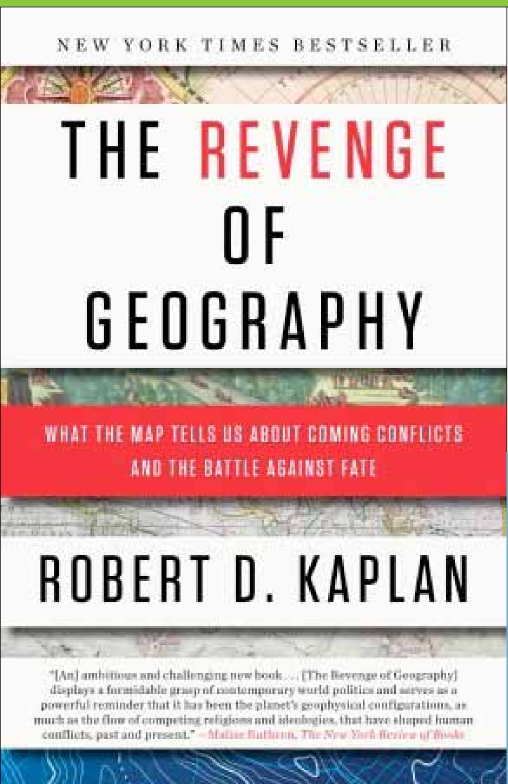
The geopolitics of raw materials for agriculture and food production

Part A: Advisory memorandum for the Minister for Agriculture of the Netherlands and the European Commission

Part B: Analysis

Platform Agriculture, Innovation & Society

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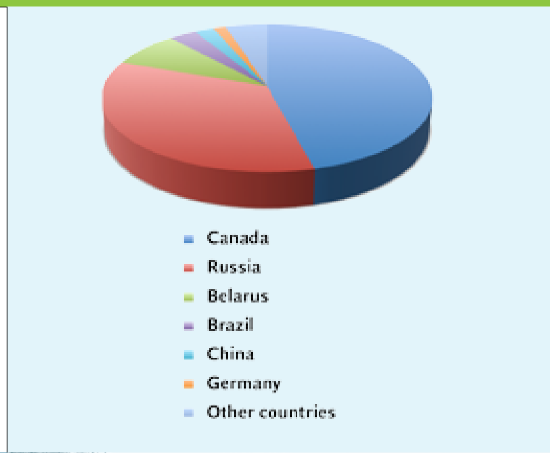

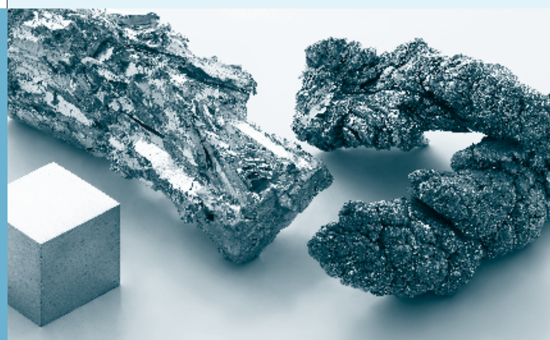

Platform
Agriculture, Innovation & Society

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Part A

Advisory memorandum for the Minister for Agriculture of the Netherlands and the European Commission

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Part B

Analysis

Drs. Wouter J. van der Weijden, Platform LIS

Dr Eric Hees, CLM Research and Advice

Dr Ton Bastein, TNO

Prof. dr Helias A. Udo de Haes, Platform LIS

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Pictures on the cover from top left clockwise:
- Cover of the book ‘The revenge of geography’ from Robert D. Kaplan
- Article of GlobalPost, November 21, 2013: “Here’s why the world’s food supply depends on Morocco”
- Distribution of global potassium reserves
- Zinc
- Phosphate mining in Togo
- Global trade flows of soya products

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The geopolitics of raw materials for agriculture and food production

Part A

Advisory memorandum for the Minister for Agriculture of the Netherlands and the European Commission

Platform Agriculture, Innovation and Society

Summary

The EU is largely self-sufficient in basic foodstuffs. Therefore, the food security of the EU seems assured. But appearances are deceiving: the EU is relatively poor in resources and raw materials, including raw materials for agriculture. In recent years, the EU has become aware of its own vulnerability to scarcity of raw materials, but the focus so far has been primarily on raw materials for industry, not for agriculture.

This advisory memorandum of the Platform Agriculture, Innovation and Society focusses on seven critical raw materials for European agriculture: soya, the mineral macronutrients phosphate and potassium, and the mineral micronutrients zinc, selenium, molybdenum and boron. These mineral raw materials are *not* replaceable in agriculture or in the food chain, but they are replaceable in industry to a greater or lesser extent.

Scarcity
Mineral resources never run out completely, but economically recoverable reserves will sooner or later become depleted. The number of years that "world reserves will last" is often expressed in R/P: the currently recoverable global reserve – R – divided by current annual production – P. On a global scale, the depletion of the reserves of most raw materials will only occur after many years, but this will happen much sooner on a regional scale. One example is copper in Western countries: although the investments in exploration have increased sharply since 2002, fewer and fewer new reserves are being found. In this advisory memorandum, we have used a broader definition of scarcity, which is based not only on the R/P ratio.

Scarcity on the market could happen much sooner as a result of geopolitics or market manipulation by cartels of private and/or state-owned companies. The latter is already the case on the markets for phosphate and potassium fertilizer. On the world market, state-owned companies are playing an increasingly important role. Exporting countries can restrict their exports based on political motives: protectionism and/or price manipulation to compel an importing country to make economic or political concessions. China, for example, has done all of this quite recently. We can therefore no longer rely blindly on a free world market. However, the primary concern of most companies is not the price, but the supply risk.

Soya
The European livestock sector is highly dependent (for 70%, excluding grass) on imported soya meal for protein-rich feed. A sudden collapse of soya imports would cause severe problems for the European economy, especially the livestock and meat sectors. Replacement of soya by European protein crops would be possible in that case, but this would require more than 10 years. The collapse of soya imports is therefore more of a risk for the short and medium term than for the long term. But for a number of the minerals discussed below, the situation is reversed.

Phosphate
In 2011, a controversy erupted about the magnitude of the global phosphate reserves. In that year the U.S. Geological Survey (USGS) sharply raised its figures for phosphate reserves (especially for Morocco), and estimated the R/P ratio at 370 years. According to various experts, however, these figures were poorly supported and much too high.

