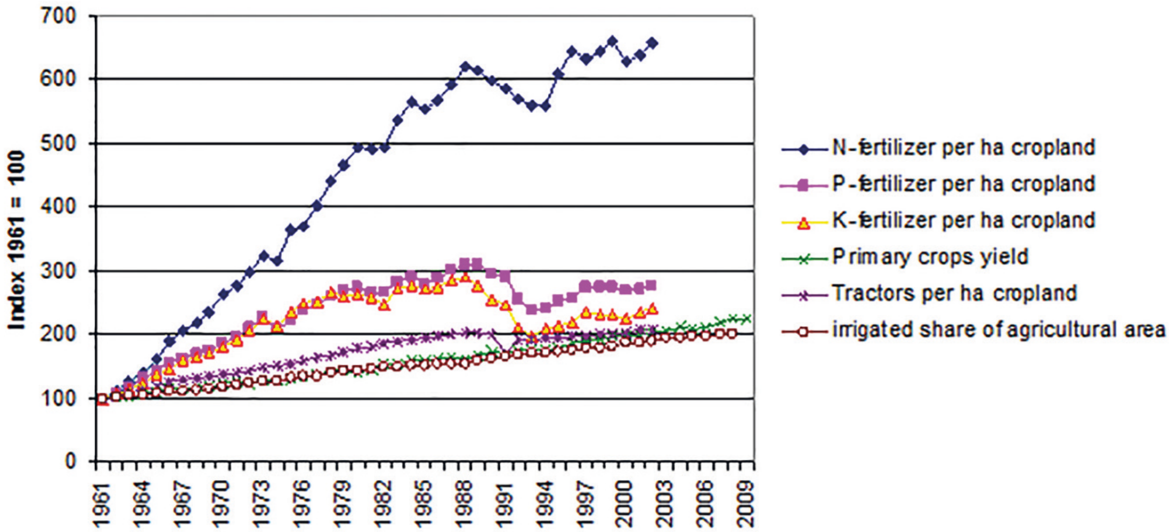
### 17.6.2 Land-Use and Soils

A century of steadily declining food prices came to an end at the turn of the millennium. Since then food prices have been rising steadily and so has the number of large-scale land transactions (including so-called 'land grabbing'). Except for the first decade of the twenty-first century, there has been no decade since 1900 where there is evidence of steadily rising food prices. This pattern is expected to continue with major implications for land use and food security (Swilling/Annecke 2012: Chapter 6).

Following Scherr, the total ice-free land surface of the Earth is 13 *billion hectares* (Bha) of which 1.5 Bha is unused 'wasteland' and an additional 2.8 Bha is unused and inaccessible. This leaves 8.7 Bha which humans in the Anthropocene can choose to 'use' for a wide variety purposes, including pasture, forests and cropland. Of this, 3.2 Bha are potentially arable, the rest being marginal land from a cultivation perspective and covered by forest, grassland and permanent vegetation.[7] Of the potentially arable land, only 1.3 Bha is deemed to be moderate to highly productive. Just under half of the 3.2 Bha of potentially arable land (1.47 Bha) is cultivated as cropland. This means that just over ten per cent of the ice-free land surface of the Earth is the resource on which humans depend

7 Lambin and Meyfroidt estimate that there are approximately 4 Bha available for 'rain-fed agriculture' (Lambin/Meyfroidt 2011: 3466).

**Figure 17.14:** Agricultural inputs relative to crop yields (1961–2009). **Source**: FAO data compiled by Schutz, cited in Bringezu, Schutz, Pengue et al. (2014).




for the bulk of their food. This 1.47 Bha of cropland, plus approximately 3.2 Bha of permanent pasture and 4 Bha of permanent forest and woodland, is what makes up the 8.7 Bha of 'usable' land (Scherr 1999). Half of the developing world's arable and perennial cropland is in just five countries–Brazil, China, India (with twenty-two per cent), Indonesia and Nigeria. It is noticeable that the only African countries with very extensive or moderately extensive arable land resources are Nigeria, Ethiopia, South Africa and Sudan. The majority of African countries have limited arable land resources with high population pressures and it is estimated that sixty-five per cent of Africa's agricultural land is degraded (Scherr 1999). Yet African countries are earmarked by all the models of the future for substantial yield increases–it is also where most of the land grabs are taking place (Cotula/Vermeulen/Leonard et al. 2009).

