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TNO

# THE CIRCULAR ECONOMY AND DEVELOPING COUNTRIES

## A DATA ANALYSIS OF THE IMPACT OF A CIRCULAR ECONOMY ON RESOURCE-DEPENDENT DEVELOPING NATIONS

ENVIRONMENTAL POLICY

COE-RESOURCES ISSUE BRIEF 3

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# 1 INTRODUCTION

The industrial revolution led to the modernization of production methods, bringing about significant gains in efficiency and efficacy. Innovations in agriculture, transport, and communications have all improved our standard of living. However, despite ongoing advancements, the principle model of industrialization has remained largely unchanged, as it was – and still is – characterized by linear consumption. After consumer goods become redundant they turn into waste, putting significant strain on our planetary limits. In western economies we have developed a 'take-make-consume and dispose'-mentality based on the assumption that 'resources are abundantly available, easy to source and cheap to dispose of'.[1] However, as the world's population grows towards 7.5 billion people, with a burgeoning middle class demanding access to increasingly sophisticated goods, the burden on our natural boundaries looks set to increase further.

A transition towards a 'circular economy' -in which redundant consumer goods are viewed as input rather than waste - offers great potential for societies to reduce their environmental footprint. Once products reach the end of their lifespan new value can be generated by re-using valuable resources.[2] The circular economy is characterized by its ability to restore and regenerate through intention and design: '[i]t replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, it removes the use of toxic chemicals, which impair re-use, and aims for the elimination of waste through a superior design of materials, products, systems, and, within this, business models'.[3] The circular economy is not necessarily a novel concept per se. Rather, it is similar to – although not necessarily on par with – concepts such as *Cradle to Cradle, Performance Economy,* and *Industrial Ecology*.[4]

1 Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, 'Towards a Circular Economy: A Zero Waste Programme for Europe,' February 7, 2014, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0398R%2801%29.

2 Ibid.

3 The Ellen MacArthur Foundation, 'Towards the Circular Economy Vol. 1: An Economic and Business Rationale for an Accelerated Transition' (The Ellen MacArthur Foundation, January 25, 2012), 7, http://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf.

4 Ibid., 26–27.

Sectors where it is expected that a circular economy could have major benefits are in Dutch High-Tech Systems and Materials (HTSM) and the automotive and construction industries.[5] Calculations by The Netherlands Organisation for Applied Scientific Research (TNO) suggest that the Netherlands' transitions towards a circular model in the long term could generate € 7 billion in revenue, roughly 1.4% of Dutch GDP.[6]

In addition to the immediate benefits, there are numerous positive indirect effects, such as the export of knowledge, and the ability for a circular economy to act as a driving force for the Dutch manufacturing and recycling industry.[7] At the European level, depending on the pace of transition, estimates of material cost savings range between € 300-560 billion per annum.[8] Moreover, a circular economy could dampen the effects of price volatility and losses resulting from the (unexpected) unavailability of raw materials. By the same token, circular practices reduce several negative externalities as a result of more efficient resource use; such as $CO_2$ emissions, a heavy ecological footprint, and significant land use Furthermore, a circular economy promotes the development of innovation and increases the security of resource supply.[9]

In today's globalized world, widely used (consumer) goods such as mobile phones, are generally composed of resources and materials from all corners of the world. For example, in 2014, Brazil was the largest exporter of iron ore to the EU. Lithium, a key component of batteries, is mostly imported from the US. And nearly half of aluminum ores and concentrates imported by the EU come from Guinea.[10] Various economic sectors in Europe (e.g. aerospace, renewable energy, technology, etc.) are highly dependent on the availability of specific sets of raw materials.

However, in spite of the strong interconnectivity between export markets and countries of origin, meager attention is paid to the consequences that a transition to circularity may have on countries that rely on the export of raw materials for (economic) stability, in particular developing countries. After all, a circular economy could, *ceteris paribus* (all things remaining equal), result in reduced revenues for resource-exporting developing countries.[11] By assessing global exports of critical (CRMs) and non-critical raw materials (non-CRMs) to

5 Workshop on the Circular Economy and Developing Countries. The Hague Centre for Strategic Studies, 23 June 2016.

6 Ton Bastein et al., 'Kansen Voor de Circulaire Economie in Nederland' (TNO, June 11, 2013), 47, https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2013/06/20/tno-rapport-kansen-voor-de-circulaire-economie-in-nederland/tno-rapport-kansen-voor-de-circulaire-economie-in-nederland.pdf.

7 Ibid., 50–51.

8 The Ellen MacArthur Foundation, 'Towards the Circular Economy Vol. 1: An Economic and Business Rationale for an Accelerated Transition,' 66.

9 Ton Bastein et al., 'Kansen Voor de Circulaire Economie in Nederland,' 32.

10 'List of Supplying Markets for a Product Imported by European Union (EU 28),' *International Trade Centre*, n.d., http://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1|||14719|||2606|||4|1|1|1|2|1|4|1|1.

11 See the forthcoming study by the Planbureau voor de Leefomgeving. "Potential Effects of Circular Economy Policies in the Netherlands and Europe on Developing Countries – a Quick-Scan" (The Hague: Planbureau voor de Leefomgeving (PBL), 2016).

the Netherlands and the EU, this paper assesses the impact that Dutch and EU wide transitions to a circular economy may have on their trading partners. Clearly, the effects of alternating trade patterns will not be the same on each individual country. Some countries are more capable of adapting to such a transition than others, especially those with a diversified portfolio of export goods. Conversely, countries who rely heavily on a small portfolio of export products are expected to have less room to maneuver for compensating any export losses.

In conjunction with the upcoming Dutch government-wide program on the circular economy and the EU's circular economy action plan, this Issue Brief presents the outcome of a data-analysis into the effects that a circular transition in the Netherlands and Europe may have on developing countries heavily reliant on the export of a select number of raw materials (minerals and metals) to the Dutch and EU market. The paper is structured as follows. Section 2 discusses the methodology applied in the data-analysis underpinning this report. Section 3 provides a brief overview of the current state of the circular economy. Section 4 shows the results of the analysis, highlighting the impact circularity has on exporters of CRM and non-CRM exports to the Netherlands and the EU. Section 5 builds on the findings of the previous section and examines the extent to which countries that were found to be vulnerable to circularity also exhibit other characteristics of state fragility which can act as risk multipliers. Section 6 provides the main conclusions of our research, as well as a set of policy relevant observations in light of the upcoming Dutch government-wide program on the circular economy.

# 2 METHODOLOGY

The difference between CRMs and non-CRMs is rooted in two indicators: (i) its economic importance and (ii) the risk of supply interruptions. The latest EU report on CRMs assesses economic importance as 'the proportion of each material associated with industrial mega sectors at an EU level, [...] combined with the mega sectors' gross value added (GVA) to the EU's GDP'.[12] The EU study defines supply risk as a combination of several factors and dynamics: (a) substitutability; (b) end-of-life recycling rates; and (c) a high concentration of producing countries suffering from poor governance.[13]

On the basis of these indicators the European Commission (EC), in 2011, classified fourteen materials as CRMs. The EC added another seven in 2014, whilst dropping one, classifying a total of twenty CRMs. In addition to this list, the Dutch Ministry of Foreign Affairs added two more materials: gold, and tin (see Table 1).

| CRITICAL RAW MATERIALS | | |
|---|---|---|
| Antimony (Sb) | Beryllium (Be) | Borates |
| Chromium (Cr) | Cobalt (Co) | Coking coal |
| Fluorspar | Gallium (Ga) | Germanium (Ge) |
| Gold (Au) | Indium (In) | Magnesite |
| Magnesium (Mg) | Natural Graphite | Niobium (Nb) |
| PGMs | Phosphate Rock | REEs (Heavy) |
| REEs (Light) | Silicon Metal | Tin (Sn) |
| Tungsten (W) | | |

TABLE 1: CRITICAL RAW MATERIALS ACCORDING TO THE EU/THE NETHERLANDS[14]

12 European Commission, 'Report on Critical Raw Materials for the EU,' May 2014, 21, http://ec.europa.eu/DocsRoom/documents/10010/attachments/1/translations/en/renditions/native.

13 Ibid., 22.

14 Ministerie van Buitenlandse Zaken, 'Grondstoffennotitie,' July 15, 2011, https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2011/07/15/grondstoffennotitie/grondstoffennotitie.pdf.

All nine Dutch top sectors[15], identified by the government, are, to varying degrees, dependent on the availability of CRMs.[16] This dependency concerns both raw materials and intermediates.

A 2015 study by of a consortium lead by TNO assessed the criticality of 64 (abiotic) raw materials to the Netherlands, by gauging the short- and long term supply risks set against their relative importance to the Dutch economy.[17] Rather than presenting a dichotomy (i.e., the material is either critical or not), the study created a continuum without a clear break-off point, offering a more nuanced view of the criticality of raw materials. For example, while some of these 64 raw materials are considered of greater economic importance than other CRMs, the supply risk may be less pronounced and *vice versa.*

The TNO study served as the point of departure for our analysis. For each of the 64 raw materials, we collected data on import and export figures for the Dutch and European economy. Table 5 in the ANNEX lists all raw materials with their corresponding HS code from the UN Comtrade database (2016).[18] In some instances materials were grouped together in a single category (e.g. the rare earth metals, Scandium and Yttrium: HS 280530), despite a focus on individual raw materials in the TNO report. As a result, providing an individual breakdown of the rare earth metals on import and export figures proved impossible.