In the short and medium term, the main risks are geopolitical. The reserves are strongly concentrated in Morocco including the Western Sahara, together accounting for 74% of global reserves. Phosphate prices are kept artificially high by means of a global duopoly of the Moroccan state-owned company OCP and the export association PhosChem (consisting of the Canadian Companies PotashCorp and Agrium and the American company Mosaic; this association is legal due to a special provision in U.S. legislation). In 2008, when the price rose sharply in response to high food prices, China imposed an export duty of 135% to slow the rising price on the domestic market. This duty pushed prices on the world market even higher, to 800% above the previous year. Under pressure from the WTO, the export duty was withdrawn. The price fell rapidly, but remained higher than it had been previously.

In the EU, only Finland possesses any reserves worth mentioning, but these are less than 0.5% of global reserves. Although the Netherlands has pioneered the recycling of phosphate from sewage sludge, this initiative experienced a severe setback in early 2013 due to the bankruptcy of Thermphos, a company that recovered phosphorus from sewage sludge. That bankruptcy was partly the result of phosphorus dumping by a Kazakh company. Immediately preceding the bankruptcy, an anti-dumping procedure of the EU was withdrawn under pressure from Germany.

In short, phosphate is not extremely critical for the EU in terms of recyclability. However, it is unclear how long global phosphate reserves will last. And phosphate is extremely critical in terms of geographical concentration, geopolitics and substitutability.

Potassium
The USGS estimates the R/P ratio for potassium at 288 years. Over the short and medium term, geopolitics and cartels pose a supply risk. This is because potassium reserves are nearly as concentrated as phosphate, with 46% in Canada, 35% in Russia, with much smaller reserves in Belarus, Brazil, China and USA. Most of the reserves are in the hands of privately owned companies, with the exception of Belaruskali, a Belarusian state-owned company. Moreover, the Canadian companies PotashCorp and Agrium, together with the American company Mosaic, founded an export association on this market. And Belaruskali established an export cartel with the Russian company Uralkali. Together, these cartels formed a global duopoly, which kept potassium prices artificially high. These festivities were interrupted – perhaps only temporarily – when Uralkali withdrew from the East European cartel in July 2013. Attempts are being made to restore the cartel.

The EU is vulnerable: together, Germany Spain and the UK possess only 2% of global potassium reserves. Potassium can be recycled, for example from the urine of livestock and people, but this is difficult and costly, and is not yet commercially feasible (in the Netherlands, experiments in potassium recycling are ongoing).

In short, potassium is not extremely critical for the EU in terms of global depletion, but it is critical in terms of geographical concentration, geopolitics and possibilities for substitution and recycling.

Zinc

Large areas of agricultural land in the world are deficient in zinc. Every year, approximately 800,000 people die from the consequences of zinc deficiency, which is comparable to the mortality from malaria. In Turkey, fertilization of the soil with zinc resulted in spectacular increases in agricultural production at some locations.

The USGS estimates the R/P ratio at only 19 years. This sounds more alarming than it actually is, because this ratio has been at this low level for decades; apparently, new reserves are continually being discovered and exploited. However, the zinc price peaked in 2007/08, which indicates scarcity on the market, or speculation based on scarcity.

Zinc reserves are geographically less concentrated than those for phosphate and potassium. However, the EU possesses only 1% of global reserves. On the other hand, 99% of zinc is used in industry, where extensive possibilities for substitution exist. About 50% of the metal is currently being recycled, but 80% is thought to be feasible.

In short, zinc is a critical nutrient for the EU with respect to import dependency, but is less critical in terms of geographical concentration, geopolitics and possibilities for recycling and substitution. It is unclear how quickly the reserves will become depleted.

Selenium

Large areas of agricultural land are deficient in selenium, in countries such as China, Russia, New Zealand and, until recently, Finland. The USGS estimates the R/P ratio at only 49 years. Moreover, selenium is chiefly produced as a by-product of copper mining, and the supply of the latter metal is uncertain. As a result, the price is rising and is erratic. An additional risk is formed by the geographical concentration. Nearly 70% of the reserves are located in only four countries: Chile (25%), Russia 20%), Peru (13%) and the USA (10%), while the EU has virtually no reserves of this mineral.

Selenium – with boron – is the only micronutrient for which a substantial proportion (more than 10%) is used in the food chain. In theory, this means that a significant percentage of the selenium can be recovered from sewage sludge. In industry, substitution is possible, but difficult. Little recycling from industrial products is currently taking place, but the Umicor company in Antwerp is now recovering selenium from urban waste.

In short, selenium is moderately critical for the EU with respect to geopolitical risks, but it is highly critical in terms of tight global reserves, the unpredictable possibilities for mining, import dependence and the limited possibilities in industry for recycling and substitution.

Molybdenum

More than 99% of molybdenum is used in industry, especially in the steel industry and green technology. The USGS estimates the R/P ratio at only 44 years. An additional factor is that 84% of the scarce reserves of the mineral are concentrated in only three countries: China (39%), the USA (24%) and Chile (21%). Moreover, China is the

largest user and imposes export restrictions to support its own steel industry. The EU, without any of its own molybdenum reserves, has challenged these restrictions in the WTO. Recycling is possible. Substitution is also possible, but this primarily involves other critical minerals.

In short, molybdenum is not a critical nutrient for the EU in terms of recyclability, but it is critical in terms of global reserves, import dependency, geographical concentration, geopolitics and possibilities for substitution.

Boron

Approximately 12% of boron is used in chemical fertilizers, and 88% in other industry. The USGS estimates the R/P ratio at only 46 years. More than 95% of the reserves are concentrated in the following five countries: Turkey (29%), Russia (19%), the USA (19%), Chile (17%) and China (15%). The EU does not possess any boron reserves. The Turkish producer is a state-owned company. Substitution is certainly possible, but recycling is difficult.

In short, boron is not a critical nutrient for the EU in terms of substitution possibilities, but it is critical in terms of import dependency, geographical concentration, geopolitical risks and recyclability.

Vulnerability of other countries

The EU is not the only vulnerable major power with respect to the supply of crucial nutrients. India is faced with a similar situation, except for zinc; the same applies to Brazil, except for potassium; the USA is now, or will become, dependent on imports of phosphate, potassium and selenium; and China is vulnerable for potassium and selenium. But the EU is vulnerable across the board.

EU policy

The EU has implemented a Common Agricultural Policy (CAP) since 1957, but a critical resource policy in the form of the Raw Materials Initiative (RMI) has been in place only since 2008. However, that initiative has a one-sided focus on industry, except for phosphate. Another deficiency of the RMI is its short-sightedness: the time horizon is only 10 years. The CAP, even following the recent reform, is entirely blind to a possible shortage of critical raw materials. These are two serious shortcomings in EU policy.