Global land use, rising food prices, soil degradation and accelerated land transactions (as countries scramble to secure food supplies) provides the context for the IRP Report entitled *Assessing Global Land Use: Balancing Consumption with Sustainable Supply* (generally referred to as the *Land and Soils Report)* (Bringezu/Schutz/Pengue et al. 2014). Launched at the World Economic Forum in January 2014, the report raises very serious questions about the sustainability of expanding agricultural production in a world dominated by a resource inefficient food system that does not cater for the needs of the nearly billion or so people who are undernourished.

Figure 17.14 reveals that since 1961, inputs (nitrogen, phosphorus, potassium, tractors) have tended to rise at a faster rate than crop yields, and this within the context of a doubling of irrigated land area.

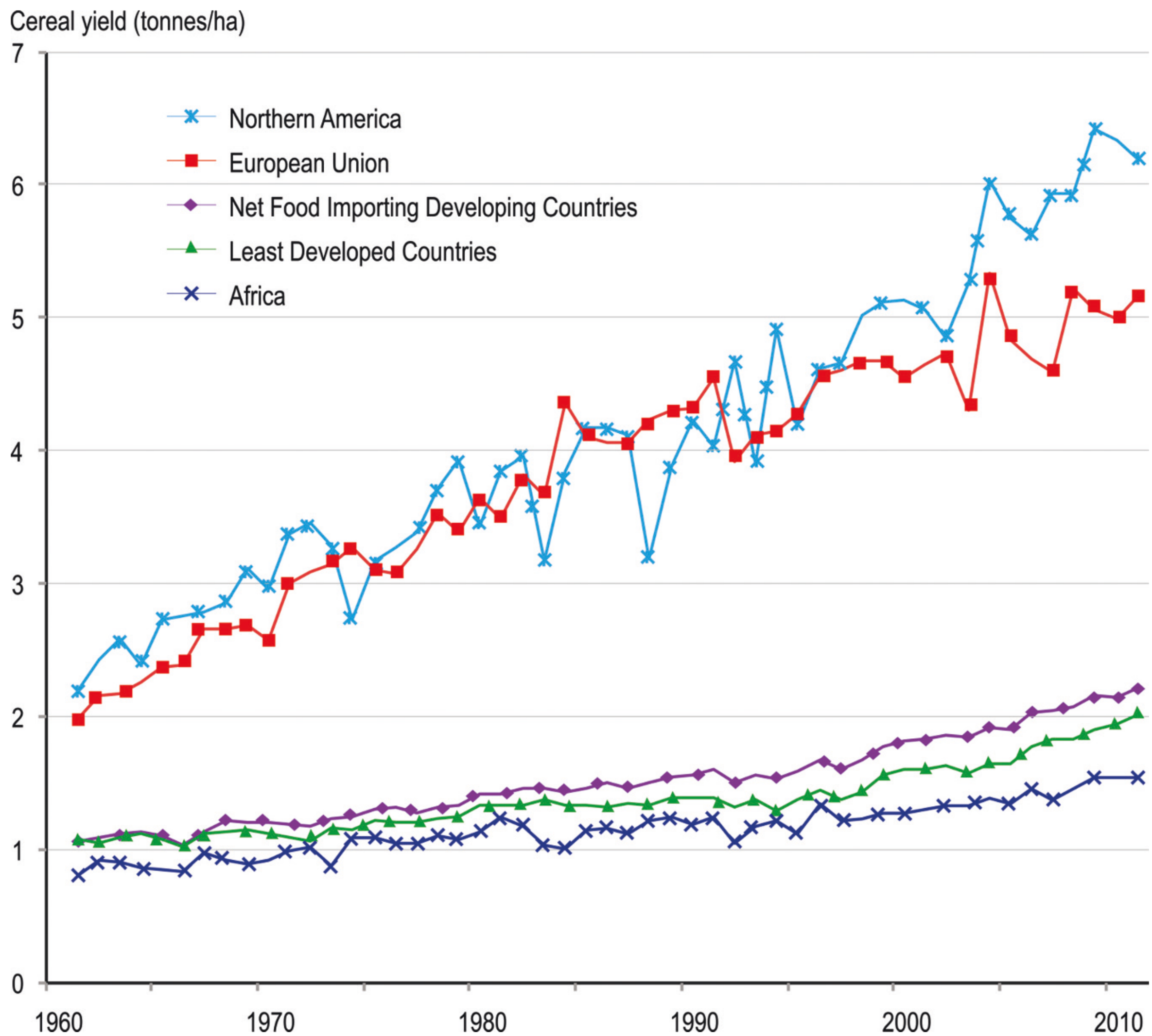
At the same time, soil degradation continues, with twenty-three per cent of soils degraded by 1990. Two to five million hectares are degraded per annum.