Due to the unavailability of data, all data (except the estimation of public revenue) is from the year 2014. Both 'developed' as well as 'developing' countries are included in the list of exporting countries to the Netherlands and the EU. The classification of 'developed' and 'developing' country is based on the UN report 'World Economic Situation and Prospects 2012'.[19] We also examined whether an individual sourcing country is a 'focus country' of the Netherlands.[20]

Due to large discrepancies between listed import and export numbers (e.g. higher values for the total import from country X to the Netherlands than the total export to country X from the Netherlands), we gathered data solely on the basis of import figures. In order to calculate the total export value of country X for a particular raw material to the EU, we used the sum of all import figures for a particular raw material from country X by individual EU states. For

15 (1) Horticulture and propagation materials; (2) Agri-food; (3) Water; (4) Life sciences and health; (5) Chemicals; (6) High tech; (7) Energy; (8) Logistics; (9) Creative industries.

16 Ministerie van Buitenlandse Zaken, 'Grondstoffennotitie.'

17 Ton Bastein and Elmer Rietveld, 'Materialen in de Nederlandse Economie - Een Kwetsbaarheidsanalyse' (The Hague: TNO, January 12, 2015), https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2015/12/11/materialen-in-de-nederlandse-economie/TNO+2015+R11613+Materialen+in+de+Nederlandse+economie+webversie+definitief.pdf.

18 Ibid.

19 'World Economic Situation and Prospects' (New York: United Nations, 2012).

20 A focus country includes those countries with which the Netherlands has a close trade or development aid relationship.

all 64 materials, we collected trade data with a baseline of 1 million dollars (USD). This baseline was set in order to get an adequate representation of countries and to also allow for the inclusion of economically 'small' developing nations. These countries will not dominate the list in terms of trade volume, but are nonetheless relevant due to the contribution made by the export of the raw materials to their GDP.

In addition to the relative contribution of EU exports to a country's GDP, we also included data on the total market value of a country's exports to the world market. The relative contribution of the total export value of the sourcing country to its GDP was calculated to see the dependency of each individual country on the export of the raw materials in question. A filtered data set was then included to show the aggregated value of all investigated raw materials exports for each individual sourcing country.[21]

As a proxy for determining how much the 64 raw materials contribute to a government's finances, we looked at the mining tax rates for all sourcing countries. Although the available data in this field is limited in both scope and depth, Otto and Andrews (2006), collected data on the effective mining tax rate for 24 large mining countries.[22] For all the missing countries from Otto and Andrews' investigation, we used the mean value of the 24 countries as a proxy indicator for the average effective mining tax rate. This estimated mining tax rate was then multiplied by the sum of a country's exports (either to the EU or all trade partners), and labelled as the potential contribution to a government's finances.

Additionally, we were interested in the contribution of raw material exports as a share of total public revenue. Bearing this in mind, we relied on the World Bank World Development Indicator dataset on public revenue, excluding grants as a percentage of GDP. Due to the fact that the availability of public revenue data varies greatly per year and country, we based our calculations on the average of the years 2009-2014 in order to generate a dataset that was as complete as possible. To calculate the estimated public revenue we subsequently multiplied the percentage of average public revenue by the sourcing country's GDP. In order to calculate the percentage of the potential contribution to government finances to the total estimated public revenue, we divided the former by the latter.

Lastly, to test our findings we held an expert workshop on 23 June 2016 which was attended by representatives of various Dutch ministries (Foreign Affairs, Infrastructure & the environment), think tanks and knowledge institutes, and numerous independent experts on sustainable development.

21 Please note that because Rhodium (Rh) (711031) is a subcategory of Platinum (7110), the trade volume of Rhodium is subtracted from the trade volume of platinum in the EU filtered sheet to prevent overlapping data.

22 The World Bank, 'Mining Royalties: A Global Study of Their Impact on Investors, Government, and Civil Society' (Washington, D.C., 2006), 36, http://siteresources.worldbank.org/INTOGMC/ Resources/336099-1156955107170/miningroyaltiespublication.pdf.

# 3 THE CURRENT STATE OF THE CIRCULAR ECONOMY

In a circular economy, recycled materials can be injected back into society. Secondary materials, such as primary materials, can be traded . However, a circular economy is about more than the mere recycling of products. The transition to a circular economy requires both consumers and companies to abandon the linear use of materials, and separate their waste in ways that allows it to be brought back into the (material) cycle.[23] Nine different levels of singularity can be distinguished, ranging from high to low levels of priority (see Figure 1).

Level of Priority


| | |
|---|---|
| REFUSE: | PREVENT THE USE OF RESOURCES |
| REDUCE: | DECREASE THE USE OF RESOURCES |
| RE-USE: | FIND NEW PRODUCT USE (SECOND HAND) |
| REPAIR: | MAINTAIN AND REPAIR |
| REFURBISH: | IMPROVE PRODUCT |
| REMANUFACTURE: | CREATE NEW PRODUCT FROM SECOND HAND |
| RE-PURPOSE: | RE-USE PRODUCT FOR DIFFERENT PURPOSE |
| RECYCLE: | RE-USE RAW MATERIALS OF PRODUCT |
| RECOVER: | RECOVER ENERGY FROM WASTE |

FIGURE 1: LEVELS OF CIRCULARITY: 9 R'S[24]

For each level, different provisions need to be created. Although the Netherlands performs better compared to other EU Member-states when it comes to recycling, the use of recycled (secondary) raw materials remains relatively low. According to a 2011 report by the United Nations Environment Programme only 18 of the 60 examined metals had an end of life

23 Cramer, 'Moving towards a Circular Economy in the Netherlands: Challenges and Directions,' 2014, http://www.usi.nl/files/2015/04/Paper-HongKong-JC-april-2014.pdf.

24 Ibid.

(EoL) recycle rate (EOL-RR; i.e. ‘recycling in which the physical and chemical properties that made the material desirable in the first place are retained for subsequent use’) of 50% or more (See Table 6 in the ANNEX).[25] Of these materials, 34 had a rate of <1%. Interestingly, however, the recycling rates tend to be structurally higher (all are above 50%, with the exception of Molybdenum which has a rate between 25-50%) with raw materials the EU imports in the largest quantities (i.e. >€1 billion; Aluminum, Copper, Gold, Iron, Nickel, Platinum, Palladium, Silver, and Zinc).

One of the main challenges of recycling raw materials is the collecting and dismantling of products which contain these materials, and handling the release of toxic materials during the process. Due to the rising complexity of modern consumer goods consisting of an increasingly complicated mixture of metal-containing products, there is a need to shift recycling practices from a material-centric to a product-centric view. Recycling products at their EoL, instead of focusing on the individual materials contained in them, would constitute a significant step towards a more efficient recycling system.[26]

One of the most promising recycling sources is waste electronic and electrical equipment (WEEE), post-consumption waste of consumer and business devices such as mobile phones, computers, fluorescent lamps, and kitchen appliances. WEEE volumes are enormous. In Europe alone the amount of WEEE generated per year is around 12 million tons and is expected to increase in the coming decades at a rate of at least 4% per annum.[27] In the Netherlands, current practices regarding reparation, dismantling, re-use, and recycling in the metal electro-sector contribute an estimated €3.3 billion to the Dutch economy per annum.[28]

Through technological advances, recycling becomes an increasingly economically viable option. New technological discoveries including improved knowledge sharing, better tracking of materials and improved logistics, have become available at a large scale and enable the creation of a circular economy.[29]

25 United Nations Environmental Programme, ‘Recycling Rates of Metals: A Status Report’ (United Nations Environmental Programme, 2011), 19, http://www.unep.org/resourcepanel/Portals/24102/PDFs/Metals_Recycling_Rates_110412-1.pdf.

26 Ibid., 25.

27 Ibid., 69.

28 Ton Bastein et al., ‘Kansen Voor de Circulaire Economie in Nederland,’ 24.

29 Ellen Macarthur Foundation, ‘Towards a Circular Economy: Business Rationale for an Accelerated Transition,’ 2015, 4, https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf.

Examples of new technologies for recycling include:

- Radio-frequency identification (RFID): enables the tracking of the whereabouts and conditions of materials, components and products;
- The Internet of Things (IoT);
- 3D printing; reduces waste of materials, allows repairing and creates opportunities for customer led designs;
- Innovative Hydrometallurgical processes; enables the separation of precious and critical metals from WEEE and other high tech products.[30]

It is essential that products are redesigned to improve their durability and recyclability ('design for resource efficiency, dismantling/recycle/repair/re-use'). For instance, constructing 'bondings' or joints between components in a manner where they can be opened during mechanical pre-processing.[31] According to the Ellen MacArthur Foundation 'the costs of remanufacturing cell phones could be reduced to 50% per device if the industry would make more easily disassemble devices, improve the reverse cycle, and offer higher incentives to customers to return unused devices'.[32]

Although current practices regarding reparation, re-use, and recycling in the Netherlands and the EU are gaining ground, there remains plenty of room for growth and improvement. It should be emphasized that a circular economy is about more than recycling alone: it is also about maintenance, the reuse/redistribution and refurbishment/remanufacture of goods. It is about optimizing our use of materials in a more resource efficient way, and shifting our recycling practices from a material centered to a product centered view. This transition involves both producers and consumers. In order to do so, it is vital to overcome a wide range of economic, technological and societal hurdles.