The current EU policy on critical raw materials appears to be “every Member State for itself”. In particular, Germany gives the impression that it has chosen for an *Alleingang*. This could ultimately be harmful for other Member States and for resource efficiency and recycling in general.

Policy in the Netherlands

As a trading nation, the Netherlands has relied on the free market for centuries. The scarcity of raw materials has been on the political agenda only since 2008, when an interdepartmental working group on Scarcity and Transition was established. Since then, policy has been developed, but it continues to be fragmented between various departments. And the policy still has important shortfalls with respect to potassium and micronutrients, among other raw materials. Considering the uncertainties about the free

market, it appears necessary to take account of other scenarios, and choose a no-regret policy.

Recommendations for the EU and the Netherlands

1. General recommendations: **in agricultural policy, take account of the *supply risk* for raw materials; and in raw materials policy, take more account of agriculture and food.** For both aspects, choose a time horizon of at least 50 years. And try to avoid a rat race for diminishing raw materials.

2. Reduce dependence on imports of critical nutrients. This can be done primarily by developing a **resource-efficient and circular economy.** This requires:

- Innovation in efficiency.
- Innovation in recycling, using cities as “hotspots” of secondary nutrient reserves.
- Promoting stable rather than low prices for raw materials, through measures such as strict antidumping policy and variable duties.
- Stepwise imposing a recycling obligation for critical nutrients and a blending obligation for recycled nutrients.

In addition, wherever possible, **substitution** would be pursued, both of imported soya by European-grown protein crops and of micronutrients in industry by less critical raw materials.

3. In the EU, address the emerging **resource nationalism** of countries such as Germany, and as an alternative develop a **stronger European raw materials policy**, focusing partly on innovation.

4. Engage in **partnerships** with exporting countries (such as Morocco) on the one hand and with import-dependent countries (such as India and Brazil) on the other.

5. Reduce the current chaos surrounding figures on reserves and stocks of raw materials. To this end, initiate a **European (or International) Raw Materials Agency.**

6. Actively pursue a **leading position in research on efficiency and recycling** of raw materials, which may benefit from the Dutch phosphate recycling case.

1. Scarcity of raw materials

The EU is largely self-sufficient in basic foodstuffs. Therefore, the food security of the EU seems assured. But appearances can be deceiving. In fact, the EU is relatively poor in resources and raw materials, including raw materials for agriculture. Long-term food security is thus by no means guaranteed. In recent years the EU has become aware of its vulnerability regarding raw materials, but the focus so far has been primarily on raw materials for industry. Phosphate is the only raw material for agriculture that has received much attention, and that has happened only recently. In the Common Agricultural Policy (CAP), even after the recent reform, raw materials for agriculture are conspicuous by their absence.

The dominant view in the West, including the Netherlands, is that raw materials scarcity will only occur in the distant future when global stocks become depleted, and that until that time we will be able to purchase sufficient raw materials on a free global market. But scarcity could happen much sooner as a result of geopolitics or market manipulation by cartels of private and/or state-owned companies. For example, during the past decade the potassium market was manipulated by a *de facto* duopoly of two Eastern European and three North American companies, while the phosphate market was manipulated by a duopoly of two North American companies and one Moroccan company. And on the world market, state-owned companies are playing an increasingly important role; we can therefore no longer rely blindly on a free global market.

History has provided countless examples of conflicts about land, resources and energy. Recent examples include two Gulf Wars, which were motivated in part by a need for energy security in the West. A recent conflict about a crucial agricultural raw material – phosphate – concerns the annexation of the Western Sahara by Morocco in 1975, which has never been acknowledged by the UN.

In recent years, various reports have been written in the Netherlands about the scarcity of agricultural raw materials (nutrients), but only two of these concerned geopolitics, one focussing on phosphate[1] and the other on phosphate and soya, mainly from a Dutch perspective.[2] The present advisory memorandum focuses on the geopolitics of phosphate, soya and five other agricultural raw materials, from a Dutch as well as a European perspective.

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1 De Ridder, M., S. de Jong, J. Polchar & S. Lingemann (2012). *Risks and opportunities in the Global Phosphate Rock Market.* The Hague Centre for Strategic Studies. Report no 17|12|12.

2 HCSS & LEI (2013). *The emerging geopolitics of food – A strategic response to supply risks of critical imports for the Dutch agro-food sector*. The Hague Centre for Strategic Studies. Report no 19|02|13

2. Some key concepts

Geopolitics is often defined as how states take account of geographical realities in their foreign policy: location, country profile, the presence or absence of sea routes, availability of fresh water, but also the presence of mineral raw materials.

The literature on raw materials is often characterized by confusion about the terms “resources”, “reserves”, “scarcity” and “criticality”.

Regarding the terms “resources” and “reserves”, the present report makes a simpl distinction:

- *Resources* (of a raw material) are defined as the total quantity of this resource that can potentially be extracted.
- A *reserve* is defined as that part of the resources which can feasibly be extracted with current technology at current market prices.

Scarcity can be subdivided into three types: physical, economic and political scarcity. Absolute *physical scarcity* of resources/raw materials does not exist. In contrast to fossil energy resources, mineral resources do not disappear after use. But they do become diluted or dispersed. As a result, recovering these resources requires more – sometimes vastly more – energy and money. However, high-grade mineral resources can become depleted – first at the regional level, later at the global level. The number of years that “world stocks will last” is often expressed in R/P: the reserve – R – divided by current annual production – P. Therefore, if annual production rises and no new reserves are found, then the number of years can become substantially fewer. The fact that annual production is going to grow is certain, in view of the growth in the world population, the shift to a more animal-based diet and increasing demand for biofuels.

Regional depletion already appears to be occurring with copper in the West: although the investments in exploration have increased sharply since 2002, fewer and fewer new reserves are being found. The remaining low-grade reserves have lower concentrations of the metal and higher levels of contamination, which increases the cost of extraction and purification, and results in more waste.

