Globelics Seminar: From resource based to knowledge based economic development

Copenhagen, March 26-27, 2014

Do the different narratives about raw materials supply and use add up to a promising Natural Resource Based Development Scenario?

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March 2014

Abstract:

Since a few years, natural resources are back in the public policy debate. This is evident in the debate about the future use and opportunities of raw materials, especially metals. However, this increased interest is triggered by various rationales, and is taking place in very different arenas. From the perspective of developing economies, strategies of natural resource based development (NRBD) can only be successful if they are robust with regard to resource strategies and related innovations occurring on a global scale. The paper presents five different narratives about metal resource supply and use, and contrasts them with each other. Matching the prospect of NRBD with other narratives provides a differentiated picture. The advantages might be less broad than a first glimpse seems to promise. A successful strategy should account for environmental and social aspects, and identify the segments of the market which are likely to grow and fit the national capabilities. Given to the diversity of the mining sector in developing countries, it will be a key challenge to transform economic success of a NDBR also to an inclusive development of the part of the population which depend on artisanal and small scale mining.

1 Introduction

Since a few years, natural resources are back in the public policy debate. This is evident in the debate about the future use and opportunities of raw materials, especially metals. However, this increased interest is triggered by various rationales, and is taking place in very different arenas. From the perspective of developing economies, strategies of natural resource based development (NRBD) can only be successful if they are robust with regard to resource strategies and related innovations occurring on a global scale. The paper will present various rationales and narratives which exist for future raw material supply and use, and will contrast them with each other, in order to figure out if they add up to a consistent story, or if they provide conflicting views about the future of raw materials.

The next chapters look into five different rationales, which relate to economic, environmental and social dimensions:

- Technical characteristics, which influence availability and importance of raw materials.
- Environmental aspects, related to mining and use of material.
- Economic considerations from the perspective of developed countries, which focus on market disequilibria, price volatility and access to natural resources.
- Economic considerations from the perspective of emerging and developing countries, which focus on the potential to develop along a natural resources base.
- Social dimension, which focus on improving living conditions in developing countries.

The last chapter will deal with the question how the different perspectives add up with regard to future development of natural resource based development.

2 Technical characteristics of raw material

The publication of the Club of Rome on the limits to growth in 1972 pushed the debate about geological limits of resources to the forefront. Recently, this debate is taken up in the discussion about peak oil. First publications transfer this debate also on natural resources. The main criticism of the peak oil and minerals position argues that technological development and economic mechanisms are not to be taken sufficiently into account. However the outcome of this debate will be: In general, geological scarcity of metals is seen less as a problem today (e.g. Poulton et al. 2013, Graedel et al. 2014). However, lower metal ore contents will make it likely that the costs of mining metals will increase in the long run (Humphreys 2014).

The availability of metals is seen as a problem of adjustments between supply and demand. An increase in demand is occurring, on the one hand, due to fast growth in emerging economies. On the other hand, increase in demand for some metals is also occurring due to specific technological development. Increasing the functionality of products also leads to increasing the variability of metals which are used. A computer chip, for example consisted of 12 elements in the 1980s. Currently there are around 50 different elements used (NRC 2008). Increasing heterogeneity of materials use is triggered by employing very specific material characteristics. However, if these specific characteristics can only be fulfilled by one or few metals, these metals tend to become indispensable, because they cannot be substituted. Forecasting studies show that especially various key future technologies depend on some specific metals: A study analyzing material demand for 32 future technologies shows that the demand for these technologies alone is likely to exceed total current world supply for Gallium, Indium, Scandium, Germanium, Platinum und Neodymium (Angerer et al. 2009; Marscheider-Weidemann et al. 2011; see also Table 1). Thus, the specific characteristics of some metals have led to a renewed debate about availability of metals.

Table 1: Raw material demand for 32 selected technologies in 2006 and in 2030 in relation to world supply in 2006