30 European Commission, 'Questions and Answers on the Commission Communication 'Towards a Circular Economy' and the Waste Targets Review,' July 2, 2014, http://europa.eu/rapid/press-release_MEMO-14-450_en.htm.

31 Working Group on the Global Metal Flows, United Nations Environment Programme, en International Resource Panel, 'Metal Recycling: Opportunities, Limits, Infrastructure,' 2013, 20, http://www.unep.org/resourcepanel/Portals/50244/publications/UNEP_summarybooklet_2b_130911_web.pdf.

32 Ellen Macarthur Foundation, 'Towards a Circular Economy: Business Rationale for an Accelerated Transition,' 6.

# 4 RAW MATERIALS EXPORTS DEPENDENCY

A transition to a circular economy is unlikely to leave global trade flows unaffected. As the economy increasingly focuses on the re-use, remanufacturing and recycling of certain resources, the demand for these primary raw materials is, *ceteris paribus,* likely to decrease. As a consequence, economies that tend to rely on such exports appear more vulnerable to economic downturns resulting from a reduction in demand.

Accounting for 3.6% of global raw material imports in 2014, the Netherlands occupies a relatively small position in the world market.[33] The EU as a whole covered 12.3% of the global import of raw materials, making the Union the world's second largest importer after China. [34] Given the combined weight of its member state economies, the impact of an EU wide transition to a circular economy is therefore expected to be much greater than if the Netherlands were to transition on its own. This section analyzes the extent to which sourcing countries financially rely on the export of CRM and non-CRMs materials to the Netherlands, and Europe as a whole, and could thus be considered to be vulnerable to a transition towards a circular economy.

## 4.1 Vulnerability to a Dutch transition to circularity

### Critical raw materials exports to the Netherlands

The Netherlands imported its 22 CRMs from a variety of developed and developing countries (see Table 2). A quick analysis shows that most of the Netherlands' important trade partners concerning the import of the listed raw materials are other EU Member-states. Moreover, the database indicates that only five of these CRMs exceed a total import value of € 10 million: (1) gold, (2) tin, (3) natural phosphates, (4) activated carbon, and (5) niobium.

33 Eurostat, ERO_ITEM CSL_CITATION {"citationID":"CAKFw9sP","properties":{"Eurostat, n.d., http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tet00006&plugin=1.

34 Eurostat, 'Share of EU in the World Trade,' *Eurostat*, n.d., http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.

| CRM | LARGEST EXPORTING COUNTRIES TO NL | LARGEST EXPORTING COUNTRIES TO EU |
|---|---|---|
| Antimony | China | China, Vietnam, Kyrgyzstan, Turkey |
| Beryllium | United Kingdom | US, China |
| Borates | | Turkey, US, China |
| Chromium | China, Slovakia | South Africa, Turkey, India, Pakistan |
| Cobalt | Uganda | Russian Federation |
| Coking coal | China, India, Belgium, Australia, US, Sri Lanka | China, US, India, Philippines, Sri Lanka |
| Fluorspar | | South Africa, Mexico, Namibia, China, Kenya, Morocco |
| Gallium | Poland, Belgium | Brazil, China, US, Rep. of Korea, Canada, Japan, Russian Federation, Hong Kong, Peru |
| Germanium | South Africa, US, Germany | China, US, South Africa |
| Gold | Germany, United Kingdom, Austria, Cuba | Canada, Switzerland, South Africa, US, Brail, Australia, Russian Federation, Japan, Hong Kong, Turkey, Suriname United Arab Emirates, Mexico, Singapore, Papua New Guinea |
| Indium | See Gallium | See Gallium |
| Magnesite | | Turkey, China |
| Magnesium | France, Germany | Israel, US, Mexico, China |
| Natural Graphite | | China, Brazil, Norway, US, Ukraine, Madagascar, Russian Federation |
| Niobium | South Africa, Australia, Senegal | South Africa, Australia, Mozambique, US, Ukraine, Senegal, Kenya, China, Madagascar |
| PGMs | | |
| Phosphate Rock | | Russian federation, Morocco, Algeria, Israel, Syria, Senegal, Egypt, Jordan, South Africa |
| REEs (Heavy) | | |
| REEs (Light) | | |
| Silicon Metal | | |
| Tin | Indonesia, Bolivia, Thailand, Germany, United Kingdom, Chile, Malaysia | Indonesia, Peru, China, Bolivia, Thailand, Malaysia, US |
| Tungsten | Austria, China | China, US, India, Russian Federation, Switzerland, Canada, South Africa |

**TABLE 2: LARGEST EXPORTING COUNTRIES OF CRMS**[35]

35 United Nations, 'UN Comtrade: International Trade Statistics,' accessed February 15, 2016, http://comtrade.un.org/data/.

Gold is by far the most valuable imported good and most gold imports in 2014 came from Germany and the United Kingdom, at a total (EU) value of € 653.4 million and € 31.7 million respectively. Clearly, neither Germany, nor the UK, qualify as a developing country. Moreover, both countries export a wide range of goods, which limits the impact of gold exports on their GDP: German gold exports contributed a mere 0.14% to the GDP, while the contribution of UK exports to its GDP was close to zero (1.2e-8%).

With regard to the other raw materials that exceed an import value of € 10 million, the Netherlands relies on a wide variety of trading partners. Not only does this limit the external impact if the Dutch economy becomes circular, it also distributes the supply risk. When accumulating the total export of all CRMs of individual countries to the Netherlands, none exceeded a contribution of 1% to the sourcing country's GDP. In most cases, the total value of exports amounted to less than 0.1% of a country's GDP. The share of exports to the Dutch economy is generally only a small portion of a country's total exports for a specific commodity. This means that if the Netherlands wishes to transition towards a circular economy solely in order to limit the import of CRMs, this would have little impact on the economic stability of its developed and developing trade partners.

### Non-critical raw materials exports to the Netherlands

CRMs set aside, a transition to a circular economy would also involve the re-use, remanufacturing, and recycling of non-CRMs. Based on the full list of the 64 (abiotic) resources, numerous materials are imported in large quantities. In 2014, the Netherlands imported large quantities of Aluminum and Bauxite (€ 5.2 billion), Copper (€ 1.4 billion), Iron ore (€ 661.4 million) and Nickel (€ 875.7 million), which accounted for over 27% of the total import value. That said, our analysis indicates that the importance of this trade relative to a sourcing country's GDP remains limited. Iceland is the only exception. In 2014 Iceland exported over € 1 billion worth of non-CRMs to the Netherlands. This contributed to 6% of its GDP. However, other countries experienced no more than a contribution of 1% to their GDP from the Netherlands in their exports of non-CRMs.

## 4.2 Vulnerability to an EU level transition to circularity

### Critical raw materials exports to the EU

The EU imports large quantities of CRMs and non-CRMs from both economies in transition (e.g. Russia, Ukraine, Brazil) and developing countries (ranging from China, and South Africa to Angola, Iraq, and Vietnam) (see Table 2 in section 4.1).[36]

In 2014, the EU imported large sums (> € 1 billion) of gold, PGMs[37], silicon, and tin. South Africa has been (and still is) one of dominant trading partners, importing both gold and

36 The authors adopted the UN Country classification, labelling countries as 'developed countries', 'economies in transition', and 'developing countries'. For the sake of the analysis, the authors merged the latter two labels.

37 PGMs is a cluster of six Platinum, Osmium, Iridium, Ruthenium, Rhodium, and Palladium.

platinum group metals (PGMs) especially. When adding the revenues earned through the export of other CRMs by South Africa to this amount, South African exports to the EU were valued at € 6.5 billion in 2014. Although in absolute terms this amount exceeds the GDP of Niger, Guinea, Suriname, and Togo, in relative terms it represented a mere 2.1% of South African GDP.

A similar situation applies to Russia. As a large exporting country of, *inter alia,* gold (€ 644.8 million), PGMs (€ 549.8 million), and phosphates (€ 221.7 million), CRM exports generated € 1.6 billion in 2014. However, given the overall size of the Russian economy (valued at € 1,669.8 billion in 2014) these exports reflected less than 1% of Russian GDP.

Assessing the exporting value of CRMs in absolute terms limits our understanding of the impact that a circular economy may have on smaller countries. Smaller countries tend to be overshadowed by larger exporting ones, such as Brazil, China, and Russia. When (re)examining the data, a different pattern emerges. Few countries depend on the export of a single CRM to the EU for more than 1% of their GDP. In 2014, gold exports to the EU contributed around 1% to the GDP of Guyana, 1.4% to that of South Africa, and 3.5% to Suriname´s GDP. When adding up the value of all CRM exports per country, this image does not change.