This means *economic scarcity*. This is primarily a problem for poor countries and poor farmers, for whom the raw material can become unaffordable. This scarcity can occur *long before* depletion of the global reserves takes place, especially if the "peak" is reached when demand starts to exceed the shrinking supply. Moreover, scarcity can be manipulated by oligopolists. According to the American Antitrust Institute, this is already the case on the markets for nitrogen, phosphate and potassium fertilizers.[3]

[3] Taylor, C.R. & D.L. Moss (2013). *The Fertilizer Oligopoly: The Case for Global Antitrust Enforcement.* AAI Working Paper no.13-05. http://www.competitivemarkets.com/wp-content/uploads/2013/09/WP13-5_Fertilizer_Body.pdf

Politically driven scarcity, in short *political scarcity*, occurs when an exporting country restricts exports of a raw material due to political motives: protectionism, forcing prices up or pressuring another country to make economic or political concessions. The likelihood of such policy is greatest with raw materials for which the majority of the reserves are concentrated in a limited number of countries. If only one of these countries restricts exports to support its own agriculture or industry, this can cause prices on the world market to rise sharply.[4] For example, China recently used this method to drive up the world market prices for zinc, molybdenum and especially phosphate. Sometimes China also uses export restrictions to exert political pressure. By restricting its exports of rare earth metals, China recently forced Japan to make concessions in a territorial conflict about disputed islands. And by briefly interrupting its gas exports, Russia compelled Ukraine to pay higher prices for natural gas. At such a time, the import-dependent country is faced with a "critical" raw material. For that matter, the factor of greatest concern for most parties concerned is not the price, but the *supply risk*.

Macronutrients and micronutrients are both essential nutrients for agriculture and the food chain, the difference being that macronutrients are required in much larger quantities than are micronutrients, which are sometimes called "trace elements". Micronutrients include organic substances such as vitamins, but the scope of this advisory memorandum is limited to the *mineral* micronutrients (as well as soya). Nutrient deficiency can have both quantitative and qualitative effects: lower agricultural production and lower nutritional value, respectively.

For *critical nutrients*, the following criteria have been used in this advisory memorandum: the ratio R/P, the natural prevalence of the mineral in agricultural soils, the geographical concentration, the trade politics of the states concerned, the concentration of companies concerned, the nature of these companies (privately owned, state-owned or state-related) and the replaceability of the mineral. Note that the raw materials addressed in this memorandum are *not* replaceable in agriculture or in the food chain, but they are replaceable in industry (to a greater or lesser extent).

Based on these considerations, the Platform has selected seven raw materials: soya, the macronutrients phosphate and potassium[5] and the micronutrients zinc, selenium, molybdenum and boron. Soya is indeed interchangeable with other protein-rich crops, but has been included because intensive livestock production in Europe, and especially in the Netherlands, is highly dependent on imported soybean meal.

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4 A relatively large number of countries use export restrictions to control their domestic food prices. For example, Argentina does this by imposing export levies on soya, and especially on meat, to keep domestic prices low. The EU has imposed export levies on grain a number of times during the occasional periods when the world market price was higher than the internal price. During the food crisis of 2007/08, various countries (including Russia and India) temporarily restricted food exports by means of export levies, export bans and export quotas.

5 The macronutrient nitrogen has not been included because it is not a finite mineral, but is part of a natural geochemical cycle. Atmospheric nitrogen can be processed both biologically and synthetically into nitrogen compounds usable by plants; after decomposition of the plant, nitrogen is released from the soil or surface water back into the atmosphere. Biological fixation takes place by bacteria that live symbiotically with legumes and several other plant groups. Nitrogen is also fixed synthetically in industrial processes. The first method requires land, the second requires energy.

3. Soya

Soybeans are used for the production of vegetable oil and high-protein soya meal; the vegetable oil is processed in food, and soya meal is used as a high-quality ingredient in animal feed. The European livestock sector is highly dependent on imported soya meal for protein-rich feed (for 70%, excluding grass).

The world market for soya shows a high level of concentration. The supply side is dominated by three countries: the USA, Brazil and Argentina. Nearly all imports into the EU come from Brazil and Argentina. The demand side has become increasingly dominated by China (65% in 2012), followed by the EU.

This situation makes the European livestock sector vulnerable. Firstly, this applies to natural disasters (major drought, volcanic eruptions) and epidemics of plant diseases in the producing countries, especially in South America. Secondly, there is vulnerability to geopolitics. Argentina imposes export duties of 35% on soya, and since 2009 on meat, with the aim of generating income for the state and keeping domestic meat prices low. By imposing even higher export duties on soya, the country could drive up the soya price on the world market for years. In case of soya scarcity and the resulting high meat prices on its domestic market, mega-importer China could decide to purchase all available soya on the world market in one go. This would lead to a crisis in the intensive livestock sector in Europe (and especially in the Netherlands), resulting in severe price fluctuations for meat and eggs.

The EU would then initially attempt to moderate the fluctuations by restricting its own grain exports. But that could drive up the grain prices on the world market, which in turn could lead to food scarcity and political unrest in grain-importing countries such as Egypt.

In addition, the EU could start producing more protein-rich crops itself, such as forage peas and soya. This would not necessarily impinge on the production acreage for grain, since this acreage is inversely proportional to the productivity trend in grain production, which averages 1% per year; consequently every year more acreage becomes "available" for other crops. With this approach, in about 11 years, the EU could even replace all imported soya with European-grown protein crops *without expanding* the current grain acreage.[6] The collapse of soya imports is therefore more of a risk for the short and medium term than for the long term. But with mineral nutrients, this is the reverse.

6 Platform Agriculture, Innovation and Society (2012). *The vulnerability of the European agriculture and food system for calamities and geopolitics – A stress test*, p. 78.

4. Macronutrients

4.1 Phosphate

Phosphate is essential for all life, including crops, livestock and people. World-wide, 96% of phosphate is used in agriculture (as a fertilizer) and in livestock farming (as a feed additive). Substitution is possible only for the remaining 4%, which offers little solace.

In 2011, a controversy erupted about the magnitude of the phosphate reserves. In that year, the U.S. Geological Survey (USGS) sharply raised its estimates for phosphate reserves (especially for Morocco), up to an R/P ratio of 370 years. According to various experts, however, these figures are poorly supported and much too high.[7] Previously, several researchers had predicted that Peak Phosphorus, when supply falls behind demand, would happen as soon as 2033. They no longer use this date, but still argue – even if the new USGS figures are correct – that Peak Phosphorus could still occur in this century as a result of population growth, shifts in diet and increasing production of biofuels.