Raw material	2006	2030	Emerging technologies (selected)
Gallium	0.28	6.09	Thin layer photovoltaics, IC, WLED
Neodymium	0.55	3.82	Permanent magnets, laser technology
Indium	0.40	3.29	Displays, thin layer photovoltaics
Germanium	0.31	2.44	Fibre optic cable, IR optical technologies
Scandium	low	2.28	SOFC, aluminium alloying element
Platinum	low	1.56	Fuel cells, catalysts
Tantalum	0.39	1.01	Micro capacitors, medical technology
Silver	0.26	0.78	RFID, lead-free soft solder
Tin	0.62	0.77	Lead-free soft solder, transparent electrodes
Cobalt	0.19	0.40	Lithium-ion batteries, synthetic fuels
Palladium	0.10	0.34	Catalysts, seawater desalination
Titanium	0.08	0.29	Seawater desalination, implants
Copper	0.09	0.24	Efficient electric motors, RFID
Selenium	low	0.11	Thin layer photovoltaics, alloying element
Niobium	0.01	0.03	Micro capacitors, ferroalloys
Ruthenium	0	0.03	Dye-sensitized solar cells, Ti-alloying element
Yttrium	low	0.01	Super conduction, laser technology
Antimony	low	low	ATO, micro capacitors
Chromium	low	low	Seawater desalination, marine technologies

Source: Angerer et al. 2009

3 Environment – natural resource nexus

Mining and refining of metal resources lead to substantial environmental effects. There are emissions during operation of mining, but also from tailings leading to pollution of water and negative effects on biodiversity. The deposition of waste and tailings from mining has been increasing continuously; its volume has been increasing by a factor of ten during the last 30 years (Poulton et al. 2013). The environmental effects of mining are very substantial. This also can be seen from the latest report of Blacksmith Institutes (2013), which names among the ten most polluted places on earth also three which are characterised by mining (Kabwe, Sambia; Kalimantan, Indonesia; Norilsk, Russia).

Among mining, artisanal and small scale mining pose specific problems. It is responsible for about one-quarter to one-third of global mercury pollution (Siegel and Veiga 2009 and 2010). Other environmental impacts which tend to be even higher than in large scale mining are emissions of cyanides, and biodiversity loss and water pollution from missing waste management.

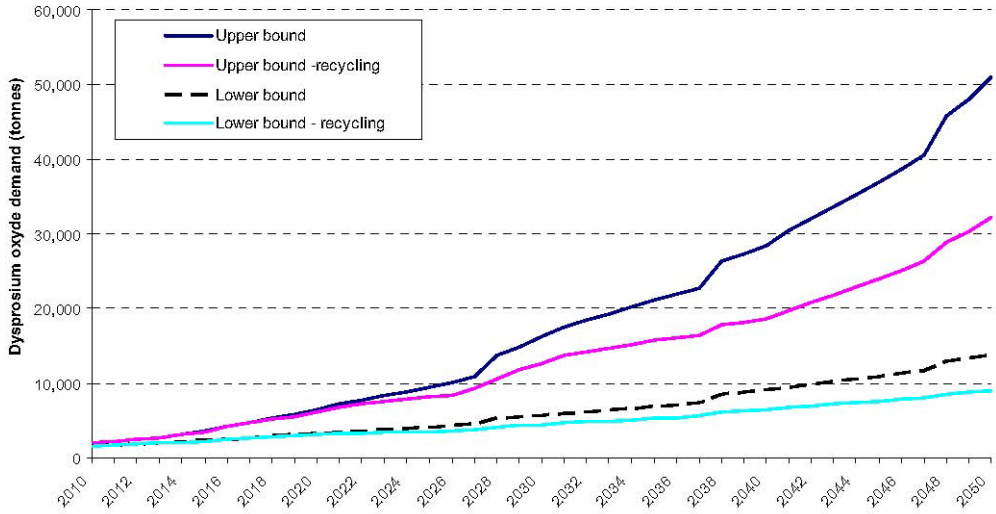
The lowering of metal content in the ores will work towards increasing the environmental effects of mining furthermore (Mudd 2010). There are numerous technical devices to reduce the environmental effects. However, they will work towards increasing the costs furthermore, which raises additional questions towards the utilisation of new mines (Poulton et al. 2013).

Environmental effects also happen during processing of raw materials along the value chain. Thus, reduction of material demand reduces the emissions along the value chains. In addition to energy related environmental targets, increase in material efficiency has become a prominent policy target. On a national, but also international level, policy strategies increasingly push towards reducing material demand, by calling for recycling and material efficiency strategies. To sum up the argument, environmental concerns will not only push towards employing less environmental harmful mining technologies, but will increasingly be tailored towards reducing the demand for raw materials per se.