## Non-critical raw materials exports to the EU

With other EU Member-states included, aluminum exports contributed 11% to Iceland's GDP, generating € 1.9 billion in 2014. The GDP of other countries, such as Mozambique (7.2%), Montenegro (2.1%), and Bosnia Herzegovina (1.7%) also involves the export of aluminum. Additionally, the export of bauxite - the main source of aluminum - represented 7.2% of Guinea's GDP in 2014 at a total value of over € 425.2 million.

As mentioned earlier, other (non-critical) raw materials include the large-scale import of copper from the Republic of the Congo (3.5% of GDP), Chile (2.1% of GDP), Democratic Republic of the Congo (DRC) (2.0% of GDP) and Namibia (1.8% of GDP); Iron ore from Liberia (7.9% of GDP), Mauritania (6.4% of GDP), and Ukraine (1.2% of GDP); and Nickel from Madagascar (2.0% of GDP). All these countries are classified as either a country in transition or a developing country.

From all the countries examined, Iceland appears most dependent on the export of raw materials to the EU. The EU is Iceland's primary trading partner when it comes to the export of aluminum and silicon, accounting for €1.7 billion in 2014, which represented 11.0% of Icelandic GDP, as it also includes the export of (much smaller quantities of) copper and silicon.

Table 3 shows that several sub-Saharan African countries rely between 3.5% to 8.1% of their GDP on raw material exports to the EU. Unsurprisingly, most of these countries rely on the export of one, or only a narrow range of raw materials. Whereas, Liberia (8.0% of GDP) and Mauritania (6.4% of GDP) are largely dependent on the export of iron ore, Guinea relies heavily on the European demand for bauxite and gold (8.1% of GDP). Other countries include Mozambique (7.8% of GDP; primarily aluminum and titanium); Niger (6.2% of GDP; Uranium/uraan); Namibia (5.2% of GDP; primarily copper, uranium/uraan, and zinc); and the Republic of the Congo (3.5% of GDP; copper). Of these countries Mozambique represents the largest economy, with a GDP of € 14.2 billion in 2014.

| COUNTRY | VALUE (IN €) | % OF GDP | PUBLIC REVENUE |
|---|---|---|---|
| Iceland | € 1,683,036,160 | 11.01% | 29.4% |
| Guinea | € 478,323,897 | 8.05% | n/a |
| Liberia | € 143,865,200 | 7.97% | n/a |
| Mozambique | € 1,117,401,430 | 7.81% | 20.4% |
| Mauritania | € 289,343,558 | 6.38% | n/a |
| Niger | € 453,972,403 | 6.20% | n/a |
| Namibia | € 600,824,516 | 5.16% | 27.1% |
| Rep. of Congo | € 446,276,620 | 3.51% | 34.9% |
| Suriname | € 163,451,735 | 3.50% | 23.5% |
| Dem. Rep. of the Congo | € 830,202,923 | 2.80% | 14.2% |
| South Africa | € 8,385,747,370 | 2.67% | 27.1% |
| Montenegro | € 105,818,920 | 2.57% | n/a |
| Guyana | € 68,497,078 | 2.47% | n/a |
| Bosnia Herzegovina | € 399,117,369 | 2.40% | 26.1% |
| Madagascar | € 227,399,246 | 2.39% | 10.1% |
| Sierra Leone | € 103,170,656 | 2.38% | n/a |
| Chile | € 5,153,535,160 | 2.23% | 21.3% |
| Switzerland | € 12,118,109,400 | 1.93% | 11.8% |
| Serbia | € 556,994,649 | 1.42% | 35.8% |
| Ukraine | € 1,607,045,620 | 1.36% | 35.7% |
| Armenia | € 130,760,581 | 1.25% | 22.6% |
| Peru | € 2,223,199,140 | 1.22% | 20.4% |
| TFYR of Macedonia | € 122,647,322 | 1.21% | 28.9% |
| Norway | € 5,299,026,900 | 1.18% | 47.5% |
| Ecuador | € 11,589,922 | 1.09% | n/a |
| Georgia | € 161,984,608 | 1.09% | 25.0% |
| Papua New Guinea | € 152,293,179 | 1.00% | n/a |

TABLE 3: HIGHEST CONTRIBUTIONS OF RAW MATERIAL EXPORTS (TOTAL VALUE) TO EU AS A SHARE OF GDP AND PUBLIC REVENUE (ALL RAW MATERIALS) [38]

38 United Nations, 'UN Comtrade: International Trade Statistics.'

Other non-sub-Saharan African countries in our analysis include South-American countries (i.e. Suriname, Guyana, Chile, Peru, Ecuador), and Eastern/South-Eastern European countries (i.e. Montenegro, Bosnia Herzegovina, Serbia, Ukraine, Macedonia). With few exceptions, the common denominator among these countries appears to be that they tend to export large quantities of a maximum of one to three raw materials.

Export taxes represent a substantial share of fiscal revenues for these countries. On average, the contribution to public revenues is around 25%, with outliers between 10.1% and 47.5% (see Table 3). In the case of Mozambique, with a GDP of €14.3 billion and (an estimated) 20.4% share going to fiscal revenues, this implies that a reduction in raw materials-exports following an EU-wide transition could result in a direct loss of 1.6% of the country's revenues. Other developing countries, such as Namibia and the Republic of the Congo could lose 1.4% or 1.2%, respectively, in fiscal revenues, following such a transition. In this scenario, Iceland stands to lose most in terms of public revenue, as it earns 29.4% of its GDP through export taxes, which makes up 3.2% of its fiscal revenues.

## 4.3 Reliance on raw material exports worldwide

In determining the impact of a circular economy on developing countries, it is also important to look beyond Europe. After all, if other major raw material importers worldwide were to transition to a circular model, the impact on natural resource exporting developing countries would be profound. Table 4 gives an overview of the countries whose raw material exports to the global market have the highest relative contribution to their GDP. Note that also in this case African countries top the list, with at least six that have a contribution to their GDP above 15% resulting from global raw material exports.

| COUNTRY | MATERIALS | APPROX. TOTAL VALUE OF COUNTRY'S EXPORT | % EXPORTS TO EU / GDP | SHARE OF EXPORTS TO THE EU | % TOTAL EXPORT / GDP |
|---|---|---|---|---|---|
| Sierra Leone | Iron ore | $ 1.7 billion | 0.07% | 0.20% | 34.36% |
| Mauritania | Iron ore | $ 1.3 billion | 6.38% | 25% | 25.39% |
| Suriname | Gold | $ 1.2 billion | 3.46% | 15% | 23.01% |
| Mali | Gold | $ 2.7 billion | 0.06% | 0.27% | 22.31% |
| Guyana | Gold | $ 688.2 million | 1% | 5% | 22.22% |
| Liberia | Iron ore | $ 411 million | 7.89% | 39% | 20.42% |
| Zambia | Copper | $ 5.5 billion | 0.76% | 3.76% | 20.23% |
| Chile | Copper | $ 5.3 billion | 2.05% | 15% | 15.45% |
| Rep. of Congo | Copper | $ 1.9 billion | 3.51% | 25.9% | 13.56% |
| Guinea | Bauxite (Aluminium) | $ 834 million | 7.18% | 57% | 12.60% |
| | Gold | $704.3 million | 0.79% | 7.45% | 10.63% |
| Dem. Rep. of Congo | Copper | $ 3.8 billion | 2.02% | 18% | 11.45% |
| Burkina Faso | Gold | $ 1.4 billion | 0.16% | 1.48% | 11.06% |
| Papua New Guinea | Gold | $ 1.7 billion | 0.43% | 4.19% | 10.2% |
| Ghana | Gold | $ 3.7 billion | 0.00% | 0.05% | 9.6% |
| Mozambique | Aluminium | $ 1.9 billion | 7.22% | 80.78% | 8.12% |

TABLE 4: HIGHEST CONTRIBUTIONS OF EXPORTS (TOTAL VALUE) TO THE WORLD MARKET AS A SHARE OF GDP (ALL RAW MATERIALS) [39]

What is clear from Table 4 is that it can be expected that in the case major non-European economies were to transition to a circular economy, the effect on African raw material exporters' GDP is profound. It should be pointed out that although a country such as Chile also has a relatively high contribution to its GDP resulting from commodity exports; it has a significantly higher development ranking than many of the other countries in this table. Additionally, the Chilean economy is more diversified compared to the economies of African raw material exporting countries. The risks resulting from the effects of circular transitions worldwide therefore are expected to be less profound in the Chilean case compared to the other countries in Table 4.

39 Ibid.

# 5 RISK MULTIPLIERS

The analysis in section 4 generated a long list of countries that, to varying degrees, are dependent on the export of critical and non-critical raw materials to Europe. Countries that emerged as particularly reliant are Guinea, Liberia, Mozambique, Mauritania, Niger, Namibia, Republic of the Congo, Suriname, DRC and South Africa. This list expands to include Sierra Leone, Mali, Guyana, Zambia, Burkina Faso, Papua New Guinea and Ghana when taking into account the reliance on raw material exports to the world market.