The international division of agricultural labour is clearly reflected in figure 17.15, which reveals the gap between yields in Europe and North America, where high external input intensive industrial farming is prevalent, and the yields in developing countries where soil degradation levels are high, infrastructures are poor and farming is still dominated by 400 million small farmers (only forty per cent of whom use chemical inputs).

Expanding agricultural land use is driven in part by rising demand for food and non-food biomass which cannot be compensated by higher yields. This net expansion occurs at the expense of grasslands, savannahs and forests. However, expansion is also driven by the need to compensate for expanding cities and soil degradation. This plus net expansion results in gross expansion. Based on an assessment of a wide range of studies (for sources of data cited see original diagram in *Land and Soils Report)*, the dimensions of the net and gross expansion of agricultural land are represented in figure 17.16.

The Land and Soils Report shows the future land requirements to meet food supply (after exhausting yield growth potential) are estimated to be between 71 *million hectares* (Mha) and 300 Mha. The rapidly

**Figure 17.15:** Cereal yields by selected world regions (1961-2011). **Source**: FAO data cited in Bringezu, Schutz, Pengue et al. (2014).




expanding demand for land to grow biofuel crops is estimated to be 48 MHa to 80 Mha, and the requirements for additional biomaterials (wood, textile crops, etc) is estimated to be be 4 MHa to 115 Mha. To compensate for the expanding built environment (that tends to destroy the most valuable agricultural land), between 107 Mha and 129 Mha may be needed. Assuming that a significant proportion of degraded soils cannot be restored,[8] estimates of the requirements to compensate for degradation range from 90 Mha to 225 Mha. This means that the estimates for gross additional agricultural land requirements to meet growing needs range between 320 Mha and 849 Mha. This suggests that the needs are much greater than FAO's estimate of 120 Mha (Bringezu/Schutz/Pengue et al. 2014).

It needs to be recognized that land-use change in favour of agriculture is one of the primary drivers of rising CO2 emissions and biodiversity loss. We need, therefore, to accept that there are absolute limits to the quantity of global land that can be used for agriculture. Taking into account various factors, the *Land and Soils Report* proposes that the expansion of global cropland should be halted by 2020, at which point it is estimated global cropland will have expanded from about 1.5 Bha to 1.64 Bha. In other words, although an additional 140 Mha of cropland is

8 Although seriously degraded soils are difficult and costly to restore, there are still about 300 Mha of lightly degraded soils that can be restored mainly by changing management practices.

**Figure 17.16:** High and low estimates of net and gross expansion of agricultural land, 2005-2050. **Source**: Bringezu, Schutz, Pengue et al. 2014—note: for detailed references to the sources of data cited here, see original diagram in this report.

| Business-as-usual expansion | Low estimate (Mha) | High estimate (Mha) |
|---|---|---|
| Food supply | 71 | 300 |
| Biofuel supply | 48 | 80 |
| Biomaterial supply | 4 | 115 |
| **Net expansion** | **123** | **495** |
| Compensation for built environment | 107 | 129 |
| Compensation for soil degradation | 90 | 225 |
| **Gross expansion** | **320** | **849** |

bound to have very negative environmental effects, the *Land and Soils Report* nevertheless estimates that it may be possible to remain within this 'safe operating space' and thus avoid the far more negative consequences of an expansion in the range 320 Mha to 849 Mha, as suggested by the sum of existing research. To achieve this reduction in future requirements, the *Land and Soils Report* recommends the following (Bringezu/Schutz/Pengue et al. 2014):

- massively increase the existing land potential by restoring degraded soils and using existing soils optimally—how to do this is the focus of the next report on land and soils that is currently under way;
- ensure that national governments have the capacity to control expansion of agricultural land in order to avoid uncontrolled destruction of biodiversity, forests and pastures;
- limit meat/dairy consumption and change the way the food system works—again, as mentioned earlier in this chapter, this is the focus of the forthcoming IRP report.