A transition of the energy system, characterized by higher energy efficiency, more renewable energies and smarter grids, has been among the top priorities of environmental goals. Key energy transition technologies, such as PV, wind energy, electromobility, but also energy storage and lighting, are associated with an increase in demand for specific raw materials. Hendrix (2012) names especially Indium, Gallium und Tellur (PV), Lithium, Nickel, Kobalt und Mangan (energy storage), Terbium, Cer, Europium und Yttrium (lighting technologies) and Neodymium and Dysprosium (permanent

magnetes). Especially the demand for dysprosium will be substantially increasing, due to its specific characteristic to keep its permanent magnetic function even under higher temperatures. Even if new recycling technologies will be successful (e.g. Hagelüken 2014), scenario analysis points towards a substantial increase in demand for primary dysprosium. With China currently being the main supplier (Wall 2014), and given the recent dispute about export restrictions, this raises concern about availability of this rare earth metal.

Figure 1: Scenarios for dysprosium demand



Source: Hoenderdaal et al. 2012

4 Economic considerations in countries of the North

Some raw material markets are characterized by high concentration of supply and market dominating positions of a few companies. Opening up new mines is associated with high risks and is very capital intensive. Substantial parts of the investments have to be covered before any revenue is coming in, as summarized by Cuddington und Jarett (2008, p. 544): „Where exploration is successful, there is an average of 27.5 years from initial spending to cash flow generation“. Furthermore, most investments into mining projects show a sunk cost character. Newcomers in the market must be prepared that incumbents won't leave the market as long as their revenue covers part of the fixed costs. Recovering the fixed costs is highly uncertain under such conditions. Long lead times and sunk costs both support barriers to entry.

From the perspective of traditional raw material importing industrialized countries from the North, this leads to three different economic concerns:

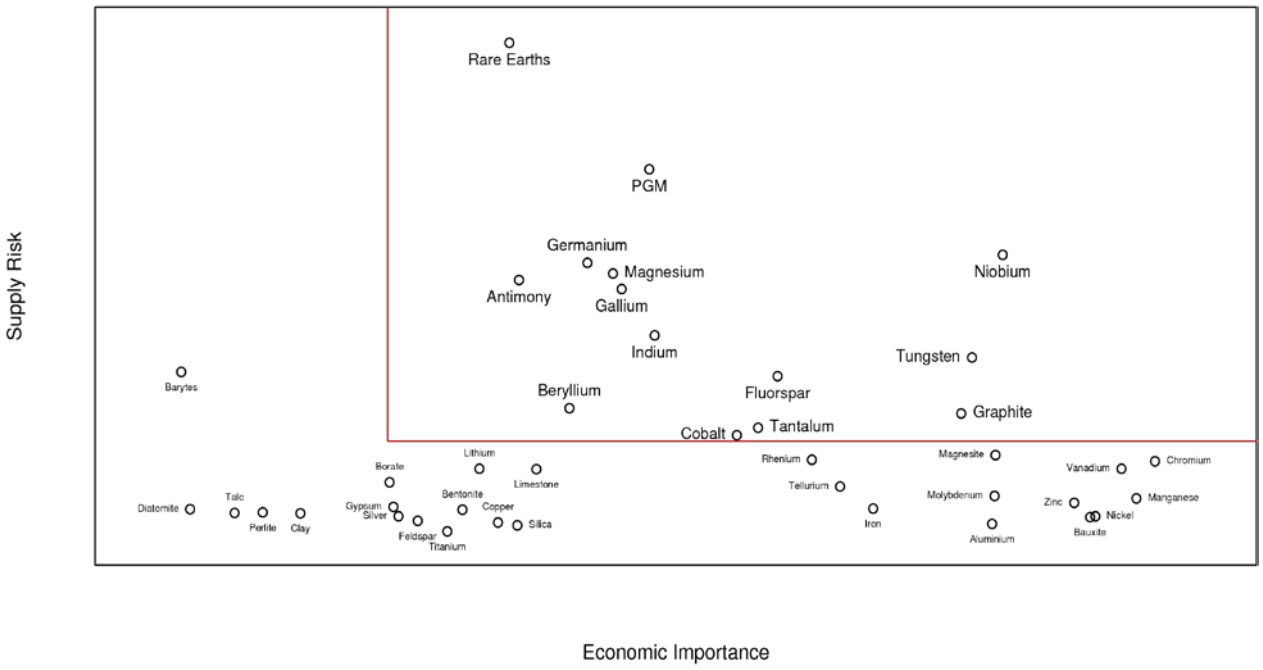
- If demand is increasing very fast, e.g. driven by demand from fast growing economies or for new technologies, supply cannot react in the short term. There are temporary market imbalances, which affect also the downstream of the value chain.
- Price volatilities on raw material markets are seen as another effect of these imbalances, which further distort the decisions taken upon the price signals. Derivative financial products can support hedging against these price risks, but might also open the door that price developments are driven by financial speculation instead of real scarcities.
- Barriers to entry lead to monopolization of markets, which enable monopoly rents. The extent of these rents depend on the elasticity of demand, which is in itself a function of the substitutions potential fort he materials. Thus, the technical properties of the materials described above also support the possibility of higher prices.