In this section we combine the insights from the data-analysis with an analysis of the intra-state fragility (or resilience) of around 200 countries around the world with respect to several economic, societal, environmental, political and security challenges based on the HCSS evidence-based *Drivers of Vulnerability* Monitor, zooming in on the countries that stood out from section 4.[40] The reasoning behind this exercise is that if countries are highly dependent on raw material exports, the risks resulting from a transition to circularity in important export markets is amplified by the presence of underlying factors that cause intra-state fragility.

The maps presented in this section illustrate how developing countries (such as the DRC for example) and rising/emerging economies (such as China or Russia) are prone to intra-state fragility. This Monitor includes a number of drivers illustrating these challenges, and maps them on the basis of open source datasets. For example, growth in income inequality is a significant factor in assessing vulnerability to conflict. Conversely, a rise in income is suggested to strengthen governments.[41] For this reason we included GDP growth datasets from the World Bank and the CIA World Fact Book as one of the economic indicators.

Figure 2 provides an assessment of the security situation in developing and rising/emerging countries worldwide by measuring conflict magnitude, number of conflicts, number of deaths, the scale of political terror, the number of refugees produced and the number of conflicts in neighboring countries.

40 The HCSS Drivers of Vulnerability Monitor is an interactive tool that allows users to assess intra-state fragility worldwide on the basis of a vast indicator dataset. The monitor can be accessed via this link: http://projects.hcss.nl/monitor/86/.

41 Paul Collier and Anke Hoeffler, 'Greed and Grievance in Civil War' (Washington, D.C.: World Bank, 2002), 34.

## SECURITY

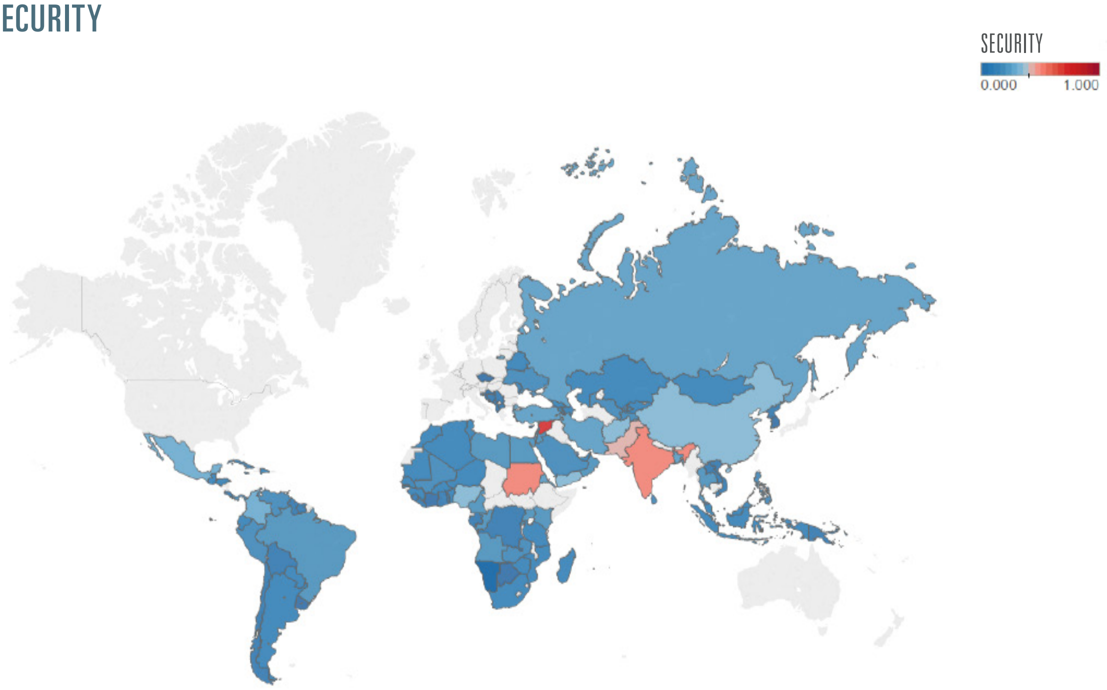


FIGURE 2. INDEX COMPRISING THE SECURITY-RELATED DRIVERS OF VULNERABILITY: CONFLICT MAGNITUDE, NUMBER OF CONFLICTS, NUMBER OF DEATHS, POLITICAL TERROR SCALE, REFUGEES PRODUCED AND CONFLICTS IN NEIGHBORING COUNTRIES IN 2014.

What stands out from Figure 2 is that most of the countries mentioned at the beginning of this section appear in blue, indicating that they may experience the occasional rise to the surface of low-intensity conflict. Examples are Mauritania, Sierra Leone, Liberia, Guinea, Ghana, DRC, Madagascar, Mozambique, Niger, Suriname, Guyana, Papua New Guinea and Namibia.

One of the reasons behind low-intensity conflict in these countries is the troublesome political situation that many of these nations find themselves in. Figure 3 gives an overview of the political situation in developing and emerging countries worldwide through an assessment of civil liberties, control of corruption, factionalism, government efficiency, political rights, regime duration and the rule of law.

## POLITICAL

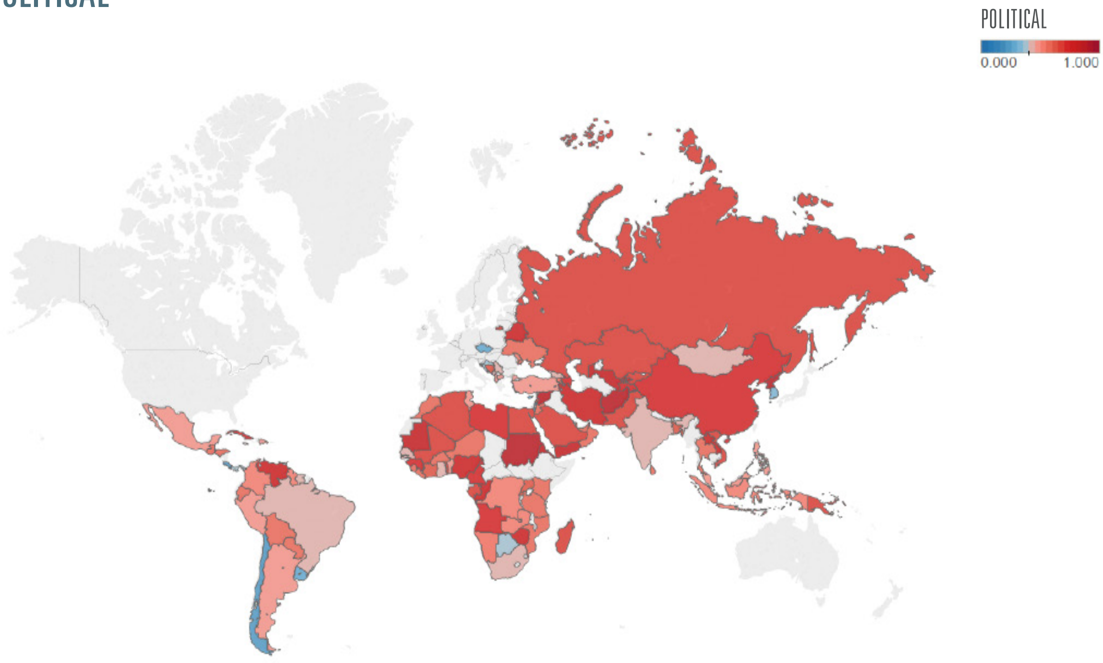


FIGURE 3. INDEX COMPRISING THE POLITICAL DRIVERS OF VULNERABILITY: CIVIL LIBERTIES, CONTROL OF CORRUPTION, FACTIONALISM, GOVERNMENT EFFICIENCY, POLITICAL RIGHTS, REGIME DURATION AND RULE OF LAW IN 2014.

What is immediately clear is that when looking at political indicators, most countries score relatively poorly. The positive exceptions are Chile, South Korea, Singapore and Hong Kong. The countries most dependent on raw material exports score particularly badly. Examples are numerous, including Mauritania, DRC, Madagascar, Guyana, Mozambique, Guinea, Suriname, Liberia, Niger, Ghana, Namibia, South Africa and Papua New Guinea.

A look at the socio-demographic situation gives few additional reasons for optimism (see Figure 4). An analysis of the human development index, female labor force participation rate, ethnic and religious fractionalization, infant mortality and the presence of youth bulges shows that countries at risk are primarily located in Africa, the Middle East and parts of South America.