The Report recommends the following specific sets of interventions (Bringezu/Schutz/Pengue et al. 2014):

- reducing the demand for meat/dairy products and reducing the levels of food waste could save between 96 and 135 Mha;
- halving the global biofuel targets could save between 24 and 40 Mha;
- controlling the demand for biomaterials could save up to 57 Mha;
- limiting the expansion of cities into productive agricultural by just ten per cent of the expected impact could save between 11 and 13 Mha;
- restoring a third of degraded soils could save between 30 and 74 Mha.

In short, a mix of strategies and measures to reduce overconsumption of certain foods, reduce food waste and limit the consumption of non-food biomass products while at the same time improving land management could save between 160 and 320 Mha by 2050. Cropland area would still expand to meet, in particular, the demand for increased food production to meet the needs of those who have enough, but not as much.

### 17.6.3 Water

According to the Water Decoupling Report (Urama 2015), integrated water resources management faces two closely interlinked obstacles—one, on the supply side, of unpolluted freshwater resources for a growing world population, and the other, on the demand side, of water for increased agricultural output, water-intensive industries and domestic use. The problems associated with the supply and demand of water, such as significant increases in water pollution and freshwater withdrawals, are driven by population increase, urbanization, rising living standards, unsustainable water governance (which includes inefficient supply and demand management), agricultural land uses (specifically irrigation), industrial production, ecosystem degradation and climate change.

The as yet unpublished but completed *Water Decoupling Report* addresses the challenge of water availability and use in light of mounting global challenges to security of supply (Urama 2015). Water withdrawals on a global scale have increased at a rate almost double the human population growth rate, from 600 billion cubic meters in 1,900 to 4,500 billion cubic meters in 2010. This could grow to between 6,350 and 6,900 billion cubic meters by 2030 if an average economic growth scenario and efficiency gains are assumed. This represents a forty per cent demand gap above currently accessible water resources, including return flows.

Table 17.1 illustrates the expected increases in water withdrawal demand for human activities by 2030. The highest incremental demand is expected to occur in sub-Saharan Africa at 283 per cent, while the lowest is expected in North America at 43 per cent.

In terms of global freshwater use to support human activities, currently 70% is used in agriculture

**Table 17.1:** Increases in Annual Water Demand, 2005–2030. **Source:** McKinsey (2009), cited in Urama (2015).

| Region | Projected Change from 2005 |
|---|---|
| China | 61% |
| India | 58% |
| Rest of Asia | 54% |
| Sub-Saharan Africa | 283% |
| North America | 43% |
| Europe | 50% |
| South America | 95% |
| Oceania | 109% |

(output of which is estimated to increase by another 65% by 2030) of which 15–35% is considered unsustainable, especially in cases where groundwater is extracted faster than it can be recharged. An additional 22% of fresh water is used in industries (estimated to grow by an additional 25% by 2030), but this can range from as high as 60% in industrialized countries to as low as 10% in some developing countries. Lastly, 8–11% is for domestic use (estimated to grow by another 10% by 2030), at an average of about 50 litres per person per day, although also with great variability (International Water Management Institute 2007 and Gleick 2010, both cited in Urama 2015).

On the supply side, it is estimated that over the next twenty years, water supply would need to be 140% higher than in the past twenty years to meet the increasing demand and ensure accessible, reliable and sustainable provision of existing water supplies (Urama 2015). The obstacles are as follows. Readily available sources of fresh water are under significant stress already, with the shrinking of many freshwater lakes, the drying up of rivers that subsequently never reach the ocean, and the overuse of groundwater resources, something that is already occurring in many regions. Further limiting these water resources, the Water Report argues, are increasing rates of pollution with over 405 dead zones currently on record globally in coastal waters. Lastly, further water is lost due to inefficiencies in technologies, the most pertinent example being the loss of drinking water from municipal distribution systems before it even reaches the consumer, where on average thirty per cent (and in extreme cases up to eighty per cent) of water is lost. This is equivalent to over US$18 billion worth of water per year that does not generate revenue, indicating the need for efficiency and productivity gains (Urama 2015).