However, the concern in the traditional countries of the North extends beyond paying higher monopoly rents. Access to raw materials could be restricted for industrial policy reasons, in order to monopolize the downstream of the value chain. Especially countries which hold a high share of supply and want to use that supply in order to develop their downstream industries could use such a position to benefit their home industry on international markets. Clearly the debate about the Chinese rare earth export restrictions is triggered by this concern.

The economic concerns in industrial countries of the North have resulted in a renewal of raw material strategies. One important element is strategy building with regard to

identification of raw materials which might be critical because they show a high level of vulnerability of supply and high economic importance. Various schemes have been developed to identify these resources (see Graedel et al. 2014). However, they are only able to provide a static snapshot picture so far, as the evaluation of resources might change very quickly with changing market developments.

Figure 2: Critical resources according to EU raw materials initiative



Source: EU raw materials initiative

There are various policy reaction based on the economic concerns:

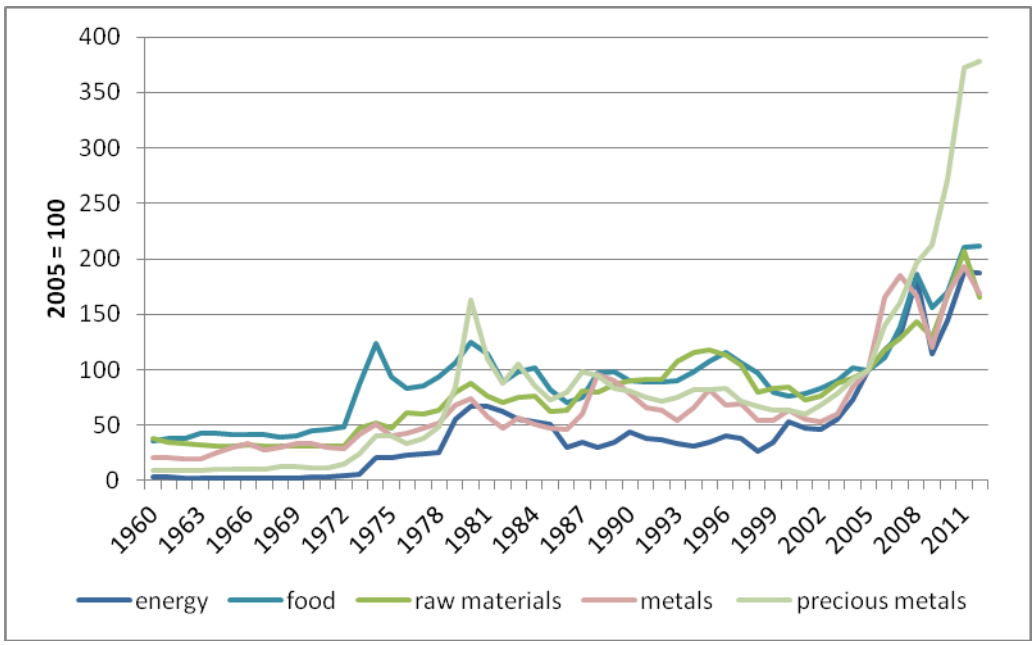
- emphasizing access to raw material on the world market, by pushing provisions of international trade regime;
- increasing the diversity of supply, by fostering strategic alliances with different raw material providing countries, or even re-orientation towards domestic mining;
- ushing material efficiency, in order to reduce demand for materials.

Thus, the last two approaches are likely to alter the dynamics of supply and demand development.

5 Economic considerations in emerging and developing resource rich countries

Prices for natural resources have been increasing substantially after 2005. This holds not only for food and energy resources, but also metals. Consequently, resource rich emerging and developing countries are looking into the prospects of using the availability of resources as a basis for their economic development.

Figure 3: Development of raw material prices



Sorce: Data from Worldbank Database, 2013

The debate about natural resources as a base for development has been shaped by the discussion about the existence of a resource curse. There are two streams of argument: (e.g. Sachs und Warner 2001; Mehlum et al. 2006; Frankel 2010): The first focuses on increase in real exchange rates and crowding out of other export oriented industries, the second on the interplay between bad governance and rents from resources. However, beyond this fundamental debate, there are additional aspects which have to be considered.

