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Sustainable Resources – Managing Markets, Increasing Efficiency and Establishing Partnerships

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Introduction

The contemporary debate offers two perspectives on natural resources, especially regarding minerals and metals: One perspective looks at environmental pressures and scarcities; it often contrasts environmental constraints with extraction figures that have been on the rise since decades. The other perspective looks at development opportunities for resource-rich countries and analyses the governance conditions that may help to turn natural endowments into prosperity for the people.

Indeed, both perspectives are justified and resemble the broader debate on the environmental and socio-economic dimensions of sustainable development. Not surprisingly, there are a number of trade-offs and synergies between both angles that need to be considered. The aim of our contribution is to analyse key trends of international resource consumption and evaluate sustainability perspectives for resources focusing on material resources. We seek to demonstrate that the broader picture is neither gloomy (*limits to* growth or *resource curse*) nor should one become overly optimistic about transitions to market-based and equitable democracies based on commodities. Underlining the importance of natural resources, we argue that the notions of a green economy and green growth require incorporating the topic of sustainable resource management. A particular objective of our paper is to highlight resource efficiency as an opportunity, which is in line with both perspectives. Evidence, however, shows that resource efficiency occurs insufficiently and under what we call a *web of constraints*, i.e. interconnected barriers to resource efficiency improvements. Such barriers obstruct efficiency gains at different levels and should be removed by more ambitious, better coordinated and more internationally oriented strategies by multiple actors, including policy makers. Finally, we will draw several conclusions about the future role of resources in development cooperation.

International commodity markets – a rollercoaster

Material resources are vital for an economy. Societies need construction minerals and other materials for housing and urban development; they need steel and copper and other metals for mobility; and fuels plus a number of materials for energy systems, not to mention biomass and food for nutrition and human survival. Typically, the more economic activity takes place, the more materials are being consumed. The following analysis outlines (i) global trends in material consumption, (ii) the impact of a rising material consumption exemplified by volatile commodity prices and (iii) a brief outlook on commodity markets.

Global trends in material consumption

Global consumption of material resources has almost doubled in absolute terms between 1980 and 2009. Global GDP measured in constant 2005 US-Dollars has been growing faster compared to global material consumption, whereas population growth has decoupled from material consumption since the turn of the century, i.e. material consumption per capita has increased (Figure 1).

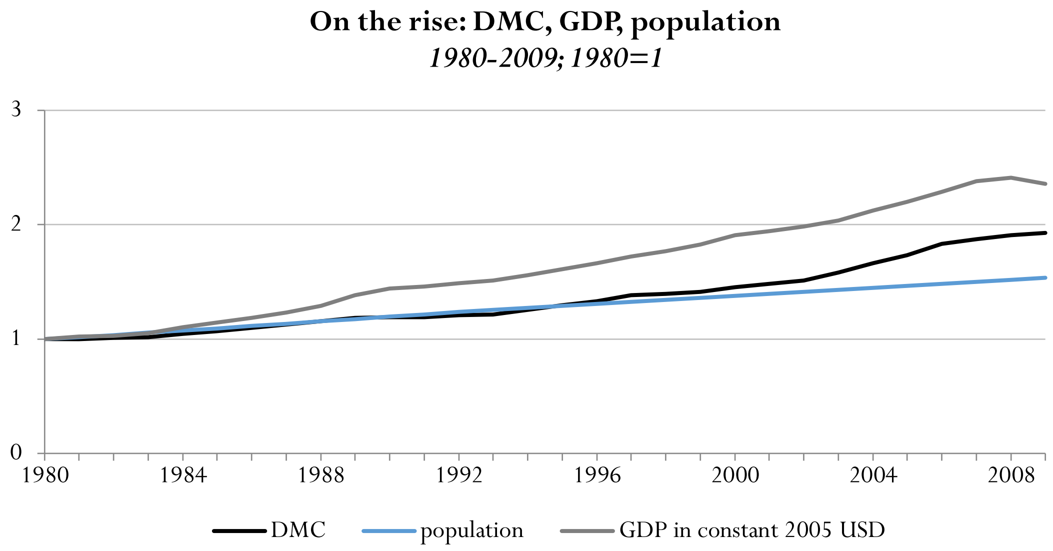

Figure 1: Data based on DMC[1], GDP in constant 2005 USD and population from 1980 to 2009. The base year is 1980. Sources: SERI, World Bank, UN, own calculations.

But what has caused the increase in material consumption over time? The academic literature has identified numerous drivers of material consumption (e.g. Bringezu et al., 2004; Moll et al., 2005; Steinberger et al., 2010; Weinzettel and Kovanda, 2011). Besides a country's economic structure, technological change and resource policies, economic growth is considered a key driver of material consumption.

As visible in Figure 1, the growing consumption of materials is certainly correlated with economic growth – without inferring any causal relationship. The industrialised world, in Figure 2 below represented by the United States of America (USA) and the United Kingdom (UK), decreased their absolute domestic material consumption compared to the global trend, which is shown as the horizontal axis. Industrialised countries typically have stayed below the world's average of almost doubling material consumption between 1980 and 2009 (e.g. Canada, Finland, France, Germany, Australia, Japan). Thus, emerging economies have been driving the growth in material consumption (e.g. Brazil, Chile, Indonesia, Turkey – except South Africa and Russia since 1992) by increasing their material consumption above the global average, in line with average income growth.

[1] Domestic Material Consumption (DMC) is a variable commonly used by e.g. the OECD, EU, UN in material flow accounting. DMC measures the mass (weight) of the materials that are physically used in the consumption activities of the domestic economic system (i.e. the direct apparent consumption of materials, excluding indirect flows). In economy-wide material flow accounting, DMC equals DMI minus exports, i.e. domestic extraction plus imports minus exports. See e.g. Bringezu and Bleischwitz (2009).

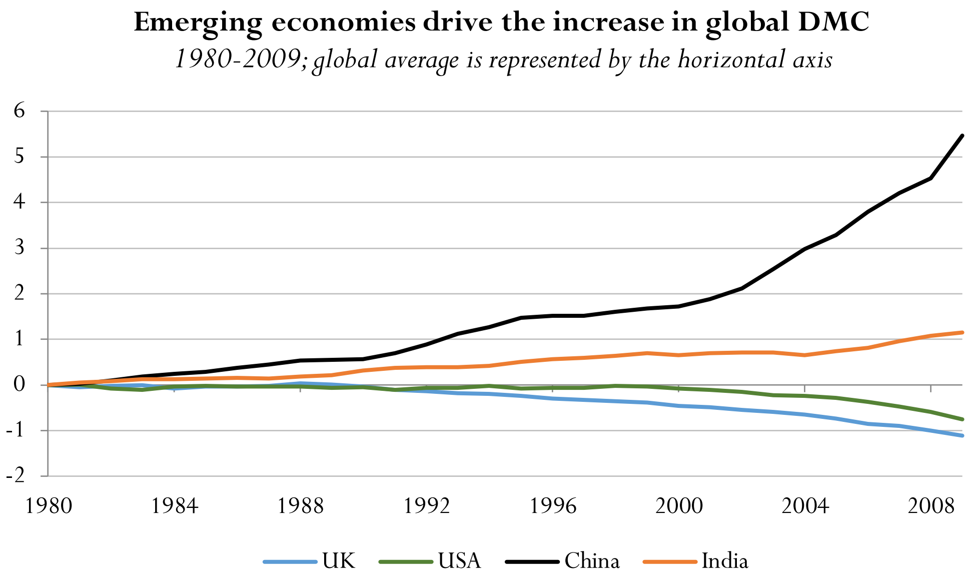

Figure 2: The base year is 1980. All positive values indicate a faster increase in material consumption compared to the world's average (represented by the horizontal axis). Sources: SERI, own calculations.