Figure 17.17 shows the number of people living in water-stressed areas between 2005 and 2030, as calculated by UNEP (UNEP 2011, cited in Urama 2015). The OECD estimates that nearly 3.9 billion people will experience severe water stress by 2030.

One of the greatest issues relevant to the supply of fresh water is the level of pollution through human activities. The most relevant sources include mining activities, agriculture, landfill, and industrial and urban wastewater effluents. The main pollutants from agriculture, for example, include pesticides, organic compounds and nutrients from fertilizer that end up in water bodies, causing eutrophication and ultimately leading to "dead zones" (Urama 2015). Furthermore, pollution from industrial activities is in the form of seventy per cent of untreated industrial wastes being dumped into waters (UN-Water 2009 cited in Urama 2015).

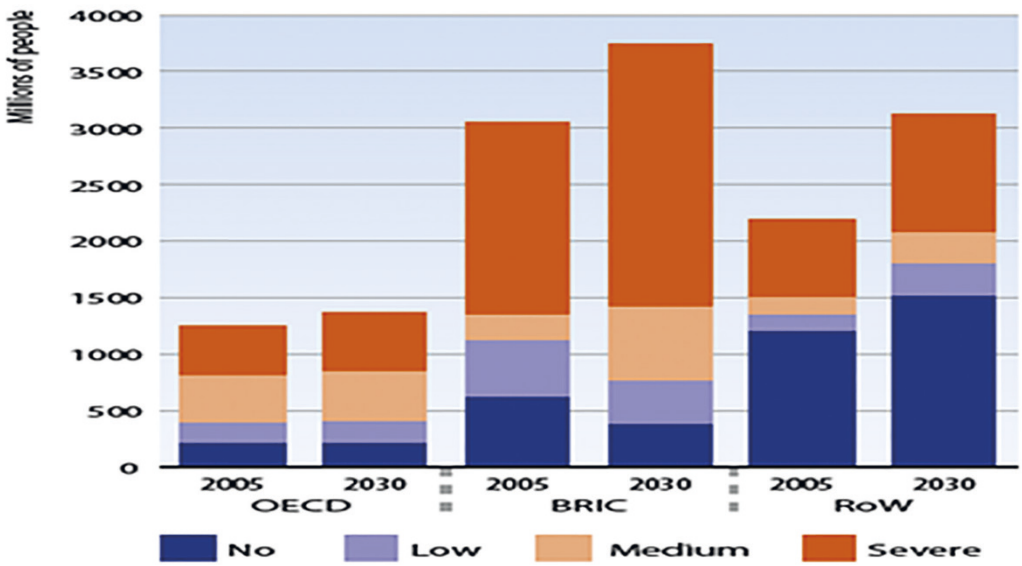
In many developing countries sanitation and wastewater treatment causes major water pollution, and scenarios have been found where as much as eighty-five to ninety-five per cent of sewage is discharged directly into rivers, lakes and coastal areas, causing large amounts of revenue to be spent dealing with waterborne diseases instead of generating new wealth (Tropp 2010 cited in Urama 2015). .

Lastly, the number of people vulnerable to water-related disasters, particularly flooding as a result of climate change, deforestation, population growth, rising sea levels, and human settlement in flood-prone lands, may reach two billion by 2050 (Urama 2015).

All these obstacles make a strong case for water decoupling, that is, using fewer units of water resources per unit of economic output, while also reducing other adverse socio-economic and environmental trade-offs downstream, such as rates of water pollution, known as impact decoupling.

Relative decoupling is shown to be beneficial to human well-being, environmental flows in river basins, and to economic growth (Urama 2015). Achieving sustainable decoupling in the water sector will require innovative structural transformations in economic pathways; integrated water management policy and practices at local, national, river-basin, and global scales; and substantive investments in improved technologies and innovations for improving water efficiency and productivity at the appropriate temporal and spatial scales. Improving technical and allocative efficiency and resource productivity in the key water use sectors could offset up to sixty per cent of the

**Figure 17.17:** Number of people living in water-stressed areas in 2030, by country type. **Source**: UNEP (2011), cited in Urama (2015).




anticipated growth in demand for water by 2030 (Urama 2015).