## SOCIODEMO

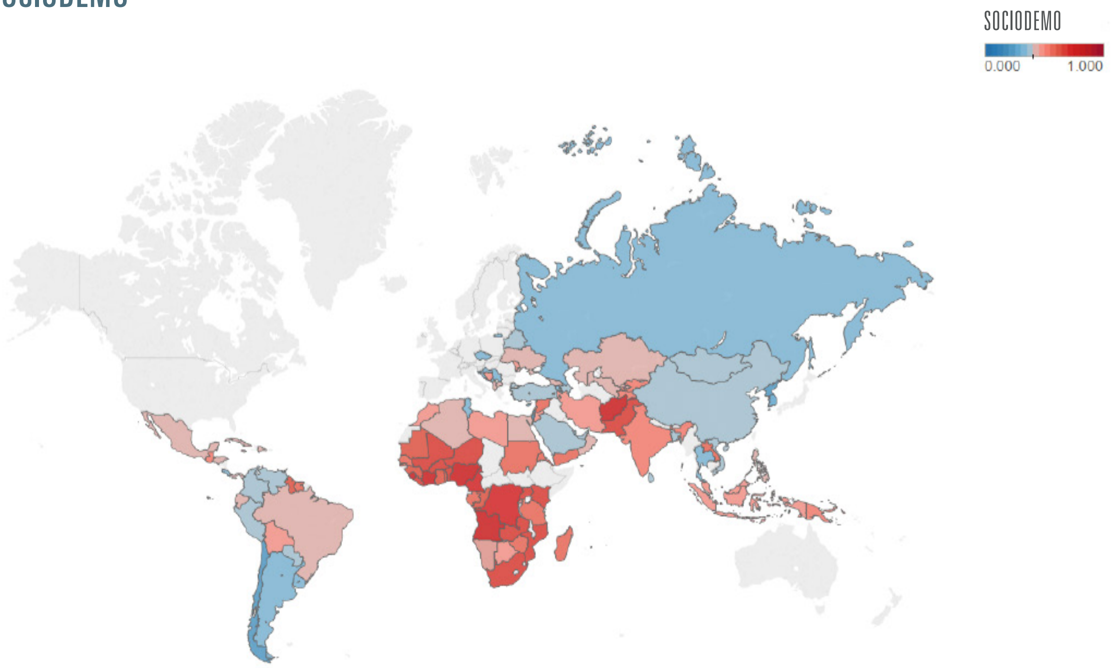


FIGURE 4. INDEX COMPRISING THE SOCIO-DEMOGRAPHIC DRIVERS OF VULNERABILITY: HUMAN DEVELOPMENT INDEX, FEMALE LABOR FORCE PARTICIPATION RARE, ETHNIC AND RELIGIOUS FRACTIONALIZATION, INFANT MORTALITY AND YOUTH BULGES IN 2014.

African countries have particularly deep-seated problems when it comes to development indicators and the presence of youth bulges that battle for scarce employment opportunities. Raw material exporting countries suffering from poor socio-demographic scores include Mauritania, Liberia, Guinea, Madagascar, Mozambique, South Africa, Niger, Namibia, Suriname, DRC, Guyana, and Papua New Guinea.

Finally, Figure 5 looks at the economic vulnerability of developing and emerging countries worldwide by assessing GDP growth, food dependence, inflation, the ranking on the globalization index and the level of resource rents.

## ECONOMIC

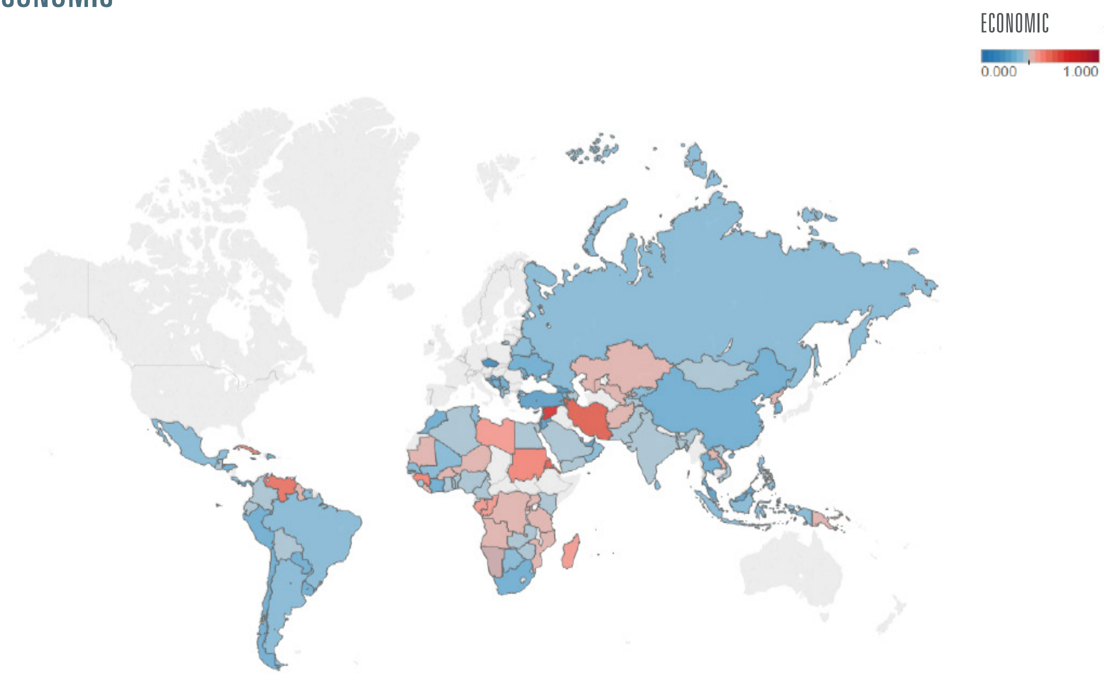


FIGURE 5. INDEX COMPRISING THE ECONOMIC DRIVERS OF VULNERABILITY: GDP GROWTH, FOOD DEPENDENCE, INFLATION, GLOBALIZATION INDEX AND RESOURCE RENTS IN 2014.

Here again the focus is primarily on African raw material exporters such as Mauritania, Guinea, Mozambique, Madagascar, Liberia and Niger. Other countries that have a relatively high level of economic vulnerability are Guyana and Papua New Guinea.

In general, it is safe to say that the countries discussed in this section suffer from a wide range of risk aggravating factors on the political, socio-demographic and economic level that will undoubtedly rise to the surface in case of an economic downturn. Although a transition to circularity at the European level is unlikely to pose problems to the whole range of countries, African raw material exporting nations are often among the exceptions. Moreover, if with time, a transition to circularity were to take root in major importing countries worldwide, the list of countries at risk would expand significantly.

# 6 CONCLUSION AND RECOMMENDATIONS

The analysis performed in this study allows us to make several observations. First, when it comes to a transition to circularity, the Netherlands itself is too small a player to generate a significant impact on raw material exporting developing countries. Second, at the EU level, the effects are understandably greater, yet only when one takes the combined number of CRMs and non-CRMs exported to Europe. A total of 24 developing countries rely on raw material exports to the EU for more than 1% of their GDP – in a range from 1-8.1%. Countries that are most exposed are Guinea, Liberia, Mozambique, Mauritania, Niger, Namibia, Republic of the Congo, Suriname, DRC, South Africa, Guyana, Madagascar and Sierra Leone, including countries that suffer from poor governance and high demographic pressure. That said, even then, the levels of exposure to fluctuations in raw material exports to Europe barely reach 10% of GDP and for the vast majority of countries examined the contribution to their GDP is even below 5%.

This leads us to a third observation. Even if Europe were to transition to a circular model, in determining whether this will have a major impact on developing countries much will depend on what other major importers in the rest of the world will do. Looking at the relative contribution to a sourcing country's GDP from global raw material exports we found a range from 8.12% in the case of Mozambique to 34.36% in the case of Sierra Leone. These are significant shares with ten developing countries showing a GDP dependency ratio of over 10%. Again, the demographic pressure and poor levels of governance in these countries act as a significant risk multiplier on top of their economic vulnerability.

Arguably, whether or not other parts of the world will see their economies transition to circularity is the big question and one which was debated thoroughly in the workshop held on 23 June 2016 in the Hague. A fourth observation thus relates to future demand patterns for raw materials. In light of population growth in emerging economies, it should be expected that demand for raw materials will grow alongside a rise in local purchasing power and a population that seeks to acquire more sophisticated goods. Demand for critical, or high-tech, materials as such is not expected to slow down anytime soon. Conversely, in countries whose population figures are stable, raw material demand is likely to behave differently. Although here too, demand for critical/high-tech materials is unlikely to subside soon, major strides could be made with respect to demand for 'low-tech' commodities such as copper and iron ore. An interesting issue to watch in this regard is that, given that CRMs are often mined as a byproduct of larger mine flows, price dynamics of CRMs are likely to change if greater circularity causes 'bulk' mines to close.[42]

Despite the fact that the Netherlands performs better in comparison to other EU Member-states, the use of recycled raw materials still remains low. Given the increasing complexity of metal-containing products, their collection, dismantling, and recycling is often difficult. Although current practices related to the circular economy gain momentum, both the Dutch and the European economy remain far removed from a full transition. That leads us to observation number five. A transition to circularity may very well progress slowly; however, that does not mean sourcing countries have an eternity to prepare for the effects of these transitions on their economies. The tendency to rely on the long return on investment from mining is a potential pitfall for raw material exporting countries as it puts off the incentive to diversify their economic base. This risk is amplified in case a greater recycling rate of (base) metals causes a reduction in prices in the long term. Countries with the highest resource rents and few other sectors to fall back on will thus be most exposed, i.e. many of the African raw material exporters examined in this study.