Decomposing the group of emerging economies, especially China, India and Chile show a substantial increase in material consumption. China has exponentially increased its consumption by a factor of 7.5 since 1980, whereas India *only* tripled and Chile *only* approximately quadrupled its consumption. China's growth particularly started to pick up since the early 2000s coinciding with its membership in the World Trade Organisation. In the case of India and Chile, this increase can somewhat be explained by an increase in population (70% between 1980 and 2009 for India and 52% for Chile). Given China's relatively lower increase of around 30% (partly due to policies restricting population growth) and without going into details, one should consider the industrialisation in China and its increasing exports as main driver for such a trend (Economy and Levi 2014).

Generally, the higher growth rates in material consumption could indicate a conventional catch-up scenario: Once economic activity of emerging economies catches-up to industrialised countries, they also catch-up in terms of material consumption. Therefore, one has to keep in mind that the average *per capita consumption* in the industrialised world is still higher compared to the emerging economies. In 2009, the USA consumed 21 tonnes of materials per person compared to 4 tonnes in India, almost 16 tonnes in China and 12 tonnes in Russia (Lutter, Giljum, and Lieber 2014). The majority of EU countries consumed more than 16 tonnes per capita (EC 2013a). Resource-rich economies such Chile with 43 tonnes per capita are rather an exception to this rule.

Occasionally, urbanisation is considered a further driver of material consumption. Cities consume a lot of materials in absolute terms also because most economic activity takes place there (McKinsey Global Institute 2011). However, urban areas may profit from economies of scale and density. Thus, material consumption per capita might actually be lower compared to rural areas. Hence, urbanisation does not appear to be a key driver of material consumption, at least in per capita terms.

The impact of rising material consumption

We showed that there has been a substantial increase in material consumption, predominantly driven by economic expansion in emerging economies. This increase has several implications, both for the environment and the economy.

Environmental pressures can arise in each stage of material consumption, for example by emitting particulates during material production, erosions from mining and leakages of chemicals into the environment during the separation process of metals (UNEP IRP 2010). Environmental impacts are also related to negative externalities resulting from material waste. For instance, the greenhouse gas methane is emitted from landfills and thus not only negatively impacting the environment locally, but also globally by contributing to climate change (IPCC 2007). Such environmental costs associated with material consumption (including those interlinked with energy use) can also negatively impact economic activity directly and indirectly (UNEP 2014), such as negatively impacting human health and thereby reducing labour productivity.

There are also economic implications from an increase in material consumption. We will restrict our focus on material prices here. The rise in material consumption and thus demand for materials can be considered a key driver of the structural price increase of commodities since the year 2000 (Valiante and Egenhofer 2013). While demand pressures play an important role in forming commodity prices, other factors can likewise impact on price levels as well as price volatility (Ecorys 2012; Cuddington and Nülle 2014; Ma 2013; Cavalcanti, Mohaddes, and Raissi 2011). Not surprisingly, there is some overlap between the determinants of price level and price volatility. Nevertheless, price levels are predominantly associated with long-term and price volatility with short-term developments.

	Drivers
Price level	- *Materials characteristics and properties* - *Economic growth perspectives (especially in key producer/consumer economies)* - *Investments in supply capacity (i.e. infrastructure, transportation)* - *Exploitation of market power (vertically & horizontally)* - *Input costs (i.e. labour costs, labour supply shortages, infrastructure)* - *Environmental regulation* - *Long-term energy costs* - *Storage capacities* - *Ore grades and related costs for energy and water (especially for metals)* - *Product development*
Price volatility	- *Financialisation (for most commodities since the early 2000s)* - *Short-term costs fluctuations of connected resources (i.e. energy), i.e. resource nexus* - *Shocks to the business cycle* - *Close connection between futures and spot markets (i.e. high-frequency trading)* - *Short-term production interruptions (i.e. strikes, natural disasters, water and electricity shortages, political changes)*

Table 1: Main drivers of the price level and price volatility of materials. Source: Own compilation based on Valiante and Egenhofer (2013).

Figure 3 shows trends of commodity price indices. Starting during the early 2000s, prices have increased significantly followed by a recent downward trend. The structural shift in price levels goes hand in hand with the substantial increase of material consumption by emerging economies. Supply seems to lag behind, for instance due to low investments in the nineties, decreasing ore grades and stricter environmental legislation. Therefore, nominal prices e.g. for copper have more than tripled between the beginning of 2004 and mid-2006. The same amount of increase within those 2.5 years occurred during the 44 years before 2004. Iron ore follows a comparable pattern. The prices quadrupled between 1960 and 2004 – since then they even quintupled. For a limited amount of time (approximately 2004-2006), prices even increased exponentially.

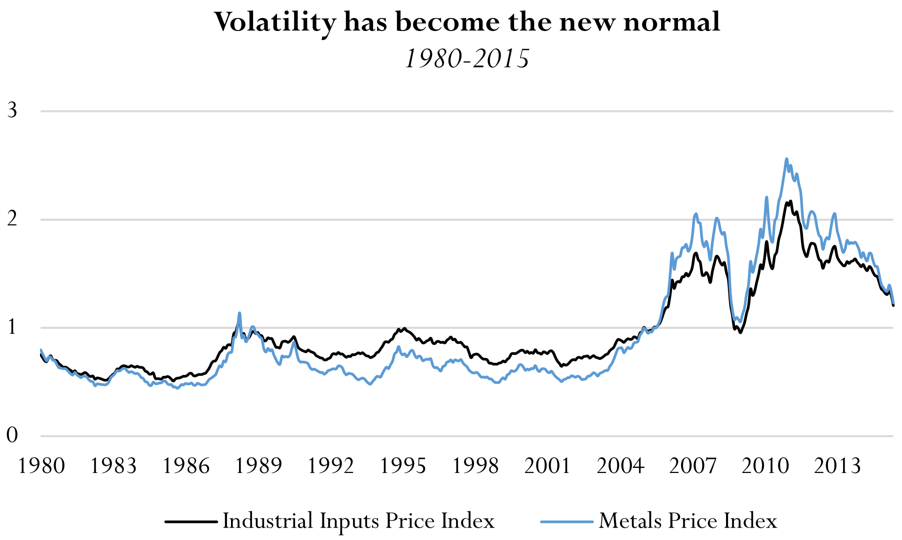

Figure 3: Monthly Industrial Input Price Index includes Agricultural Raw Materials and Metals Price Indices (based on Copper, Aluminium, Iron Ore, Tin, Nickel, Zinc, Lead, and Uranium Price Indices). Prices are non-seasonally adjusted nominal USD and range from 1980 to 2015. The base year for both indices is 2005. Source: IMF.

Once the 2008 financial crisis in the industrialised world turned into a macroeconomic crisis, demand for and trade of materials decreased sharply, also in emerging economies. This economic downturn resulted in a short-run oversupply and lowered expectations initiating a downward spiral of material prices. However, prices did not remain on these lower levels, but increased rapidly again. Currently (2015), prices may seem to be less volatile again, but they remain at higher levels compared to the pre-2000s. What becomes apparent is that material price volatility (Figure 3 shows inter-month volatility) has become the new normal, in line with energy prices (World Energy Council 2015).