In the short and medium term, however, geopolitical risks are more likely. This is because the reserves are primarily concentrated in Morocco and the Western Sahara (together 74% of the reserves, but this figure is controversial). Much smaller reserves are held by China (5%), Algeria, Syria, South Africa and a few other countries. Moreover, unexploited reserves are still present on the continental shelf in many countries. Phosphate prices are kept artificially high by means of a global duopoly of the Moroccan state-owned company OCP and the export association PhosChem (consisting of the Canadian Companies PotashCorp and Agrium, and the American company Mosaic). In 2008, a price spike occurred in reaction to high food prices. China responded by imposing a 135% export duty to moderate phosphate prices on the domestic market. Prices then peaked at 800% from the previous year. Under pressure from the WTO, the export duty was revoked, after which the price fell sharply; then rose again, but more moderately. Other current geopolitical risks include the civil war in Syria, the political turmoil in Tunisia and the controversial Moroccan claim on the Western Sahara. An additional factor is that most large production companies, including the Moroccan giant OCP, are state owned, which makes them a potential vehicle for geopolitics.

Large agricultural regions such as India, Brazil and the EU and most developing countries are entirely or largely dependent on phosphate imports. In the EU, only

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[7] Edixhoven, J.D., J. Gupta & H.H.G. Savenije (2013) *Recent revisions of phosphate rock reserves and resources: reassuring or misleading? An in-depth literature review of global estimates of phosphate rock reserves and resources.* Earth Syst. Dynam. Discuss. 4, 1005–1034. www.earth-syst-dynam-discuss.net/4/1005/2013/doi:10.5194/esdd-4-1005-2013

Finland possesses reserves worth mentioning (23 million tonnes), but this is less than 0.5% of the global total. This would appear to be sufficient justification for the EU to become less dependent on phosphate imports.

The Netherlands holds an unusual position in the EU because it imports the majority of its phosphate (in the form of soya for animal feed) and also uses the most phosphate *in organic form* (manure). Moreover, the Netherlands has pioneered the recycling of phosphate from sewage sludge. A setback in this regard was the bankruptcy of Thermphos in early 2013, a company that recovered phosphorus from sewage sludge. The bankruptcy was partly the result of high costs for environmental protection measures, which were required for the removal of radioactive uranium, and partly due to the dumping of cheap phosphate by a company from Kazakhstan. Remarkably, an anti-dumping procedure of the European Commission against Kazakhstan was halted when Germany – which was negotiating with Kazakhstan about supplying various raw materials – was able to recruit enough Member States to block the procedure. Geopolitical risks are thus a factor *within* the EU as well. Fortunately, the phosphate recycling was continued by the Amsterdam plant of the Israel-based company ICL, but this also will be vulnerable to falling prices for phosphate (and for potassium, in which the company also trades).

In short, phosphate is not extremely critical for the EU in terms of recyclability. But it is unclear how long global phosphate reserves will last. And phosphate is anyway critical in terms of geographical concentration, geopolitics and substitutability.

4.2 Potassium

Potassium, like phosphate, is an essential nutrient for all life, thus including agricultural crops, livestock and humans. Approximately 90% of the extracted mineral is used in the form of chemical fertilizer. Substitution is possible for the remaining 10% at most.

Potassium reserves are finite. The USGS estimates the R/P ratio at 288 years. Consequently, physical depletion at the global scale will become a problem only over the long term. On the short and medium terms, geopolitics and cartels are a greater risk. This is because potassium reserves are nearly as concentrated as phosphate, with 46% in Canada, 35% in Russia, followed at a distance by Belarus, Brazil, China and the USA. Most of the reserves are in the hands of private companies, with the exception of Belaruskali, a Belarusian state-owned company. The privately held Canadian companies PotashCorp and Agrium and the American company Mosaic together form an export association. Until August 2013, Belaruskali was part of an export cartel with the Russian companies Silvinit and Uralkali (which has been privatized, but still has close ties with the Kremlin). Together, both cartels formed a global duopoly, which kept potassium prices artificially high.

The party was rudely interrupted when Uralkali withdrew from the East European cartel on 1 August 2013. Uralkali was worried that Belaruskali was going to start supplying low-priced potassium outside the cartel to China, and would expand its share in the cartel, which Uralkali also wanted to do. Therefore, it decided to cut prices and increase production. This decision led to a rapidly escalating conflict between Belarus and

Russia. For that matter, the North American cartel is also having problems, but these are caused by antitrust legislation.

On the demand side, India and China are also involved in a power play by accumulating stocks of the mineral. They usually do this to prevent extreme price increases or supply shortages, but in this case also to push prices downward. This power play has been successful, partly due to overproduction, which resulted from increased production based on the expectation that chemical fertilizer prices would rise following the high food prices in 2007/08. The expected price increase did not materialize.

At this time, it is impossible to say whether the North American cartel will continue to exist or whether the East European cartel will be restored. Following pressure by Belarus, new Russian billionaire shareholders replaced the CEO of Uralkali but China and a Belarusian billionaire are also attempting to acquire shares. In addition, following the recent drop in potassium prices, various companies have cut production or suspended investments in their operations. As a result, the price decline has been limited, but the potassium market remains unpredictable.

The EU is quite vulnerable to potassium market manipulation. Together, Germany Spain and the UK possess only 2% of global potassium reserves. Theoretically, potassium can be recycled, for example from the urine of livestock and people, but this is difficult and costly, and is not yet commercially feasible. In the Netherlands, however, experiments in potassium recycling are ongoing.

In summary: for the EU, potassium is not extremely critical in terms of global depletion. However, it is critical in terms of geographical concentration, geopolitics, recyclability and substitutability. These are good reasons for the EU to try and make itself less dependent on imports.

5. Micronutrients

5.1 Zinc

Zinc is an essential micronutrient that plays a role in at least 200 enzymes and other proteins that have a metabolic function. Large parts of the agricultural soils in the world are deficient in zinc. This results in lower crop yields and zinc deficiency diseases in livestock and humans (among other problems). Every year, approximately 800,000 people die from the consequences of zinc deficiency, which is comparable to the mortality from malaria. In India and several African countries, nutritional zinc supplementation programmes for mothers and children are ongoing. In Turkey, fertilization of the soil with zinc has resulted in spectacular increases in agricultural production at some locations.

This offers perspective, as long as reserves last. The USGS estimates the R/P ratio at only 19 years. But this probably sounds more alarming than it actually is, because this ratio has been low for decades; apparently, new reserves are continually being discovered and exploited. However, the price spiked in 2007/08, which indicates scarcity or speculation based on scarcity.

For the time being, the geopolitical risks do not appear to be great because the reserves are geographically less concentrated than those for phosphate and potassium. Although Australia and China together hold 45% of the reserves, zinc is mined in more than 50 countries. The EU, however, possesses only 1% of the reserves, about half of which is located in Ireland. On the other hand, 99% of zinc is used in industry, where extensive opportunities for substitution are available. Moreover, about 50% of the metal is currently being recycled, and 80% is thought to be possible.