Resource availability in developing countries puts mining as important growth sector in the spotlight. However, the mining industry has been changing substantially during the last decades, which pose additional challenges to pursue such a resource based development strategy:

- The globalization of markets, but also high investments makes market entry difficult.

There is a strong role of the global mining companies, which are, however, mostly located in countries of the North. Thus, how to increase the role of domestic players and what role the state should play in this are seen as crucial aspects. According to Humphreys (2014), a debate about the role of the state in influencing mining is developing in countries of the South, which in a certain way parallels the debate about access to raw materials taking place in countries of the North.

- The mining business has become increasingly complex. Technological upgrading and development of knowledge intensive prospecting and supporting services (Urzua 2011; Humphreys 2014) build a complex web of competences, which are not easily to acquire. Catching-up in mining has become more difficult: in addition to the obstacles of market entry, also catching up in non-technical innovations becomes more important.

Knowledge intensive development can also based on developing downstream value chains of the mining sector. The following aspects have to be taken into consideration:

- A downstream development can potentially benefit from domestic resource availability. How big the specific advantage is to have natural resources available domestically depends especially on the costs of transportation of the natural resources. High transportation costs benefit location decisions close to resource base. However, if transportation costs continue to be low, location decisions will be driven by other factors, such as being close to markets, costs of energy, or the availability of competences.

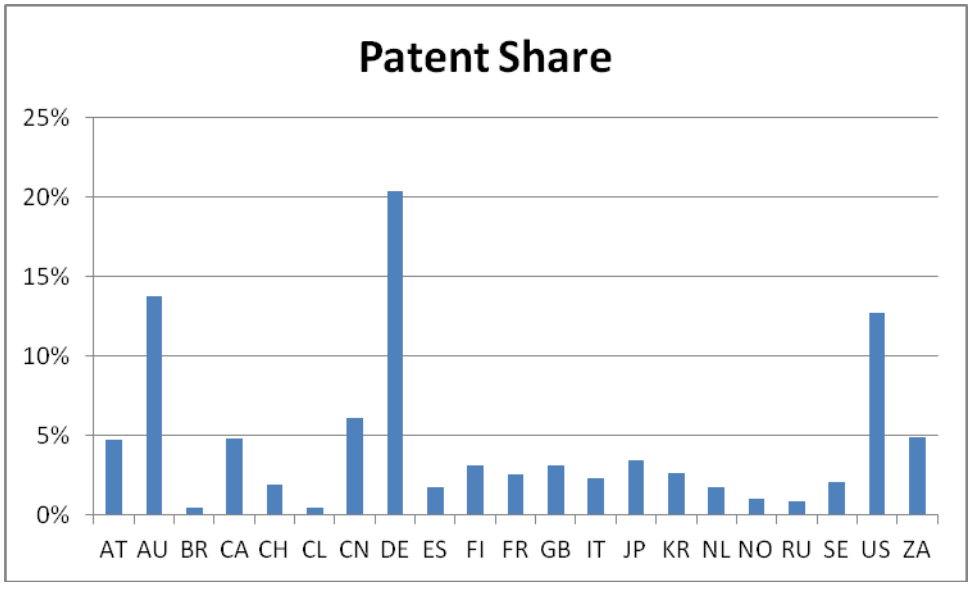
- In general, local proximity between upstream and downstream value chains which facilitates user-producer interaction could be an argument for vertical integration. However, it is not clear how important that aspect is for raw materials. Especially bulk raw materials are rather broad customized products and fulfill standardised product characteristics, which are not tailored to specific downstream needs. User-producer interaction becomes more important at more downstream parts of the value chains, e.g. in production of special steel for specific applications. However, this also supports the location of production of special raw materials close to existing industrial facilities of the using industries. Furthermore, the catching-up in these segments of the value chain even require a stronger catching up in capabilities than in the more upstream parts of the value chains.

Another option of economic development could be a backward integration into the supplying industry of mining. This also would result in a movement towards a knowledge based development. The argument here is that user-producer interaction would facilitate the development of the supplier industry. Thus, resource rich countries should

have a specific advantage.