Outlook of the commodity markets

What is the outlook for the years to come? The commodity price fluctuations of recent years has lead to market uncertainties about return on investments and the future of the mining industry (Humphreys 2015). Accordingly, exploration budgets have been cut. At a more disaggregated level, one may expect energy prices to stay slightly lower compared to metals and agricultural commodities, which is mainly due to new energy supply coming on stream (offshore oil, unconventional fuels, expansion plans of major suppliers and the likely return of Iran and others, plus an increase in renewable energies); such expansion is unlikely to be mirrored by supply increases in the latter two areas. A key factor is the future development in China and other emerging economies. China steel demand, for instance, seems to face a short-term recession, partly due to weak property markets. In the long-run, it will be essential to see whether countries such as China will continue to catch-up their currently low levels of steel stocks per capita, or to what extent any saturation effects helps to level off demand for materials (Müller, Wang, and Duval 2011).

Generally, changes in material price levels and price volatility are unlikely to disappear in the future. The resulting uncertainties may impose substantial costs on companies and entire economies, thus the need to address these developments become essentially for firms and policy makers. Resource efficiency could serve as one strategy to lower the negative impacts of high and volatile material prices for both companies as well as entire economies while addressing environmental challenges and causing multiple additional benefits (Flachenecker and Rentschler 2015).

The resource efficiency revolution – and the *web of constraints*

Resource efficiency can be seen as a core strategy to decouple the use of material resources from gross domestic product (GDP) and to innovate along the material value chains. Given the considerable rise in material consumption shown above, this seems fundamental. We also propose to see resource efficiency as a strategy to make supply chains more resilient against volatility and other uncertainties. Driven by price increases since the year 2000, efforts by industry and other factors, enhancements of resource efficiency have been labelled as a "revolution" (McKinsey Global Institute 2011). Renewable energies have been pioneering a more general upswing of clean technologies: global wind energy installations have soared about 25% per year since 2006, solar PV even 57% annually; the more recent market consolidation does not break those trends. But there is more to it. New smart products and materials emerge, be it in liquid wood, software-driven reshuffling of metal blankets, or in e-mobility. Eco-innovation clusters emerge around buildings, IT applications, agriculture and food, recycling and industrial symbiosis, water treatment, grid analytics, bio-based materials, etc. New business models are all over: leasing models bring down upfront costs for new treatment facilities and help maintain high-quality machineries, smart sharing services start to replace ownerships especially in urban markets, benefit sharing agreement between companies open the windows for better value chains.

Table 2 shows the wide range of areas for what is called here *CleanTech* covering the traditional environmental technologies, energy, mobility and resources: in a wider understanding of resources indeed all areas could be named resource efficiency.

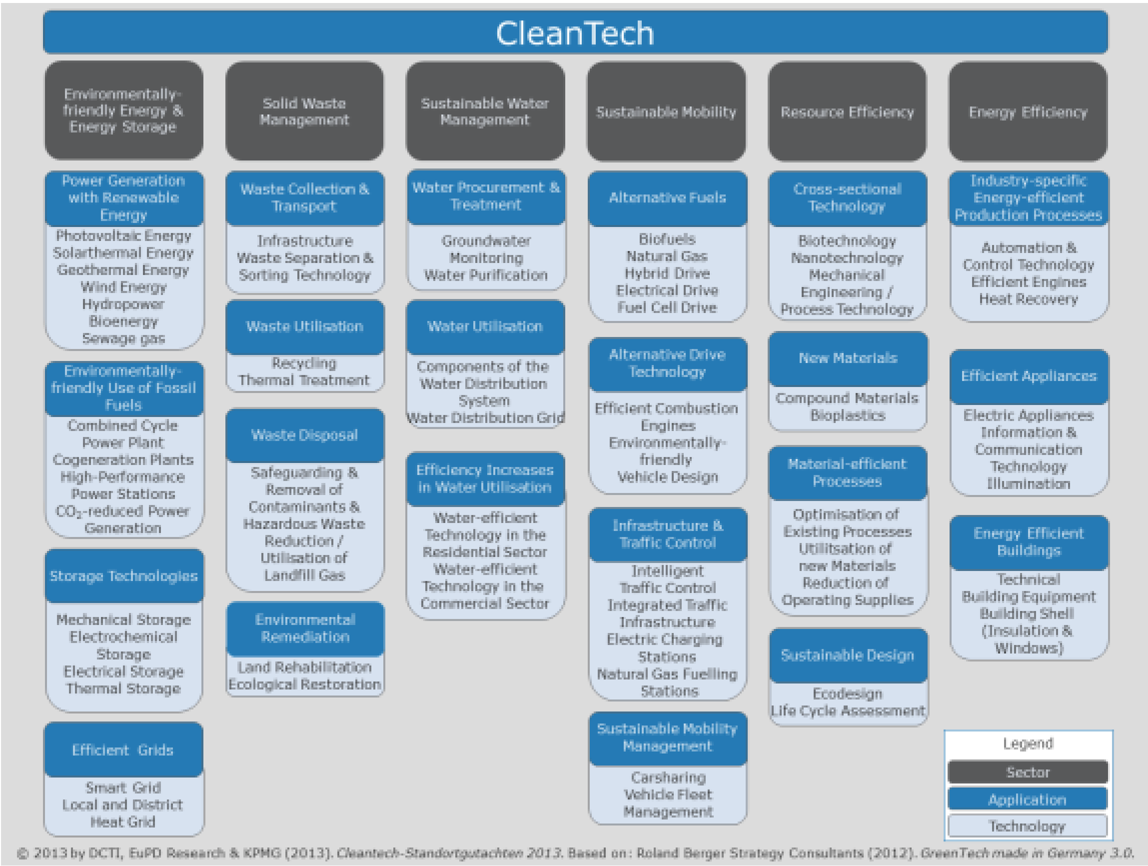

Table 2: Areas of Clean Technologies. Source: DCTI et al. (2013).

Following e.g. the EU Eco-Innovation Observatory, probably the biggest short-term gains are achievable in process innovation, as many companies have not yet fully grasped the opportunities of managing resources more efficiently (Eco-Innovation Observatory 2011; Eco-Innovation Observatory 2012). Piping construction, a key element for infrastructure development, increases resource efficiency by some twenty percent by using re-used offcuts. Given that more than half of European companies are paying at least 30 % of their total costs for their material inputs (higher than some believe!) and analyses validate cost savings in the range from 5 – 20%, there are bills left on the sidewalk that can also be utilised to unleash investments in long-term resource efficiency strategies (EC 2011a; EC 2012; EC

2013b). Generally, investments in resource efficiency tend to yield positive net benefits, both from an economic and environmental perspective (Flachenecker and Rentschler 2015).

The question then arises: why are not all manufacturing companies and economies around the globe using resources more efficiently? Research findings indicate a *web of constraints* – internal barriers within firms and external barriers resulting from both market failures and policy failures (POLFREE, 2013; Flachenecker and Rentschler, 2015; Jordan et al., 2014). A key reason is that resources are so diverse and their market applications, too. It is thus not easy to understand the world of materials from mining onto production and consumption, recycling and waste, with so many heterogeneous infrastructures, products and services involved, plus the behaviour of end users that ultimately drive market expectations. This leads to acknowledge a second main reason: human decision-making usually is not fully rational; it is driven by a bundle of rules, expectations, preferences and motivations. It is thus too easy to imagine one main barrier, or a few main barriers, that ought to be removed by smart market actors and/or policy makers. Rather, research suggests that usually barriers resemble more a complex *web of constraints* that include individual and institutional behavioural patterns, inertia and direct and indirect interconnections between the institutional, social and individual levels (POLFREE 2014a).