In short, zinc is a critical nutrient for the EU with respect to import dependence, but less critical in terms of geographical concentration, geopolitics and possibilities for recycling and substitution. It is unclear how quickly the global reserves will become depleted.

5.2 Selenium

Selenium is not essential for plants, but it is an essential nutrient for humans and animals. Large areas of agricultural land are deficient in selenium, in countries such as China, Russia, New Zealand and - until recently - Finland as well. This can lead to health problems with people and livestock. Therefore, selenium is often used as a supplementary ingredient in fertilizers (especially in Finland), feed and food.

Such suppletion is possible as long as reserves last. The USGS estimates the R/P ratio at only 49 years. Moreover, selenium is not extracted by itself, but is primarily a by-product of copper mining, and the supply of the latter metal is uncertain. The price of selenium therefore tends to increase and fluctuate unexpectedly, and spiked at the end of

2011. An additional risk is formed by the geographical concentration. Nearly 70% of the reserves are located in only four countries: Chile (25%), Russia (20%), Peru (13%) and the USA (10%), while the EU possesses little or nothing. The demand side is dominated by China, with 40% to 50%, and global demand is expected to increase.

Selenium – with boron – is the only micronutrient of which a substantial proportion (more than 10%) is used in the food chain. In theory, this means that a significant percentage of the selenium can be recovered from sewage sludge. In industry, substitution is possible, but difficult. Little recycling is currently taking place, but the Umicor company in Antwerp is now covering selenium from urban waste.

In short, selenium is not extremely critical for the EU with respect to geopolitical risks, but it is critical in terms of tight global reserves, unpredictable opportunities for extracting the mineral, import dependence and the limited possibilities for recycling and substitution. In agriculture, the risk is limited to livestock farming. The Netherlands, with its relatively large livestock sector, is particularly vulnerable.

5.3 Molybdenum

Molybdenum is an essential trace element for plants, animals and humans. Deficiencies are rare. It is also essential for those plants, including soya, able to bind nitrogen from the atmosphere in symbiosis with bacteria. Along with iron, it is a building block of the enzyme nitrogenase, which converts atmospheric nitrogen into ammonia. Consequently, molybdenum is sometimes added to fertilizers. But more than 99% of this metal is used in industry, especially in green technology.

The USGS estimates the R/P ratio of molybdenum at only 44 years. An additional risk is that 84% of the scarce reserves of the mineral are concentrated in only three countries: China (39%), the USA (24%) and Chile (21%). Moreover, China is the largest user and imposes export restrictions to support its own steel industry. The EU, which lacks molybdenum reserves, has challenged these restrictions in the WTO. In this context it is not surprising that the price during the last decade has been erratic. Molybdenum is recycled only in the form of alloys, in the USA and some other countries. There are possibilities for substitution, but with some applications it concerns other critical elements such as boron, cadmium, neodymium, nickel and tantalum.

In short, molybdenum is not a critical nutrient for the EU in terms of recyclability, but it is critical in terms of global reserves, import dependence, geographical concentration, geopolitics and possibilities for substitution.

5.4 Boron

Boron is an essential trace element for plants. Deficiencies occur in soils on all continents, but especially in soils with little organic matter. Around 1980, boron was also acknowledged as an essential nutritional element for humans and poultry. Approximately 12% of boron is used in chemical fertilizers and 88% in industry. It is rarely added as a supplement to feed.

The USGS estimates the R/P ratio at only 46 years. More than 95% of the reserves are geographically concentrated in just five countries: Turkey (29%), Russia (19%), the USA (19%), Chile (17%) and China (15%). The EU does not possess any boron reserves. The Turkish producer Eti Maden is a state-owned company, and it can be assumed that the Russian and Chinese producers also have ties with the state. Because the Chinese reserves are low grade, it is assumed that China will begin to import more boron.

Recycling of boron is scarcely possible, but substitutes are available in industry.

In short, boron is not a critical nutrient for the EU in terms of substitution possibilities, but it is critical in terms of global reserves, import dependence, geographical concentration, geopolitical risks and recyclability. The Netherlands, with its relatively large poultry-farming sector, is especially vulnerable.

6. Shared dependence

The table below summarizes the extent to which the seven raw materials discussed above can be considered to be critical for the EU, subdivided according to six criteria.

Supply risk of seven raw materials for European agriculture.

	Supply risk in terms of:						
	R/P in years	**R/P in risk classification***	**Import dependence**	**Geographical concentration**	**Geopolitics**	**Substitutability**	**Recycling possibilities**
Short/medium term							
Soya	n.a.	n.a.	+++	+	+	+	n.a.
Long term							
Phosphate	370**	+(+)	+++	+++	+++	+++	+
Potassium	288	+	+++	++	+++	++	++
Zinc	19	+++	++	+	+	+	+
Selenium	49	+++	+++	++	++	++	+
Molybdenum	44	+++	+++	++	++	+	?
Boron	46	+++	+++	++	++	+++	?

* + limited risk; ++ substantial risk; +++ high risk
** Possibly much shorter
n.a. = not applicable

For that matter, the EU is not the only vulnerable major power. India is faced with a similar situation, except for zinc; the same applies to Brazil, except for potassium; the USA is now, or will become, dependent on imports of phosphate, potassium and selenium; and China is vulnerable for potassium and selenium. The nutrient market is thus becoming contentious. The consequences are obvious: increasing competition, higher and more volatile prices, an increasing role for geopolitics at the expense of the free market, and increasing problems with food production, which will initially impact resource-importing developing countries. New technologies and new exploration may yield new reserves, but it is uncertain how long that can continue.

This uncertainty calls for a no-regret policy: a policy that will not be easily regretted would the scarcity of nutrients less severe than expected. Uses should become more selective and efficient, and a much larger proportion of the available supply should come from recycling.

7. EU policy

The EU has implemented a Common Agricultural Policy (CAP) since 1957, but a critical resource policy in the form of the Raw Materials Initiative (RMI) has been in place only since 2008. However, the CAP, even following the recent reform, completely ignores possible future scarcity of critical resources. Conversely, the RMI is focusing almost entirely on industry and is blind to applications in agriculture and the food chain. These are two serious shortcomings. Another shortcoming of the RMI is that it uses a time horizon of only 10 years. It does, however, pay explicit attention to geopolitical risks. Initially, it focused only on the procedures at the WTO against projectionist measures and on the cooperation with African countries in the sustainable extraction of mineral resources. But in the update of 2001, the RMI also announced a new impulse for reusing raw materials, as well as a European Innovation Partnership (EIP) on Raw Materials. This is a step in the right direction.