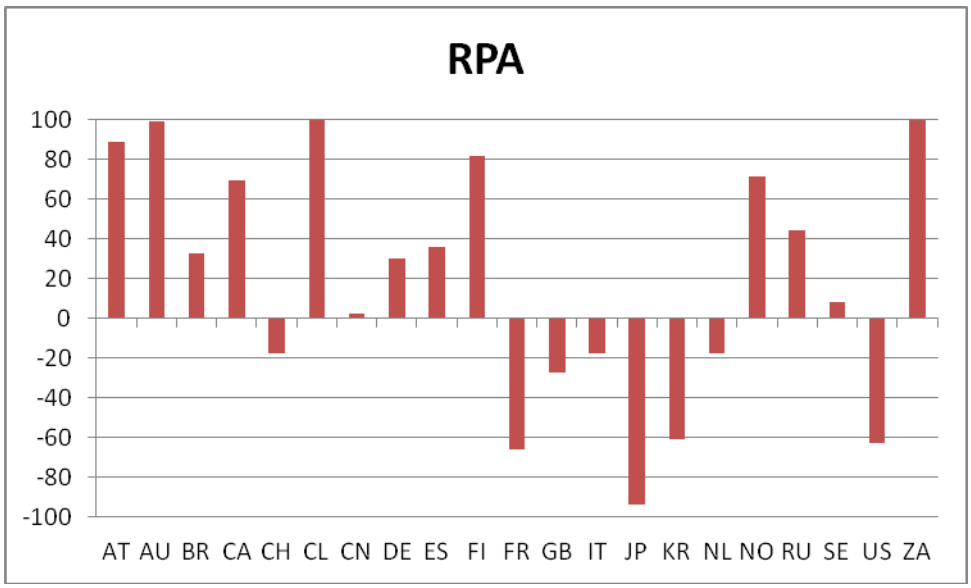
However, a first look at patent data shows that there still is a substantial need for catch-up of emerging countries in the mining supplier sector. Germany and the US show the highest shares. Traditional mining countries in the OECD such as Australia, Austria and Canada (but not Sweden) also show substantial shares. Among the emerging economies, it is especially China and South Africa which hold a substantial share. A look at the specialization pattern shows a more prominent role of mining patents among the emerging economies. In addition to both Africa and China also Brazil and Chile (but on a lower absolute level) show a positive specialization. Thus, it can be concluded that backward integration seems to take place in the knowledge creation of emerging economies. However, there is evidence that most of the new knowledge is still created in the countries of the North. The data indicates that many of the resource rich developing countries still rely strongly on knowledge from abroad if it comes to supplying the mining industry.

Figure 4: World patent share of different countries in mining related related technologies



Source: calculation of Fraunhofer ISI

Figure 5: Relative Patent Activity (RPA) of different countries in mining related technologies



Source: calculation of Fraunhofer ISI

6 Social aspects

The social dimension, that is how a natural resource based strategy influences people's living conditions, is a core theme of the Globelics seminar. Mining is very often associated with harsh living conditions in developing and emerging economies (Jennings et al. 1999; Wagner et al. 2007; Buxton 2013). Above all, this holds for artisanal and small scale mining, which is relevant especially for significant supplies for Tantalum, Gold, Cobalt, Tin and Tungsten. It is estimated that 20 to 30 million people are active in that segment of mining, with a total of around 100 million persons economically depending on it (Buxton 2013).

Further issues are land use conflicts, with peasants driven from agricultural lands, or concerns about environmental pollution effecting local population. Other issue relate to power: Large mining companies tend to link to power elites in mineral rich countries, with adverse effects on community representation and participatory decision-making (Campbell 2012, Farrell et al. 2012). In some instances, mining is linked to the financing of conflicts, due to the appropriability of (precious) raw materials. Even though there are many open questions regarding the relationship between raw materials and conflicts, (e.g. Ross 2004, Brunnschweiler und Bulte 2009), it has fostered various political initiatives such as Dodd-Frank Act or EU Transparency Directive, and civil society approaches such as Extractive Industry Transparency Initiative (EITI).

The importance of social aspects is currently increasing. In the past, the debate about corporate and social responsibility has made social concerns a subject of debate for the direct actions of large companies. Corporate and Social Responsibility has become an important topic for large scale mining companies (Hilson 2012). Even if there is a debate about how much of CSR is rhetoric and how much is real change in behaviour (see Hilson 2012, Slack 2012, Gilberthorpe and Banks 2012, Mutti et al. 2012), it cannot be denied that social effects of mining have become an issue. This development is linked to an increased importance of life cycle analysis in impact assessment. Hilson (2012, p. 133) argues that mining "being an industry' without a face'— that is, with no direct links to the consumers and general public capable of wielding the necessary pressure to facilitate change — the exact function of CSR in the sector remains unclear, and even less so in the case of operations based in developing countries". However, drawing on the experience in environmental Life Cycle Assessment, there is increasing activity in developing Social Life Cycle Assessment (Benoit and Mazijn 2010; Ekener-Petersen and Moberg 2013). Increasingly, corporate and social responsibility in the upstream value chain will influence the market access of upstream companies (Fleury and Davies 2012). Thus, such a development could strengthen the link to the consumer und increase the pressure for CSR.