Figure 4 summarises a number of such barriers as well as drivers at the firm level and illustrates the increasing importance of ‚external' factors at the level of markets and institutional frameworks rather than within business itself. It is, however, also important to recognise the multiplier effect stemming from volatile commodity markets and uncertain market expectations in the future: R&D and investments into new resource-efficient products and ‚systemic eco-innovations'[2] are more likely to be postponed or stuck at niche markets, as the mass market roll out is much more risky than experimenting in a niche, which translates into reluctance from financial investors and policy makers alike to support financing and a more stabile market demand. Thinking about how such *web of constraints* can be overcome and how promising good examples can be scaled up towards mass markets at an international scale is probably a key issue for development cooperation in the years ahead. In a wider sense, the notion of a *web of constraints* underlines the necessity more collaborative action, possibly at an international scale, and oriented towards long-term common goals.

[2] Defined as "a series of connected changes improving or creating novel functional systems that reduce use of natural resources and decreases the release of harmful substances across the whole life cycle"; see (EC 2015, 11). The cited report provides a systemic perspective on eco-innovation.

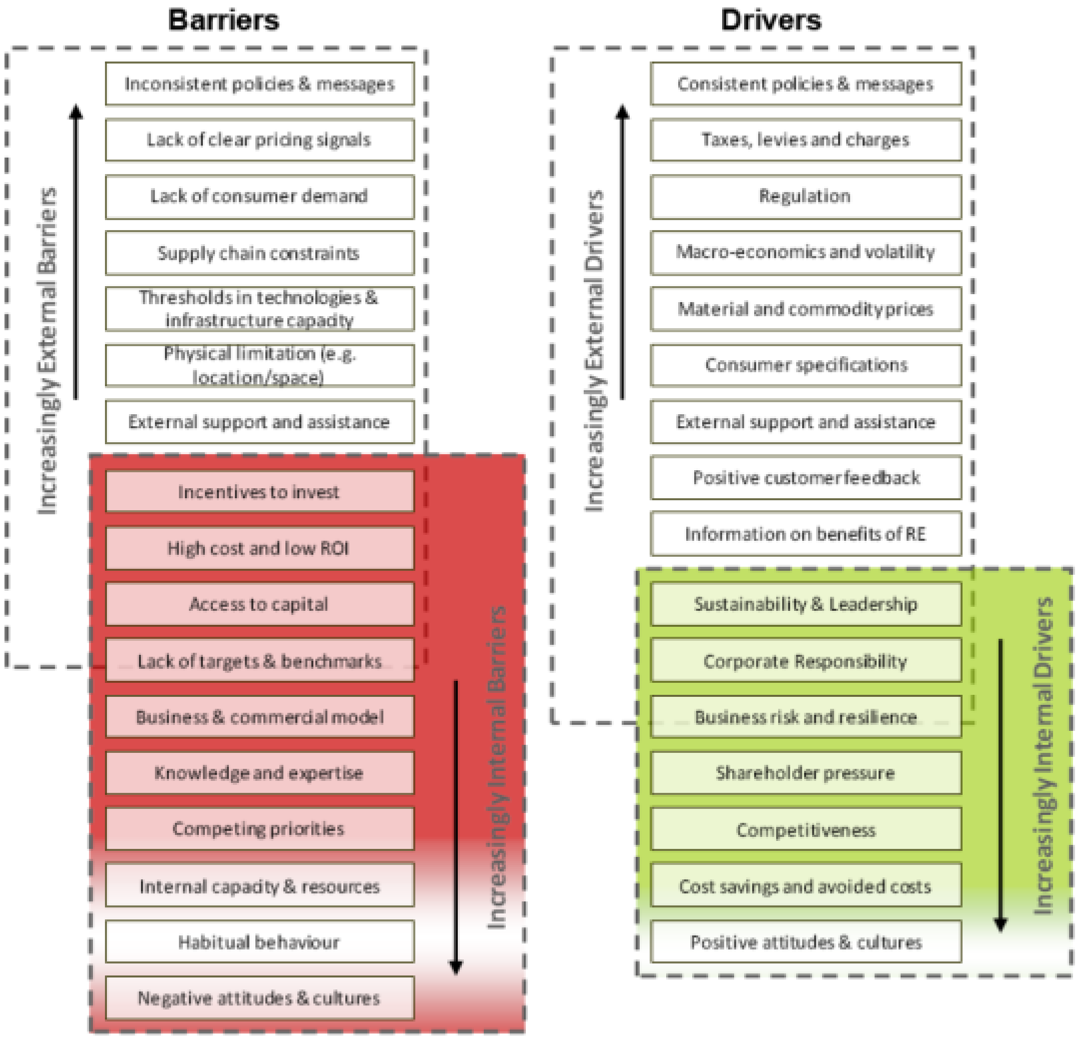

Figure 4: Why Have Resources Been Used Inefficiently? Barriers and Drivers. Source: POLFREE (2014b).

The search for strategies to unleash resource efficiency thus should address a multitude of actors and incentives, possibly along a timeline with innovative niches to be created and processes of a broader transformation towards mass markets being pursued step-by-step.

Cross-country gaps in resource efficiency

The implications of a *web of constraints* undermining and obstructing efforts to increase resource efficiency implies differences across industries and countries, depending on the severity and interlinkages between such constraints. We aim to present an indication for such heterogeneity using a comparative empirical analysis on the macroeconomic level.

Table 2 below reveals significant gaps in resource efficiency performances across a number of countries. Between 1992 and 2009, the UK for instance more than doubled its resource efficiency whereas countries such as Egypt, FYR Macedonia and Morocco remained at their 1992 levels. In terms of productivity increase, Bosnia and Herzegovina, Armenia and the Russian Federation among others outperformed the USA, Germany and Finland. Generally, the Europe and Central Asia and Middle East and Northern Africa regions performed better in terms of material efficiency improvements relative to Latin America and the Caribbean (West and Schandl 2013).

However, considering absolute material productivity, the picture turns. The *MP*-column in Table 2 provides an insight into absolute material productivity (GDP/DMC). Comparing the productivity measures for the UK, Germany and the USA with most other countries in Table 2 reveal a substantial productivity gap. The first non-EU country, Turkey, is less than one-fifth as productive as the UK. The USA is more productive than China by a factor of about 13. However, any such gaps should not be interpreted as definite and exact measures, but as a general benchmark as the underlying data comes with uncertainties.