## 17.7 Discussion: Implications of the Work of the IRP for Global Transition Thinking

It was argued at the outset that the work of the IRP can be understood within the wider context of the so-called 'third great transformation' or more precisely a 'sustainability-oriented transition'. Following the GACGC, it was argued that a structural metabolic shift would be the distinctive feature of this transition. It should be clear from the discussion thus far that although the IRP does not address the question of transition directly, when the completed and ongoing work is read together it does provide an extraordinary body of rich empirical evidence that confirms the notion that we are experiencing the endgame of the industrial socio-ecological regime.

Although the notion of decoupling is contested on the grounds that it implies that fundamental structural change can be avoided while greening consumption (Jackson 2009), the global resource perspectives provided in the Decoupling 1, Decoupling 2 and Environmental Impacts reports all confirm that unless the global systems of production and consumption are in fact radically transformed it will not be possible to build a world without poverty where average consumption (of around six t/cap) is consistent with what available planetary systems can provide on a sustainable basis. This message goes way beyond the carbon-centred argument of the IPCC that has succeeded in establishing the notion of a low carbon transition within the global policy community. From the perspective of the IRP, this will not be sufficient. A low carbon destruction of planetary resources is not an appropriate future trajectory.

The conclusions of the work on the various nexus themes confirm that superficial modifications to the sociotechnical systems that we depend on will not suffice. To double the extent of the world's urban settlements, it will be necessary to fundamentally change the way we design, build and operate cities. Many aspects of urban living that are taken for granted will clearly have to be replaced with information-rich alternatives that embed cities in sustainable technological and ecological cycles.

The crisis of the current highly complex tightly-coupled global food system poses a major risk to the survival of the global population, in particular the poor. Although this might be the most difficult socio-technical system to change, fundamental changes to this system might well be driven by the social and health consequences of deepening food insecurity.

The global trade in material resources is already changing rapidly as fewer and fewer countries become increasingly important exporters of primary resources to an increasing number of industrializing and industrialized resource-importing countries. The rise of resource nationalism in many resource-rich developing countries and the resource efficiency movement in many resource-importing developed countries suggests future trajectories that will have major implications for global trade in material resources.

Finally, although the transition to renewable energy technologies will clearly have beneficial environmental impacts compared to business as usual, it would be naïve to assume that they are a panacea that will produce an environmental utopia. Like everything we humans do, resources are required that we derive from the crust of the earth in one way or another. A future world of nine billion people where we consume six t/cap and emit two tonnes of $CO_2$ is still a world that will require the extraction of resources on a scale equal to current levels of extraction. The IRP work on renewable energy technologies shows that the demand for certain materials may well increase if we implement the low carbon transition. This is an early warning that the sustainability-oriented transition is not a simplistic break that miraculously heals the planet.

Finally, the IRP work on the specific resource challenges in the metals and ecosystems sectors clearly shows that a sustainability-oriented transition will depend on extraordinary efforts to change the way we use the three most basic ingredients of contemporary modern living: metals (in particular for the global electronic infrastructure), water and land. However, no matter what we do, there is no way we can do without these three key resources. Indeed, it is clear from the evidence that we will need more of them all and that this will have to be done in a way that ensures that those who currently live in poverty gain greater access to these resources. The challenge, however, is to trigger new consumption and production systems that create new economic opportunities out of the need, for example, to 'design for disassembly' when it comes to metals, or to design and build decentralized urban water and sanitation systems that can use water more efficiently and recycle all waste water, or replicate on a massive scale the agro-ecological farming methods that have proved to be able to increase yields by restoring the soils and ecosystems.

This discussion raises the question about whether the IRP should go beyond its current mandate and become the global body that addresses in an integrated way the challenge of making the sustainability-oriented transition happen. For this to be possible, however, it will be necessary to embed the research done to date on resource flows within an analysis of the dynamics of the global economy. During the quarter-century leading up to the great contraction of 2009, the neo-liberalization of the global economy resulted in the rise to dominance of finance capital on the back of a wave of financial innovations made possible by the low-interest-rate regime advocated by the US Federal Reserve. The global economy is now driven by debt-driven consumption and national development strategies that measure progress in terms of GDP per capita. Indeed, without growth, fractional reserve banking systems will face a serious crisis. A key result is a highly unequal world. Not only has this triggered unprecedented social movements (Castells 2012), but the popularity of Thomas Piketty's book *Capital in the Twenty-First Century* is a clear indication that 'rule by the one per cent' of an increasingly unequal world is no longer a legitimate mode of societal governance (Piketty 2014). It is arguable that this highly complex and increasingly unstable global economic architecture is incompatible with the metabolic dynamics and requirements of the third great transformation. If this argument is correct, it will be necessary to merge the body of work thus far developed by the IRP with the emerging body of work by progressive ecological and institutional economists who have begun to consider the details of alternative future economic arrangements and trajectories that will be fundamentally different to what mainstream macro-economic theory assumes is the natural order of things.