The EU has tabled several revised legislative proposals. Few of these contain clear targets. Those who do possess targets are those focusing on waste reduction. Proposed are a common EU target of 65% for recycling of municipal waste by 2030 and a common EU target for recycling 75% of packaging waste by 2030.[43] Beyond 'encouraging member states to promote recycling of CRMs in its revised proposals on waste', concrete proposals and actions with respect to CRMs are notably absent.[44] Observation number six therefore is that the timeframe within which the EU would like to transition to circularity in the area of (critical) raw materials remains unclear. Thus, one cannot give a conclusive answer on the extent to which raw material exporters may face a reduced demand for their commodities. Nevertheless, 2030 should be seen as an important date on the horizon, after which major improvements in waste recycling should be realized. Therefore, it is safe to assume that low tech materials such as copper and iron ore will be among those for which waste recycling statistics have gone up by 2030. For important exporters of iron ore and copper to Europe such as Mauritania, Liberia (iron ore), Zambia, Republic of the Congo and DRC (copper) that is something to take into account sooner, rather than later. Conversely, for the Dutch government and the EU this is something they should emphasize in their bilateral relations with these countries.

42 Workshop on the Circular Economy and Developing Countries. The Hague Centre for Strategic Studies, 23 June 2016.

43 'Circular Economy Strategy - Environment - European Commission,' *European Commission*, 2016, http://ec.europa.eu/environment/circular-economy/index_en.htm.

44 European Commission, 'EU Action Plan for the Circular Economy,' December 2015, 16, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614.

# BIBLIOGRAPHY


Bastein, Ton, and Elmer Rietveld. 'Materialen in de Nederlandse Economie - Een Kwetsbaarheidsanalyse.' The Hague: TNO, January 12, 2015. https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2015/12/11/materialen-in-de-nederlandse-economie/TNO+2015+R11613+Materialen+in+de+Nederlandse+economie+webversie+definitief.pdf.

'Circular Economy Strategy - Environment - European Commission.' *European Commission*, 2016. http://ec.europa.eu/environment/circular-economy/index_en.htm.

Collier, Paul, and Anke Hoeffler. 'Greed and Grievance in Civil War.' Washington, D.C.: World Bank, 2002.

Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. 'Towards a Circular Economy: A Zero Waste Programme for Europe,' February 7, 2014. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52014DC0398R%2801%29.

Cramer. 'Moving towards a Circular Economy in the Netherlands: Challenges and Directions,' 2014. http://www.usi.nl/files/2015/04/Paper-HongKong-JC-april-2014.pdf.

Ellen Macarthur Foundation. 'Towards a Circular Economy: Business Rationale for an Accelerated Transition,' 2015. https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf.

European Commission. 'EU Action Plan for the Circular Economy,' December 2015. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614.

———. 'Questions and Answers on the Commission Communication 'Towards a Circular Economy' and the Waste Targets Review,' July 2, 2014. http://europa.eu/rapid/press-release_MEMO-14-450_en.htm.

———. 'Report on Critical Raw Materials for the EU,' May 2014. http://ec.europa.eu/DocsRoom/documents/10010/attachments/1/translations/en/renditions/native.

Eurostat. 'International Trade of Raw Materials, by Reporting Country.' *Eurostat*, n.d. http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tet00006&plugin=1.

———. 'Share of EU in the World Trade.' *Eurostat*, n.d. http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do.

'List of Supplying Markets for a Product Imported by European Union (EU 28).' *International Trade Centre*, n.d. http://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1||14719|||2606|||4|1|1|1|2|1|4|1|1.

Ministerie van Buitenlandse Zaken. 'Grondstoffennotitie,' July 15, 2011. https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2011/07/15/grondstoffennotitie/grondstoffennotitie.pdf.

Potential Effects of Circular Economy Policies in the Netherlands and Europe on Developing Countries – a Quick-Scan." The Hague: Planbureau voor de Leefomgeving (PBL), 2016.

The Ellen MacArthur Foundation. 'Towards the Circular Economy Vol. 1: An Economic and Business Rationale for an Accelerated Transition.' The Ellen MacArthur Foundation, January 25, 2012. http://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf.

The World Bank. 'Mining Royalties: A Global Study ofTheir Impact on Investors,Government,and Civil Society.' Washington, D.C., 2006. http://siteresources.worldbank.org/INTOGMC/Resources/336099-1156955107170/miningroyaltiespublication.pdf.

Ton Bastein, Elsbeth Roelofs, Elmer Rietveld, and Alwin Hoogendoorn. 'Kansen Voor de Circulaire Economie in Nederland.' TNO, June 11, 2013. https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/rapporten/2013/06/20/tno-rapport-kansen-voor-de-circulaire-economie-in-nederland/tno-rapport-kansen-voor-de-circulaire-economie-in-nederland.pdf.

United Nations. 'UN Comtrade: International Trade Statistics.' Accessed February 15, 2016. http://comtrade.un.org/data/.

United Nations Environmental Programme. 'Recycling Rates of Metals: A Status Report.' United Nations Environmental Programme, 2011. http://www.unep.org/resourcepanel/Portals/24102/PDFs/Metals_Recycling_Rates_110412-1.pdf.

Working Group on the Global Metal Flows, United Nations Environment Programme, en International Resource Panel. 'Metal Recycling: Opportunities, Limits, Infrastructure,' 2013. http://www.unep.org/resourcepanel/Portals/50244/publications/UNEP_summarybooklet_2b_130911_web.pdf.

'World Economic Situation and Prospects.' New York: United Nations, 2012.

# ANNEX

| NR | RAW MATERIAL | HS CODE EXCEL SHEET (UN COMTRADE) |
|---|---|---|
| 1. | Aluminium (Al) | Aluminium and articles thereof: HS 76 |
| | Bauxite | Aluminium ores and concentrates: HS 2606 |
| 2. | **Graphite** | Natural Graphite: HS 2504 |
| 3. | **Platinum* (Pt)** | Platinum unwrought semi-manufactured or powder form: HS 7110 |
| 4. | Silver (Ag) | Silver, unwrought, semi-manufactured, or powder: HS 7106<br>Silver ores and concentrates: HS 261610 |
| 5. | **Antimony (Sb)** | Antimony, ores and concentrates: HS 261710<br>Antimony, articles thereof, waste scraps: HS 8110 |
| 6. | Iron (Fe) | Iron, ores and concentrates, roasted iron pyrites: HS 2601<br>Iron & steel : Hs 72 |
| 7. | Selenium (Se) | Selenium: HS 280490 |
| 8. | Feldspar | Feldspar: HS 252910 |
| 9. | Barytes | Natural Barium Sulphate: HS 251110 |
| 10. | Nickel (Ni) | Nickel, ores and concentrates: HS 2604<br>Nickel, and articles thereof: HS 75 |
| 11. | **Silicon (si)** | Silicon > 99.99% pure: HS 280461<br>Silicon < 99.99% pure: HS 280469 |
| 12. | Molybdenum (Mo) | Molybdenum, ores and concentrates: HS 2613<br>Molybdenum art. Thereof., waste or scrap: HS 8102 |
| 13. | Bentonite | Bentonite: HS 250810<br>Decolorising earths and fuller's earth: HS 250820 – *No data available* |
| 14. | Industrial sand (silica) | Silica Sands and quartz sands, HS 250510 |
| | Silica / Silicon dioxide | Silica / Silicon dioxide: HS 281122 |
| 15. | Uranium (U) | Natural uranium, its compounds, mixtures: HS 284410<br>Uranium ores and concentrates: HS 261210 |
| 16. | **Fluorspar (F)** | Fluorspar, > 95% calcium fluoride: HS 252922<br>Fluorspar, < 95% calcium fluoride: HS 252921 |
| 17. | **Beryllium (Be)** | Beryllium, unwrought powders: HS 811212<br>Beryllium, articles thereof: HS 811219 |
| 18. | Limestone | Limestone, HS 2521 |
| 19. | Talc | Natural Steatite: HS 2526 |