	RE *thousand USD per tonne*	***1992-2009*** *% RE-change*	***Industry*** *% of GDP*	***Natural resources*** *% of GDP*
United Kingdom	3.92	106	21	1.2
Germany	2.30	50	30	0.2
USA	2.04	52	20	1.3
Croatia	1.27	14	26	1.6
Slovakia	1.06	44	31	0.7
Finland	1.05	49	25	1.4
Hungary	1.04	55	28	0.9
Slovenia	0.94	23	29	0.4
Lithuania	0.87	75	28	1.0
Latvia	0.78	31	26	2.6
Turkey	0.75	30	27	0.7
Poland	0.58	65	33	1.9
Romania	0.52	39	37	2.8
Russian Federation	0.51	77	38	18.7
Tunisia	0.45	29	30	7.4
Georgia	0.41	20	22	0.9
Estonia	0.40	23	30	2.6
Albania	0.36	11	15	5.5
Bosnia and Herzegovina	0.34	88	26	2.3
Belarus	0.34	75	46	2.5
Azerbaijan	0.33	39	63	39.8
Armenia	0.32	80	37	5.2
Serbia (and Montenegro)	0.32	75	32	4.3
Jordan	0.32	40	30	2.8
Morocco	0.32	6	32	5.0
Turkmenistan	0.29	36	24	34.4
Bulgaria	0.27	26	30	2.8
Ukraine	0.25	44	30	4.6
FYR Macedonia	0.25	7	28	3.9
India	0.22	57	17	5.6
Moldova	0.21	31	20	0.5
Egypt	0.19	7	38	11.9
Kazakhstan	0.18	72	38	32.1
China	0.16	50	45	5.8
Kyrgyz Republic	0.11	36	34	15.0
Mongolia	0.04	52	33	28.7

Table 2: Cross-country gaps in resource efficiency and the role of key sectors. Absolute resource efficiency (RE) in 2009, the increase in resource efficiency in 2009 compared to 1992 in percentage, the contribution of the industrial sector to total GDP in percentage for 2013 and the percentage of rents from natural resources (oil, gas, coal, minerals, and forest rents) as part of a country's GDP in 2012. The industrial sector includes mining, manufacturing, energy production, and construction. Material productivity is measured as the ratio between GDP (in thousand constant 2005 USD) and DMC (in tonnes). Sources: World Bank, SERI, own calculations.

Four aspects can explain part of the story behind these substantial differences across countries. Firstly, a material-intensive economic structure correlates with low resource efficiency performance. This may partly be explained by statistical issues, i.e. the primary sector driving GDP and DMC upwards simultaneously, whereas the tertiary sector may increase GDP more than DMC. Additionally, a strong mining sector may trigger *Dutch Disease* issues, i.e. the macro-economics and political economy in those countries that have been focusing on the core business of 'getting the stuff out of the ground' may be more exposed to such macroeconomic developments (Gylfason, Herbertsson, and Zoega 1999). Secondly, as industrialised countries tend to import resource-intensive goods there is a bias and a potential burden-shifting associated with the international division of labour. With other words: the success of some countries is complemented by more resource-intensive patterns in others (Wiedmann et al. 2013). Thirdly, the resource efficiency agenda has been driven by environmental policy considerations e.g. in the EU (EC 2011b) and Germany (BMUB 2015), a factor that is less visible in a number of other countries. Fourthly, one may question whether resource-intensive economies may ever be able to follow pathways towards a service economy, and why they should do so (World Bank 2014). The latter indeed is a broader debate, which we will continue below and is also subject of other chapters in this book.

Nevertheless, the point to make is that such significant gaps exist despite data uncertainties and thus development cooperation has a role to play in overcoming gaps and improving resource efficiency not only within individual countries, but taking into account all repercussions arising in a globalised world.

Towards a coherent policy framework for resource efficiency

From the analysis above and the lessons learned, resource efficiency needs a policy framework to overcome the *web of constraints* resulting from a double motivation: (i) addressing environmental constraints and (ii) fostering value creation by facilitating innovation (Bleischwitz 2012). Key pillars of the approach are shown in Figure 5. Such policy framework is best conceptualized as a collaborative effort in a most coherent perspective done at multiple scales and involving a number of actors, all supported by evidence-based research, rather than an heroic attempt to develop and implement any 'optimal' solution.

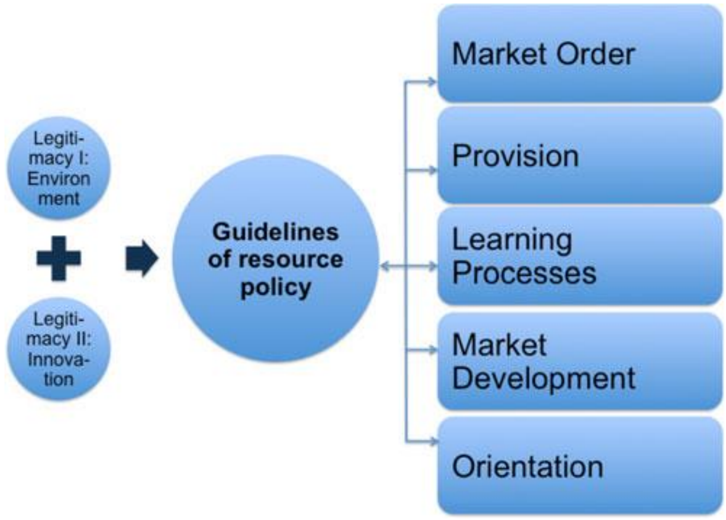

Figure 5: key pillars of a resource efficiency policy agenda. Source: Bleischwitz (2012).

One key element of the policy framework proposed is to establish a 'market order' that sets the framework conditions for an efficient use of resources. This requires internalisations of externalities through a regulatory regime based on the *polluter pays principle* and at an international scale *precautionary principles*, and the definition of instruments that foster eco-design of products and producer responsibility throughout the whole life cycle of product and services. Other important framework conditions are e.g. the removal of environmentally harmful subsidies and could include a transition to leasing models, in which producer maintain stewardship for the materials contained in products so that they can be re-used, re-manufactured or recycled at the end of their use; depreciation models; and accounting rules to create more even conditions for new business models based on performance rather than ownership. Setting such a 'market order' right is crucial in the case of lower middle income (LMI) countries with weak institutional set-ups and underdevelopment of environmental policy frameworks to correct prevailing market failures. In the case of resource-rich developing countries, extraction taxes together with international partnerships, greater transparency on the part of extractive industries (Bleischwitz 2014) and green sovereign wealth funds can apply resource efficiency to the primary sector while generating revenues that could foster education and health systems to increase the absorption capabilities of the country and overcome the institutional failures known as *resource curse*.

The second pillar of the framework proposed is 'provision'. This refers to the need to tackle information and knowledge deficits that prevent a more efficient use of resources and a better understanding of the resource interlinkages. This could take the shape of open access data sources such as a data hub on the *resource nexus* (Andrews-Speed et al. 2014) in collaboration with existing geological surveys and collaborate on defining coefficients for resource inputs across main interlinkages, benchmarks on resource productivity, main environmental pressure indicators and data at the sectoral, national and regional level of material flows and opportunities for optimisation. Indeed, existing providers such as the Green Growth Knowledge Platform or the Natural Resource Governance Institute could be helpful for such endeavour.

Information and new data per se are insufficient unless they are accompanied by learning processes that increase the knowledge base on sustainable practices of resource use, facilitates knowledge transfer and capacity building at the local level and facilitates learning both through formalised processes such as improved education systems, but also through collaborative learning at the level of firms and industries through processes such as benchmarking, reporting guidelines, audit tools, or business platforms. This is especially relevant for LMI countries where learning processes may not be well established and there is often a lack of institutional support for inter-company collaboration and learning.