## 17.8 Conclusion

In this first academic review of the IRP's body of work, it has been argued that it may be appropriate to use long-wave theories of transition to understand the contribution of the IRP to the wider field of anticipatory science. What is anticipated by those who use this perspective is that in some way the metabolic, sociotechnical and institutional regimes of the industrial epoch will be replaced over time by an alternative more sustainable epoch characterized by more sustainable metabolic flows made possible by reconfigured and transformed sociotechnical and institutional regimes. Although the IRP's work does not directly address transition per se, when read together the various strands of thought and evidence in the completed and current work do suggest that it is highly unlikely that the industrial epoch can continue into the medium- and long-term future if it depends on the continuous increase in consumption of natural resources. There are elements, of course, across the reports that could be woven into a more robust and systematic conception of transition: the types of decoupling envisaged in the Decoupling 2 Report, the recommended dietary and land-use changes in the Land and Soils Report, the key role of cities in the City-Decoupling Report, and the unintended consequences of a transition to clean energy, to cite only a few examples.

Three broad conclusions flow from this analysis.

Firstly, when collected together, the totality of evidence mobilized by the IRP supports the notion that future well-being and development (whether growth-based or not) will have to be decoupled from rising rates of resource use. Relative decoupling is not sufficient. Absolute reductions in resource use will be necessary. To implement this idea, however, a fundamental restructuring of prevailing modes of production and consumption will be necessary. Decoupling is not simply sophisticated greenwash. It will mean significant changes for consumers in developed economies, and in developing countries committed to poverty eradication it will be necessary to replace resource-intensive development pathways with resource-efficient development pathways that end up delivering to more people a fairer deal resulting in less inequality and therefore more long-term democratic stability.

Secondly, the IRP's work reveals the futility of naïve assumptions about what will be attainable in a sustainable world populated by over nine billion people, most of whom will be living in cities. All past human activity has depended on the exploitation of natural resources in one way or another. Humans currently have technical and institutional capabilities to exploit these resources on an unprecedented scale. Anticipatory science is needed to show that this cannot continue. However, if the results from IRP research are anything to go by, massive reductions in resource use are possible, but they cannot be eliminated or reduced to insignificant levels. A world of over nine billion people without poverty may well need what was extracted from the earth in 2000. The finding made in the Green Energy Choices Report that more of certain materials might be needed is highly significant. The only question is how this will be done. Will these sociotechnical processes become part of closed-loop techno-industrial and ecological cycles or not? That will become the key longer-term question, not simply a zero-sum calculation based on how much less can be consumed. This, in turn, might make it possible to make a shift from only focusing on 'resource limits' to focusing more on 'resource potential'. This shift is already under way in a number of reports.

Thirdly, the IRP work on resource limits and potentials needs to be integrated into a wider holistic theory of economic development that is not GDP-centred. The gradual dismantling of neo-liberalism is already under way as intolerance of poverty and inequality reaches new heights in the wake of the global economic crisis and states in the developing world disassociate themselves from the hegemonies of Western thinking. This is clearly a positive movement. However, if an alternative is constructed that anticipates the great transformation that once again assumes that there is an unlimited supply of natural resources, then a major opportunity will have been missed. The economic theories informing the developmental states run the risk of making this mistake. However, this is unlikely to become a mainstream habit because the century-long decline in resource prices ended in 2002. If those who have predicted a long-term supercycle of forty to sixty years of rising resource prices prove to be correct, then we can safely anticipate that the economic theory that replaces the reductionist simplicities of neo-liberalism will indeed need to come to terms with the expanding body of work produced by the IRP. This will surely justify the efforts by those who have made this work possible.

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