However, raw materials for agriculture are on the radar of some other organizations. For example, the Joint Research Centre of the European Commission published a report in 2012 on the potential future scarcity of the macronutrients nitrogen, phosphate and potassium. And in October 2013, the Directorate-General for the Environment published a comprehensive research report on phosphate.[8] The European Commission began a consultation round on phosphate even earlier.[9] In addition, the Directorate-General for Enterprise and Industry announced it was going to add phosphate to the list of critical materials. This is a second step in the right direction. But it is almost painful to see how far behind the Directorate-General for Agriculture is lagging behind.

In effect, the current EU critical resource policy now appears to be “every Member State for itself”. In particular Germany, with its *Rohstoffallianz* of big industries, which is supported by the government, seems to show a tendency towards an *Alleingang* policy, which could turn out to be harmful to other Member States. This entails the risk of political disintegration, which in the long term could even threaten food security – the original motive of the CAP.

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8 University of the West of England, Bristol (2013) *Science for Environment Policy In-depth Report: Sustainable Phosphorus Use.*

9 http://ec.europa.eu/enterprise/policies/raw-materials/public-consultation/

8. Policy in the Netherlands

As a trading nation, the Netherlands has relied on the free market for centuries. The scarcity of raw materials has been on the political agenda only since 2008, when an interdepartmental working group on Scarcity and Transition was established. In 2009, this working group ascertained increasing levels of protectionism, and the resulting geopolitical developments. According to the working group, critical raw materials for the Netherlands include soya and phosphate. In response, the coalition government published a Resource Memorandum in 2011, which heavily emphasized the interests of industry and focused on the short term. In that same year, the Rabobank also warned for nationalism with respect to agricultural raw materials. And in August 2012, Minister Rosenthal of Foreign Affairs issued a warning about the raw materials geopolitics of monopolistic states, such as Russia and China, and stated that the resource war has already begun.

The coalition agreement of the Rutte II cabinet calls for a circular and biobased economy, but without referring to the geopolitical risks. Such a reference was also absent in a letter to Parliament from Wilma Mansveld, State Secretary for Infrastructure and the Environment (20 June 2013). In this letter, she refereed to operational aims for the programme *From Waste to Resource* – the national transposition of the European *Roadmap to a Resource Efficient Europe* – that is intended to aid the Netherlands in the transition to a circular economy. This document primarily concerns the approach to specific chains, including the food chain, ensuring sustainability beginning with the design phase of products (ecodesign), and unspecified market incentives. She also referred to “green growth” as the main motive and to supply security as an additional benefit, but without explicit reference to geopolitical risks.

Henk Kamp (Minister of Economic Affairs) also did not refer to geopolitical risks in his answer to a question from Member of Parliament Van Veldhoven about raw materials uncertainty (20 September 2013).[10] However, he did state that the government

> “…initiated a study to determine where critical metals and minerals are used in the Dutch economy, what the vulnerabilities are, and which behavioural perspectives can alleviate vulnerabilities.”

In this document he referred to both biotic and abiotic raw materials. If geopolitical vulnerabilities are also revealed by that study, this may come close to a coherent policy.

Meanwhile, the Netherlands is working on a strategic partnership with Germany. In its recent work programme, the Advisory Council on International Affairs referred to the conflicting interests of both countries and the resulting dilemmas for Dutch diplomacy. In addition, in 2001 the government signed the public/private Chain Agreement on Phosphate Recycling. In that same year, Member of Parliament Van Veldhoven suggested a role for the Netherlands as a *raw materials roundabout,* where waste streams would “enter” the roundabout and, following processing, would “exit”

[10] Kamerbrief 20 September 2013.

when they were again manufactured into products. Rotterdam would have a pivotal role in this process.[11] This idea appears to be very usable for high-value industrial raw materials such as silver and gold, and perhaps for some micronutrients as well, but appears to be less appropriate for phosphate and potassium, which are less costly and are used almost exclusively in agriculture. These raw materials would be better suited to local recycling. Apart from that, it would likely be preferable to aim for multiple, specialized "roundabouts" in the European context.

In short, the Netherlands and the EU already have a policy on raw materials for all sectors, but there is still fragmentation between various departments. And there are still important shortfalls with respect to potassium and micronutrients, among other raw materials. In the section below we present a proposal for comprehensive policy. The Platform makes a series of recommendations for the EU, the Dutch government and the private sector (especially businesses and NGOs). Most of these recommendations are compatible with a no-regret strategy.

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[11] For that matter, the Belgian company Umicore and the Port of Antwerp are now recycling gold and other high-value minerals from discarded electronic equipment.

9. Recommendations to the EU

General recommendations: Do not allow the EU to focus solely on food security, because this will ultimately be undermined by declining raw materials security. In agricultural policy, it is crucial to address raw materials, and in raw materials policy to give a higher priority to agriculture and food. A "race to the bottom" caused by shrinking reserves of raw materials must be avoided. Strategic priorities are:

- **make the EU less dependent on imports of nutrients and plant-based protein;**
- **enter into strategic partnerships with countries on both sides of the raw materials equation (i.e. importing and exporting countries).**

Dependence on imports

1. **Reduce dependence on** imports of critical nutrients. This can be done primarily by developing a **circular economy**. Such an economy was suggested previously for other reasons: depletion of high-grade reserves, energy savings,[12] cost reduction and environmental protection. A circular economy can be promoted through system innovation, efficient use, recycling and substitution. The Framework Programme Horizon 2020 offers good opportunities for promoting the circular economy.

2. **Incentivize system innovations in agriculture and industry.** This should lead to production systems in which waste is used as a raw material in another process, and which thus becomes less dependent on external inputs of minerals. In this case, the system innovations primarily involve inputs of the macronutrients phosphorus and potassium and the micronutrients selenium, zinc and boron. At the same time, linkage can be sought with the new trend towards ***design for recycling (ecodesign)***: designing industrial products in such a way that their recycling and reuse becomes technically feasible.

3. **Promote/incentivize substitutions** in industry. Priorities:
   - **require substitution of phosphates in cleaning products**. This has already been done for detergents, and is going to be done for dishwashing products, but has not yet been done for industrial cleaning products;
   - **promote substitution of critical micronutrients in industrial applications.** This appears to be feasible for boron and zinc, as well as for selenium in the longer term. In that context, the European Commission correctly remarked that replacement by other critical materials must be avoided.

4. **Promote efficiency improvement.** Priorities:
   - **promote precision fertilisation** based on thorough soil testing, by means of the second pillar of the CAP;

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[12] Recycling a metal is generally much more energy-efficient than obtaining the same metal from mining. Reck, B.K. & T.E. Graedel. *Challenges in Metal Recycling.* Science 337: 690-695.