Another key pillar of an eco-innovation strategy oriented towards resource efficiency is 'market development' trough policies that foster sustainable manufacturing and the uptake of new and radical innovations and foster transitions, where resources are used in cyclical loops that helps them to retain their highest value for as long as possible and remain in the productive systems through recycling and recovery processes. Using renewable energies as a striking example, Pegels (2014) identifies the drivers and success factors of a green industrial policy, which seeks to reconcile the synergies and trade-offs, which exist between economic and environmental goals. At a future international level this could crystallise into international covenants for promoting sustainable patterns of resource management, including extraction and recycling. Recycling of metals and other valuable resources contained in e-waste should in principle provide win-win opportunities. Another waste stream of potential interest would be used cars, that as it occurs with e-waste tend to be exported as second hand goods from developed to less developed countries, where end-of-life treatment is poor and not well managed. Wilts and Bleischwitz (2012) propose the creation of a metal covenant based on a private law contract between manufacturers, recyclers and relevant authorities in destination countries. This could bring benefits at both ends of the supply chain and create incentives for eco-design of products as the *producer responsibility principle*, which is in place in Europe and other developed countries would not be undermined by exports.

In the long-term, though, Bleischwitz (2012) also proposes the creation of an international convention for sustainable resource management that would provide legal support at the international level for a better and more transparent management of natural resources and the creation of national and regional raw material funds, with a focus on resource-rich countries, to ensure that yields from extractive industries contribute to national/regional development and activities are based on a sustainable management of resources and introduction of resource efficient production patterns. This could be supported by the design of 'roadmaps for sustainable resource management' as bilateral or multilateral agreements between developed nations and BRICS (Bleischwitz 2012).

Finally, 'orientation' refers to the need to establish long-term visions of sustainable development and resource efficiency at the global and regional level that provide guidance for policy design and target setting to move towards more circular, resource efficient and low carbon systems by collaborating towards certainty and guidance. Looking at international policy trends, such orientation is also needed to align the manifold mining visions with the circular economy and the wider aims of coping with the planetary boundaries. The WBCSD Vision 2050 was a useful step in such direction, and it might now be time to establish an international process along with the Sustainable Development Goals (SDGs) that could align the various resource futures around the globe (WBCSD 2010).

Last but not least, as one would not expect one single policy instrument to be successful, *policy mixes* at a multitude of levels are needed in managing the global transition from current unsustainable consumption and production patterns towards green growth and poverty eradication. For sure, to manage such global transition policies are well advised to establish social contracts with their people and major stakeholders that are able to overcome barriers and unleash the potential of systemic eco-innovations. Given the variety of systems around the world, the interplay between actors and institutions at different levels will likely lead to quite different resource futures (see fig 6, see also Lee et al. 2012).

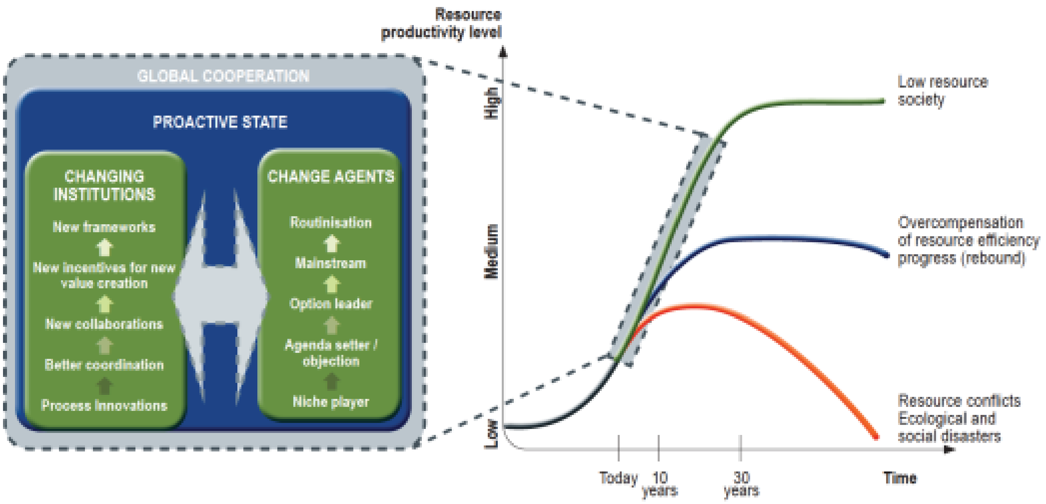

Figure 6: The role of institutions and actors in shaping resource efficiency. Source: Eco-Innovation Observatory (2012, 34), adapted from WBGU (2011).

What's next? The SDGs, an emerging international alliance and the *resource nexus*

Following our empirical analysis, up to now resource efficiency has mainly been an issue for some manufacturing industries in industrialised countries, especially those concerned with commodity prices and oriented towards consumers with environmental awareness. Those companies have improved their production processes and started to offer smarter products to their customers, which translates into a 'better' performance compared to other countries. Accordingly, the attempts to decouple resource use from GDP and create a green growth have not yet been successful at an international scale.

However, those active companies move ahead and have started to improve resource efficiency along their supply chains and collaborate with others for market development. The 2015 newly established G7 Alliance on Resource Efficiency aims to promote an exchange of concepts on how to address the challenges of resource efficiency, to share best practices and experience, and to create information networks (G7 2015a; G7 2015b). It plans a series of workshops and has invited the UNEP International Resource Panel to prepare a synthesis report highlighting the most promising potentials and solutions for resource efficiency in industrialised countries, emerging market economies and developing countries. The OECD will also support this process. In line with these efforts, the 2014 Manifesto of the European Resource Efficiency Platform calls for at least a doubling of resource efficiency compared to pre-crisis trend and develops policy pillars to unleash such dynamics (European Resource Efficiency Platform 2014). Such proposals are mirrored by national resource efficiency strategies. The Global Reporting Initiative, amongst others, calls for more stringent policies.

One may conclude that resource efficiency seem to arrive at the international level. It will be interesting to compare the recent launch of the new sustainable development goals with such efforts. In our view, the new SDGs (as approved in September 2015) are likely to have major implications for future resource markets. However, those implications are mixed:

On the one hand, many of the new SDGs will lead to an increase in demand for a number of materials:

- Goal 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture“ implies increasing demand for land, mineral fertilisers, water, biomass and food.
- Goal 6: "Ensure access to water and sanitation for all“ implies investments in water supply and a water distribution infrastructure, i.e. increasing demand for materials.

- Goal 7: "Ensure access to affordable, reliable, sustainable and modern energy for all" is likely to imply increasing demand for bio-energy and renewable energy, plus more traditional energy sources, which again implies more demand for land, biomass, water and materials.
- Goal 9: "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" will require more construction materials, metals and other materials.

Adding the promotion of economic growth to it, as well as efforts to eradicate hunger and enhance health, the signals for future demand stemming from the SDGs for materials are clearly upwards. At least for key metals (aluminium, iron ore, copper and nickel, which altogether make up for more than 80% of world production of metals), for construction minerals and for biomass, the SDGs are very likely leading to new and additional demand compared to business as usual forecasts. The situation for energy fuels is less straightforward as climate policy will probably lead to restrictions for using fossil fuels, if political efforts succeed, although major suppliers may not join any future international agreement and have announced plans to expand production; if prices for fossil fuels stay low, efforts to curb demand will be difficult to achieve.

On the other hand, the SDGs also endorse the sustainable production and consumption agenda, and call for global increases in resource efficiency as well as for aims to achieve sustainable and resource-efficient infrastructures by 2030 (Goal 9) and sustainable management and efficient use of all resources by 2030 (Goal 12). Moreover, they aim to "improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation (…)" (Goal 8).