This development is also fostered by the introduction of certification systems. They can be classified as form of non-state governance (Pattberg 2006). Typically, certification schemes require that certain social or environmental standards are met (Blore 2011). Some of them also target the artisanal mining, such as the two gold standards "Fairtrade Gold" and "Fairmined Gold" (Fairtrade Labelling Organization International 2011; Levin et al. 2012; ARM 2014). However, it is also envisaged to introduce a scheme for large scale mining administered by the "Initiative for Responsible Mining Assurance".

Some standards include specific incentives to improve living conditions, such as the premium on prices to be paid for the product. It is also argued that such certification standards could lead to improve the quality of governance in the countries. However, the limited evidence so far is mixed. First evaluations of the “Extractive Industries Transparency Initiative" point toward low effects on political stability and level of corruption (Smith et al. 2012, Corrigan 2013).

7 Conclusions: Towards scenarios for NRBD

The previous chapter introduced five different narratives, which all look at raw material supply and use from a different perspective.

- A NRBD in countries of the South has to overcome the obstacles of the resource curse. However, there are additional aspects which relate to sector specificities of raw material: The mining industry has been changing substantially during the last decades, which pose additional challenges for catch-up in technological and organizational innovations. It is also unclear, whether or not proximity between mining and production at the next downstream part of the value chain are indeed giving countries of the South a substantial competitive edge. Backward integration in the mining supply industry could be perhaps another interesting option. All strategies, however, require substantial increase in capabilities and rely on government support.

- The economic interests of the traditional raw material importers of the North call for less volatile and low prices. Concern about dependency on raw material imports increases application of WTO regulations, bilateral agreements securing access to raw materials, but also a re-emergence of mining in OECD countries. Furthermore, it fosters an interest in resource efficiency in order to reduce dependence on primary material.

- Technological characteristics support that not all materials will benefit alike from future development. Specific resources with unique properties will become more important, and will offer higher shares of value added than traditional raw materials.

- The environmental pressure will lead to more importance given towards less environmental harmful mining. Raw material producers will get under pressure to show that they use environmental friendly technologies. This will also extend to producers from developing countries. Furthermore, environmental concern will push resource efficiency. However, environmental concern will also push the importance of various raw materials needed for sustainability technologies.

- It can be foreseen that social concerns will become more important. Raw material producers will get under pressure to show that they fulfill certain minimum requirement with regard to social dimension. This will also extend to producers from developing countries.

Our main argument is that a NRBD must be able to fit into future scenarios of raw materials, which are likely to be shaped also by the narratives of other actors and their resulting actions. The better a NRBD matches likely future scenarios of the raw materials sector, the better are the chances that NRBD can be successful.

Future scenarios must also reflect the view how the world will be developed. There is considerable uncertainty about such developments, and foresight typically leads to different scenarios, which differ e.g. with regard to global governance or multi-polarity of the world, and lead to scenarios ranging from a gloomy picture of the future to a bright world (e.g. National Intelligence Council 2012). Clearly raw material scenarios will be shaped by such overriding trends as well. However, if we assume a more middle of the road scenario, which consists of increasing environmental pressure but also some form of global governance with regard to global challenges, and countries pursuing also economic policies to advance their economic interests within a trend of globalization of markets, the following development seems to be plausible with regard to raw materials scenarios.

There is a nexus between the different narratives which favor environmental and social sustainability. This nexus is also supported partially by economic considerations, e.g. with regard to the role of resource efficiency in order to reduce dependence on raw materials imports. Another nexus is that certification of environmental and social sustainability along the value chain is likely to become a product quality which enables producers to receive higher product prices. Product differentiation along sustainability characteristics of a product will support a strong move towards product standardization along the value chains. Thus, the globalization of value chains will be accompanied by a globalization of the sustainability demands, which will transfer the debates in countries of the North to the South.

NRBD in countries of the South should take this development into consideration early on. Thus, a NRBD should to take environmental concerns into account not as a burden, but a necessary prerequisite for international competitiveness. Sinking ore grades and rising costs for environmental technology are likely to increase the costs of mining. New technologies and organizational innovations will be a key to operate mines profitable. At the same time, the emphasis on resource efficiency will dampen the growth of demand for primary raw materials. Thus, the amount of monies to be extracted from natural resource development and being available for redistribution might be more limited than anticipated.