| NR | RAW MATERIAL | HS CODE EXCEL SHEET (UN COMTRADE) |
|---|---|---|
| 20. | Manganese (Mn) | Manganese ores, concentrates, iron ores>20% Manganes : HS 2602 |
| | | Manganese, articles thereof : HS 8111 |
| 21. | **Borates / Boron (B)** | Natural Borates: HS 2528 |
| | | Borates, Peroxoborates: HS 2840 |
| 22. | Clay (Kaolin) | China clay (Kaolin / Kaolinite): HS 2507 |
| | | Fireclay: HS 250830 |
| 23. | Tantalum (Ta) | Tantalum and articles thereof, including waste scraps: HS 8103 |
| 24. | Zinc (Zn) | Zinc ores and concentrates: HS 2608 |
| | | Zinc and articles thereof: HS 79 |
| 25. | **Chromium (Cr)** | Chromium, ores and concentrates: HS 2610 |
| | | Chromium, unwrought, powders: HS 811221 |
| | | Chromium, and articles thereof: HS 811229 |
| 26. | **Cobalt (Co)** | Cobalt, ores and concentrates: HS 2605 |
| | | Cobalt, mattes, scrap, articles: HS 8105 |
| 27. | Tellurium (Te) | Boron, tellurrium: HS 280450 |
| 28. | **Phosphorus (P)** | Phosphorus (P), HS 280470 |
| | | Natural Phosphates (calcium, calcium –aluminium), chal: HS 2510 |
| 29. | **Activated carbon (charcoal)** | Activated carbon: HS 380210 |
| 30. | Copper (Cu) | Copper, ores and concentrates: HS 2603 |
| | | Copper and articles thereof: HS 74 |
| 31. | Tin (Sn) | Tin and articles thereof: HS 80 |
| | | Tin ores and concentrates: HS 2609 |
| 32. | **Cerium (Ce)** | Cerium compounds: HS 284610 |
| 33. | Diatomite (kieselgur) | Siliceous fossil meals and earth: HS 2512 |
| 34. | Lithium (Li) | Lithium, primary cells: HS 850650 |
| | | Lithium, Carbonates: HS 283691 |
| 35. | Titaniumdioxide (TiO2) | Titanium ores and concentrates: HS 2614 |
| | | Titanium, Articles thereof, scraps or waste: HS 8108 |
| | | Titanium oxides: HS 2823 |
| 36. | **Tungsten (W) (Wolfram)** | Tungsten (wolfram) and articles, waste or scraps: HS 8101 |
| | | Tungsten ores and concentrates: HS 2611 |
| 37. | **Magnesite** | Natural Magnesium Carbonate (magnesite): HS 251910 |
| | **Magnesium (Mg)** | Magnesium, Strontium, Barium hydroxide, peroxide, oxid: HS 2816 |
| | | Magnesium, and articles thereof, waste or scraps: HS 8104 |
| 38. | Strontium (Sr) | Magnesium, Strontium, Barium hydroxide, peroxide, oxid : HS 2816 |
| 39. | **Neodymium (Nd)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 40. | **Praseodymium (Pr)** | Rare earth metals, Scandium and Yttrium: HS 280530 |

| NR | RAW MATERIAL | HS CODE EXCEL SHEET (UN COMTRADE) |
|---|---|---|
| 41. | **Samarium (Sm)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 42. | **Europium (Eu)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 43. | **Yttrium (Y)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 44. | **Gadolinium (Gd)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 45. | **Terbium (Tb)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 46. | **Ytterbium (Yb)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 47. | **Lanthanum (La)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 48. | **Dysprosium (Dy)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 49. | **Scandium (Sc)** | Rare earth metals, Scandium and Yttrium: HS 280530 |
| 50. | **Gallium (Ga)** | Gallium, Indium, Rhenium, Hafnium: HS 811292 |
| 51. | **Indium (In)** | Gallium, Indium, Rhenium, Hafnium: HS 811292 |
| 52. | Rhenium (Re) | Gallium, Indium, Rhenium, Hafnium: HS 811292 |
| 53. | **Germanium (Ge)** | Germanium oxide and zirconium dioxide: HS 282560 – *No data available* |
| 54. | **Niobium (Nb)** | Niobium, tantalum, vanadium and zirconium ores, concentrates: HS 2615<br>Ferro-Niobium: HS 720293 |
| 55. | Vanadium (V) | Niobium, tantalum, vanadium and zirconium ores, concentrates: HS 2615 |
| 56. | **Palladium*** **(Pd)** | Palladium unwrought or in powder form: HS 711021 |
| 57. | Gypsum | Gypsum, anhydride and gypsum plaster: HS 2520 |
| 58. | Perlite | Vermiculite, perlite and chlorites, unexpanded: HS 253010 |
| 59. | Zircon (Zr) | Zirconium ores and concentrates: HS 261510<br>Zirconium, articles thereof (8109) |
| 60. | **Rhodium*** **(Rh)** | Rhodium unwrought or in powder form: HS 711031 |
| 61. | Gold (Au) | Gold, unwrought semi-manufactured or powder form: HS 7108 |
| 62. | Ruthenium (Ru) | Iridium, osmium and ruthenium unwrought or powder for: HS 711041 |
| 63. | **Osmium*** (Os) | Iridium, osmium and ruthenium unwrought or powder for: HS 711041 |
| 64. | **Iridium*** **(Ir)** | Iridium, osmium and ruthenium unwrought or powder for: HS 711041 |

* Generally referred to as (one of) the Platinum Group Metals (PGMs)

TABLE 5: RAW MATERIALS[45] AND THEIR CORRESPONDING HS CODE

Remarks;

- The materials printed in **bold** were listed as critical in the 2014 EU criticality matrix.
- In the EU report, **Titanium and not Titanium (di) oxide** is listed as one of the candidates for the critical raw materials.
- No data was found for **Decolorising earths and fuller's earth: HS 250820.**
- No data was found for **Germanium oxide and zirconium dioxide: HS 282560.**
- The list of **rare earth metals (HS 280530)** include: Dysprosium, Neodymium, Praseodymium, Samarium, Europium, Lanthanum, Ytterbium, Gadolinium, Terbium.

45 Bastein and Rietveld, 'Materialen in de Nederlandse Economie - Een Kwetsbaarheidsanalyse.'

| PRIMARY METAL | OLD SCRAP RATIO | RECYCLED CONTENT (RC) | END-OF-LIFE RECOVERY RATE |
|---|---|---|---|
| Aluminium (Al) | 40-50% | 34-35% | 42-70% |
| **Platinum (Pt)** | 58, >80 | 16,50% | 60-70% |
| Silver (Ag) | 76-80% | 20-32% | 30-50% |
| **Antimony (Sb)** | <10% | <10% | <5% |
| Iron (Fe) | 52-66% | 28-52% | 52-90% |
| Selenium (Se) | N/A | 1-10% | <5 |
| Nickel (Ni) | 77-88% | 29-41% | 57-63% |
| **Silicon (si)** | | | |
| Molybdenum (Mo) | 33-67% | 33% | 30% |
| **Beryllium (Be)** | 15-75% | 10-25% | <1% |
| Manganese (Mn) | 33-67% | 37% | 53% |
| **Boron (B)** | N/A | | |
| Tantalum (Ta) | 1-10%, 43% | 10 –25% | <1% |
| Zinc (Zn) | 19-71% | 18-27 | 19-52% |
| **Chromium (Cr)** | 60-72% | 18-20% | 87-93% |
| **Cobalt (Co)** | 50% | 32% | 68% |
| Copper (Cu) | 24-78% | 20-37% | 43-53% |
| Tin (Sn) | 50% | 22% | 75% |
| **Cerium*** (Ce)** | | 1-10% | <1% |
| Lithium (Li) | <1% | <1% | <1% |
| Titanium (Ti) | 11% | 52% | 91% |
| **Tungsten (W) (Wolfram)** | 80% | 46% | 10-25,66% |
| **Magnesium (Mg)** | 42% | 33% | 39% |
| Strontium (Sr) | | | <1% |
| **Neodymium* (Nd)** | | <1% | <1% |
| **Praseodymium* (Pr)** | | 1-10% | <1% |
| **Samarium* (Sm)** | | 1-10% | <1% |
| **Europium** (Eu)** | | <1% | <1% |
| **Yttrium** (Y)** | 0 | 0 | 0 |
| **Gadolinium**** (Gd)** | | 1-10 % | <1% |
| **Terbium** (Tb)** | | <1% | <1% |
| **Ytterbium**** (Yb)** | | <1% | <1% |
| **Lanthanum*** (La)** | | 1-10% | <1% |
| **Dysprosium* (Dy)** | | 1-10% | <1% |
| **Scandium**** (Sc)** | | | <1% |
| **Gallium (Ga)** | <1% | 25-50% | <1% |
| **Indium (In)** | 1% | 25-50% | <1% |
| Rhenium (Re) | 50% | 10-25% | >50% |

| PRIMARY METAL | OLD SCRAP RATIO | RECYCLED CONTENT (RC) | END-OF-LIFE RECOVERY RATE |
|---|---|---|---|
| **Germanium (Ge)** | | 35-50% | <1% |
| **Niobium (Nb)** | 44-56% | 22% | 50-56% |
| Vanadium (V) | | | <1% |
| **Palladium[0] (Pd)** | >80% | 50% | 60-70% |
| Zircon (Zr) | | 1-10% | <1% |
| **Rhodium[0] (Rh)** | >80% | 40% | 50-60% |
| Gold (Au) | 75, >80% | 29 -31% | 15-20% |
| Ruthenium (Ru) | <20% | 50-60% | 5-15% |
| **Osmium[0]** (Os) | <1% | <1% | <1% |
| **Iridium[0] (Ir)** | >80% | 15-20% | 20-30% |

TABLE 6: METAL RECYCLING STATISTICS[46]

46 United Nations Environmental Programme, 'Recycling Rates of Metals: A Status Report,' 19–21.

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