The balance between such expected demand increases and other goals however is not entirely clear, in particular as key terms (such as sustainable management and efficient use of all resources) are insufficiently defined and will leave space for quite different implementation pathways. More research will thus be required to develop principles for a sustainable management of resources and to understand future dynamics on commodity markets.

The well-established principles of shifting the resource base from using non-renewable resources onto renewable resources (Daly 1990; Pearce and Turner 1990) are often quoted in the public debate and may drive a number of policies, yet they have been critically re-examined. Environmental research reveals very limited capacities of eco-systems to provide additional renewable resources at a large scale (Rockström et al. 2009; Steffen et al. 2015). The seven principles developed by Bringezu and Bleischwitz (2009, p. 8) instead focus on increasing resource efficiency and assume that non-renewable resources will maintain to have a share in providing materials (albeit possibly a smaller one compared to today); they are as follows:

1. Secure adequate supply and efficient use of materials, energy and land resources as reliable biophysical basis for creation of wealth and well-being in societies and for future generations.
2. Maintain life-supporting functions and services of ecosystems.
3. Provide for the basic institutions of societies and their co-existence with nature.
4. Minimise risks for security and economic turmoil due to dependence on resources.
5. Contribute to a globally fair distribution of resource use and an adequate burden sharing.
6. Minimise problem shifting between environmental media, types of resources, economic sectors, regions and generations.
7. Drive resource productivity (total material productivity) at a rate higher than GDP growth.

An interesting discussion therefore is related to the *saturation effect* in societies, i.e. a stage in development when a capital stock (housing, infrastructures, manufacturing industry etc.) will have been build up and countries will be able to increase GDP without further major increase in resource use. As most minerals and metals can potentially be subject to advanced recycling processes, societies may be able to provide more and more materials from secondary sources and, accordingly, establish a circular economy based on a low material input and throughput.

A more recent discussion is related to resource interlinkages, often referred to as the *resource nexus* (Hoff 2011; Andrews-Speed et al. 2012; Andrews-Speed et al. 2014). The *resource nexus* is a set of interactions between two or more natural resources used as inputs into socio-economic systems. Those interactions are manifold, as one resource input requires others and one system can impact one or many other systems, accordingly there can be tensions, trade-offs as well as synergies. The nexus approach is an understanding of such interactions and interdependencies across natural resource inputs for socio-economic systems in order to be able to increase the efficiency of resource use and to ensure a sustainable and secure supply of natural resources. Although the scope of analysis may differ, a five-node nexus (water, energy carriers, biomass and food, land, minerals, see fig. 7) can be considered useful for general purposes. In our view, the nexus research can

- apply research findings on constraints at the output side ('limited absorptive capacities of ecosystems') to analyse and assess implications on the use of resources and
- originate new knowledge on constraints at the input side (e.g. due to increasing energy- and water-intensity of extraction) and conclude on implications for the supply and use of resources.

Going forward, the nexus research may be able to close the gaps between the three different research streams on ecosystem services and natural capital, research on commodities, material flows and various footprints tracked through economies, and research on security issues.

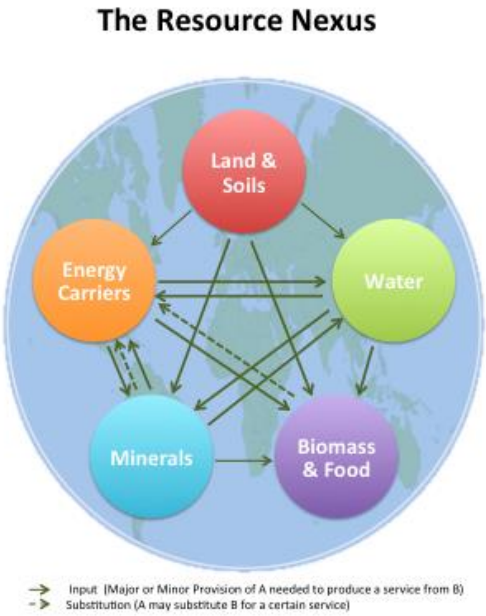

Figure 7: The resource nexus. Adapted after: Andrews-Speed et al. (2012)

The *resource nexus* approach can be well applied to local conditions and by ‚actors on the ground'; it is thus gaining momentum and probably a useful tool in improving development cooperation in the area of sustainable management of resources.

Outlook

Despite commodity prices being lower than a few years ago (but still higher compared to previous decades), it is quite clear that any development cooperation agenda needs a strong angle on natural resources. Both the socio-economic importance and the environmental dimension underline the need to enhance resource efficiency efforts, especially given the raise in material consumption that is likely to prevail in the future. Those efforts may start at the level of manufacturing industries their processing innovation in order to save costs, but they may well go beyond and address resource interlinkages along supply chains and should try to develop new sustainable products and services. Yet, ongoing efforts are visible but will need more backing through development cooperation in order to bring actors together and address institutional issues. It is also clear that the new SDGs will lead to trade-offs with aims of sustainable resource management, if no such reconciliation takes place. Thus, we expect vital debates about the resource dimension of sustainable development in the years to come.

References

Andrews-Speed, Philip, Raimund Bleischwitz, Tim Boersma, Corey Johnson, Geoffrey Kemp, and Stacy D. VanDeveer. 2012. *The Global Resource Nexus: The Struggles for Land, Energy, Food, Water, and Minerals*.

———. 2014. *Want, Waste Or War?: The Global Resource Nexus and the Struggle for Land, Energy, Food, Water and Minerals*. London, UK: Routledge.

Bleischwitz, Raimund. 2012. "Towards a Resource Policy - Unleashing Productivity Dynamics and Balancing International Distortions." *Mineral Economics Vol. 24, No. 2-3, pp. 135 – 144, http://dx.doi.org/10.1007/s13563-011-0014-5*

Bleischwitz, Raimund. 2014. Transparency in the extractive industries: time to ask for more, in: Global Environmental Politics, 14:4, November 2014, doi:10.1162/GLEP_e_00254

BMUB (Bundesministerium für Umwelt und Bauen=. 2015. "Deutsches Ressourceneffizienzprogramm (ProgRess) II: Fortschrittsbericht 2012 – 2015."

Bringezu, Stefan, and Raimund Bleischwitz. 2009. *Sustainable Resource Management - Global Trends, Visions and Policies*. Greenleaf Publisher.

Bringezu, Stefan, Helmut Schütz, Sören Steger, and Jan Baudisch. 2004. "International Comparison of Resource Use and Its Relation to Economic Growth." *Ecological Economics* 51 (1-2) (November): 97–124. doi:10.1016/j.ecolecon.2004.04.010.

Cavalcanti, Tiago V De V, Kamiar Mohaddes, and Mehdi Raissi. 2011. "Commodity Price Volatility and the Sources of Growth" (January).

Cuddington, John T., and Grant Nülle. 2014. "Variable Long-Term Trends in Mineral Prices: The Ongoing Tug-of-War between Exploration, Depletion, and Technological Change." *Journal of International Money and Finance* 42: 224–252. doi:10.1016/j.jimonfin.2013.08.013.

Daly, Herman E. 1990. "Toward Some Operational Principles of Sustainable Development." *Ecological Economics* 2 (1): 1–6. doi:10.1016/0921-8009(90)90010-R.

DCTI, EuPD Research, and KPMG. 2013. "Cleantech-Standortgutachten 2013."