However, certain specific materials will become more important and from an economic perspective more interesting. Taking advantage of this development and linking resource availability with industrial development in the specific technological areas which will trigger the demand for specific raw materials might be a promising strategy.

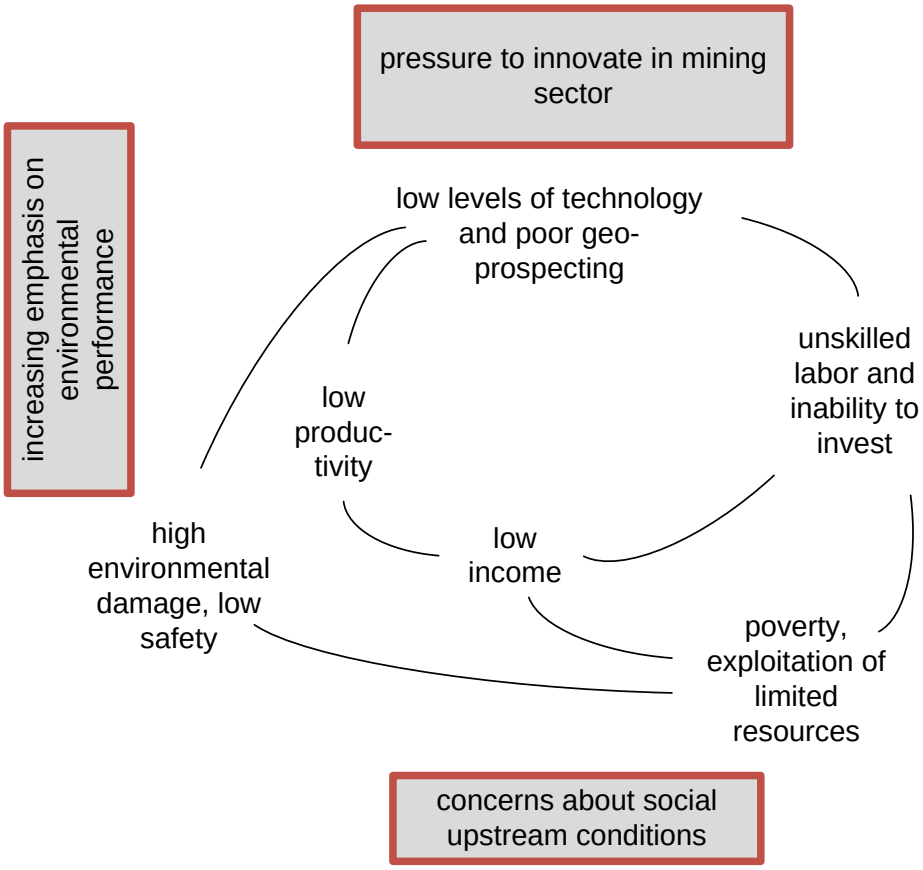
Extending towards social aspects will remain a challenge for NRBD: Even if mining and related value chains will benefit in developing countries, it is more likely that large scale

mining will benefit. It is far from certain that this development will also benefit the most vulnerable actors involved in raw material production, which are involved in artisanal and small scale mining. Figure 6 shows a representation of the poverty trap for artisanal and small scale mining, and how they might be affected by the other developments described above:

- The pressure to innovate in mining will increase in order to counter lower ore grades and upgrading of mining industry; however, artisanal and small scale mining has even greater problems to follow this trend than large scale mining in developing countries.
- There will be an increasing emphasis on environmental problems, which will require to use more environmental friendly technologies and to invest into waste and water management. It will be difficult for artisanal and small scale mining to achieve this, but certification schemes will put on pressure to do so.
- Life-Cycle thinking will make social conditions at the upstream part of the value chain an important topic. But the move to product standardization along the value chain can be also double edged for social development. It is not clear if it will lead to improvements in the small scale and artisanal mining sector, or whether it will foreclose the international markets for this segment altogether.

To sum up, matching the prospect of NRBD with other narratives provides a differentiated picture. The advantages might be less broad than the price increases for natural resources seem to promise. A successful strategy should account for environmental and social aspects, and identify the segments of the market which are likely to grow and fit the national capabilities. Given to the diversity of the mining sector in developing countries, it will be a key challenge to transform economic success of a NDBR also to an inclusive development of the part of the population which depend on artisanal and small scale mining.

Figure 6: Poverty trap for artisanal and small scale mining and how it might be affected by developments in framework conditions



Source: adaptation from Barry 1996 and Hilson 2012b

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