EC (European Commission). 2011a. "Attitudes of European Entrepreneurs towards Eco-Innovation."

———. 2011b. *Roadmap to a Resource Efficient Europe*.

———. 2012. "SMEs, Resource Efficiency and Green Markets."

———. 2013a. "Material Flow Accounts." Vol. 2009.

———. 2013b. "SMEs, Resource Efficiency and Green Markets."

———. 2015. "From Niche to Norm - Suggestions by the Group of Experts on a 'Systemic Approach to Eco-Innovation to Achieve a Low-Carbon, Circular Economy.'" Brussels, Belgium.

Eco-Innovation Observatory. 2011. "The Eco-Innovation Challenge - Pathways to a Resource-Efficient Europe."

———. 2012. "Europe in Transition: Paving the Way to a Green Economy through Eco-Innovation."

Economy, Elizabeth, and Michael Levi. 2014. *By All Means Necessary: How China's Resource Quest Is Changing the World*. Oxford University Press, USA.

Ecorys. 2012. "Mapping Resource Prices : The Past and the Future Final Report."

European Resource Efficiency Platform. 2014. "Manifesto & Policy Recommendations."

Flachenecker, Florian, and Jun Erik Rentschler. 2015. "Investments in Resource Efficiency - Costs and Benefits, Investment Barriers, Intervention Measures." London, UK.

G7. 2015a. "Leaders' Declaration G7 Summit 7-8 June 2015." Schloss Elmau.

———. 2015b. "Annex to the Leaders' Declaration G7 Summit 7-8 June 2015." Schloss Elmau.

Gylfason, Thorvaldur, Tryggvi Thor Herbertsson, and Gylfi Zoega. 1999. "A Mixed Blessing - Natural Resources and Economic Growth." *Macroeconomic Dynamics* 3: 204–225.

Hoff, Holger. 2011. "Understanding the Nexus. Background Paper for the Bonn 2011 Nexus Conference." *Stockholm Environment Institute* (November): 1–52.

Humphreys, David. 2015. "The Remaking of the Mining Industry." London, UK: Palgrave Macmillan.

IPCC. 2007. "Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change Summary: Summary for Policymakers."

Jordan, Nino David, Thomas Lemken, and Christa Liedtke. 2014. "Barriers to Resource Efficiency Innovations and Opportunities for Smart Regulations – the Case of Germany." *Environmental Policy and Governance* (March 4). doi:10.1002/eet.1632.

Lee, B., Preston, F., Kooroshy, J., Bailey, R., & Lahn, G. (2012). Resources futures. A Chatham House report. London: Royal Institute of International Affairs.

Lutter, Stephan, Stefan Giljum, and Mirko Lieber. 2014. "Global Material Flow Database Technical Report."

Ma, Yiqun. 2013. "Iron Ore Spot Price Volatility and Change in Forward Pricing Mechanism." *Resources Policy* 38 (4) (December): 621–627. doi:10.1016/j.resourpol.2013.10.002.

McKinsey Global Institute. 2011. "Resource Revolution: Meeting the World's Energy, Materials, Food, and Water Needs."

Moll, S, S Bringezu, and H Schütz. 2005. "Resource Use in European Countries - An Estimate of Materials and Waste Streams in the Community, Including Imports and Exports Using the Instrument of Material Flow Analysis."

Müller, Daniel B., Tao Wang, and Benjamin Duval. 2011. "Patterns of Iron Use in Societal Evolution." *Environmental Science and Technology* 45 (1): 182–188. doi:10.1021/es102273t.

Pearce, David W., and Kerry R. Turner. 1990. "Economics of Natural Resources and the Environment." JHU Press.

Pegels, Anna. 2014. *Green Industrial Policy in Emerging Countries*. Routledge.

POLFREE (EU project "Policy Options for a Resource-Efficient Europe"). 2014. "D1.7 Synthesis report and conclusions abaut drivers and barriers." Lead authors: Rene Kemp, Mark Dijk, Teresa Domenech, http://www.polfree.eu/publications/publications-2014/1.7

———. 2014a. "D1.6 Individual Behavioural Barriers to Resource-Efficiency." Lead author: Moritz Kammerlaender, http://www.polfree.eu/publications/publications-2014/individual-behavioural-barriers-to-resource-efficiency

———. 2014b. "D1.5 Business Barriers to the Uptake of Resource Efficiency Measures." Authors: Ton Bastein et al. http://www.polfree.eu/publications/publications-2014/Report_1.5_Business_Barriers_final_new_disclaimer.pdf

Rockström, Johan, Will Steffen, Kevin Noone, Åsa Persson, Stuart Chapin, Eric F. Lambin, Timothy M. Lenton, et al. 2009. "A Safe Operating Space for Humanity." *Nature* 461 (September). doi:10.1038/461472a.

Steffen, Will, Katherine Richardson, Johan Rockström, Sarah Cornell, Ingo Fetzer, Elena Bennett, R. Biggs, et al. 2015. "Planetary Boundaries: Guiding Human Development on a Changing Planet." *Science* 347 (6223). doi:10.1126/science.1259855.

Steinberger, Julia K., Fridolin Krausmann, and Nina Eisenmenger. 2010. "Global Patterns of Materials Use: A Socioeconomic and Geophysical Analysis." *Ecological Economics* 69 (5) (March): 1148–1158. doi:10.1016/j.ecolecon.2009.12.009.

UNEP (United Nations Environment Programme). 2014. "Sustainable Consumption and Production - Targets and Indicators."

UNEP IRP (International Resource Panel). 2010. *Assessing the Environmental Impacts of Consumption and Production - Priority Products and Materials*.

Valiante, D, and C Egenhofer. 2013. "Price Formation in Commodities Markets: Financialisation and Beyond." *Report of an ECMI/CEPS Task* ….

WBCSD (World Business Council for Sustainable Development). 2010. "Vision 2050 - the New Agenda for Business." Geneva, Switzerland. doi:10.1111/j.1530-9290.2009.00117.x.

WBGU (Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen). 2011. *World in Transition—A Social Contract for Sustainability. German Advisory Council on Global Change (WBGU)*. Berlin, Germany.

http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:World+in+Transition.+A+Social+Contract+for+Sustainability#0.

Weinzettel, Jan, and Jan Kovanda. 2011. "Structural Decomposition Analysis of Raw Material Consumption." *Journal of Industrial Ecology* 15 (6) (December 7): 893–907. doi:10.1111/j.1530-9290.2011.00378.x.

West, James, and Heinz Schandl. 2013. "Material Use and Material Efficiency in Latin America and the Caribbean." *Ecological Economics* 94 (October): 19–27. doi:10.1016/j.ecolecon.2013.06.015.

Wiedmann, Thomas O, Heinz Schandl, Manfred Lenzen, Daniel Moran, Sangwon Suh, James West, and Keiichiro Kanemoto. 2013. "The Material Footprint of Nations." *Proceedings of the National Academy of Sciences of the United States of America* (September 3). doi:10.1073/pnas.1220362110.

Wilts, Henning, and Raimund Bleischwitz. 2012. "Combating Material Leakage: A Proposal for an International Metal Covenant." *Sapiens* 4 (2).

World Bank. 2014. "Diversified Development - Making the Most of Natural Resources in Eurasia."

World Energy Council. 2015. "2015 World Energy Issues Monitor - Energy Price Volatility: The New Normal." London, UK.