- **promote better utilisation** of soil nutrients by the addition of mycorrhizal fungi (root fungi);
- **introduce maximum concentrations of micronutrients** in animal feed**.** Excessive dosing of micronutrients still occurs on a large scale, which is a perverse side effect of the competition between feed companies.[13]

5. **Promote recycling**. Priorities:
   - **authorize, gradually and selectively, the use of meat-and-bone meal in animal feed** with the aim of replacing approximately 10% of soya imports (and the phosphate contained therein);
   - **utilize cities and their surroundings as *hotspots* of phosphate, potassium and micronutrients**. This would primarily involve **nutrient recycling** during wastewater purification, waste incineration and purification of surface water. The Netherlands is already pioneering such applications.[14] There is a great need for such initiatives across Europe, and certainly for potassium and micronutrients as well. The recently established *European Sustainable Phosphorus Platform* (ESPP) is a good beginning.[15] The public Consultative Communication on sustainable phosphorus, recently launched by Environment Commissioner Potocnik, is another promising initiative;
   - **implement a progressively increasing recycling obligation** for critical nutrients from large waste streams;[16]
   - **implement a progressively increasing obligation** to blend recycled raw materials (specifically nutrients) with primary raw materials for the fertilizer and feed industry. The experiences acquired with the biofuel blending obligation for automobile fuel can be useful for this purpose. Such an obligation can provide a strong impulse to recycling while simultaneously creating more certainty for investors.[17]

6. **Increase European self-sufficiency with high-protein animal feed.** At present, the EU is 33% self-sufficient in its need for protein crops.[18] It is important that this percentage is increased gradually to **at least 80%**. The Platform previously

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13 Many livestock farmers believe that high concentrations of trace elements are beneficial to their animals. It doesn't hurt to try. But there are many cases known of health problems with pigs caused by overdosing selenium. Instead of informing livestock farmers accurately, feed companies compete with each other based on high concentrations of trace elements.

14 Recycling from wastewater is taking place at *Slibverwerking Noord Brabant*, *RWZI* (wastewater purification plant) *Amsterdam West* and ICL Fertilizers in Amsterdam. Furthermore, the *Waterschap* (Water Board) *Vallei en Veluwe* wants to convert *RWZI Apeldoorn* into an energy production and fertilizer plant.

15 Nutrient Platform Newsletter 26-8-13. Aims are: *to promote, develop and implement better stewardship of phosphorus, a greater level of recycling and the creation of green jobs in the circular economy.* Arnoud Passenier, a Dutch citizen who was formerly co-founder of the Dutch Nutrient Platform, has been appointed as the first chairman of the European Platform.

16 Sweden has already formulated objectives in this area.

17 This option is also referred to in the report *Sustainable Phosphorus Use*, published by the Directorate-General for the Environment (2013).

18 http://www.nieuweoogst.nu/scripts/edoris/edoris.dll?tem=LTO_TEXT_VIEW&doc_id=163273 Does not include grass.

published a report on this topic[19] and presented seven options. We repeat the two most important options here:

- **reintroduce meat-and-bone meal in animal feeds** (previously referred to under recycling) gradually and under strict conditions;
- **increase the promotion of protein crops** in the EU. To this end, the EU recently began "greening" the CAP. For example, 5% of the *Ecological Focus Areas* that arable farmers are required to create can also be used for producing protein crops.[20] In addition, Member States can provide limited funding for "linked" payments, i.e. a payment that is linked to a specific product. Protein crops are mentioned specifically in this policy. Mandatory crop rotation also creates room for producing protein crops. Five Member States are arguing in favour of even more incentives.[21] A potentially effective measure would be an import duty on soya, although this appears rather unlikely for the time being.[22]

Raw materials policy

7. **Address the emerging raw materials nationalism in the EU and develop a stronger common European raw materials policy**. For 50 years, the CAP has shown that cooperation in agriculture, the internal market and external trade policy can be extremely successful. Today, the need for cooperation is just as great concerning the raw materials for agriculture. Important advantages of a common approach are:
   - a stronger position of the EU when raw materials are on the agendas of international bodies such as the G8 and the G20;
   - a stronger position of the EU in bilateral trade negotiations;
   - a stronger position of the EU with respect to raw materials companies with market power;
   - joint financing of the costly investments and recycling and substitution required for the intended transition.

8. **Broaden the *Raw Materials Initiative*, including the *Raw Materials Innovation Partnership*, with critical nutrients**. This means expanding the list of critical materials. So far, the Commission has only approved this for phosphate. A subsequent priority is the inclusion of potassium selenium and boron.[23] Also of essential importance is that **the time horizon for these initiatives is extended to at least 50 years.**

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19 Platform Agriculture, Innovation and Society (2012). *The vulnerability of the European agriculture and food system for calamities and geopolitics – A stress test*, p. 78.

20 However, this would be the cost of the intended ecological aims of the EFAs.

21 *Boerderij Vandaag* 25-9-13.

22 Import duties have little chance in trade negotiations. However, the EU could propose such a duty during the ongoing trade negotiations with the Mercosur bloc in exchange for trade policy benefits. Food security and the circular economy are often at odds with free trade.

23 Cobalt also deserves further analysis. For more specific recommendations concerning raw materials, refer to the Platform reports on phosphate and micronutrients (see Appendix 2).

9. **Create more insight into and transparency about resources, reserves and flows of raw materials**, both inside and outside one's own territory.[24] The EU has already taken steps to clarify the information on its own reserves, operations and production, but there is also a need for such information world-wide. There is already some cooperation with the USA[25] on that issue, but the EU is still too dependent on data from the USGS and the International Fertilizer Development Centre (IFDC).[26] The ease with which the USGS in 2010/11 sharply increased its estimates of phosphate reserves in Iraq and especially Morocco – to subsequently sharply reduce the estimated reserves in Iraq – has drawn sharp criticism, as have its conflicting figures on boron reserves, especially in Turkey. These data do not provide a solid foundation for policy. Therefore, analogous to the International Energy Agency, the EU should take the initiative to establish an **International Raw Materials Agency**.[27] Possible tasks of such an agency include monitoring and making transparent primary and secondary flows of raw materials, early warning for scarcity, and the development of sustainable strategies to prevent scarcity. For agriculture and the food supply, the FAO should be involved in this process. "Virtual phosphate" should also be included with the national flows: this is phosphate that is used abroad in the production of imported products.

International raw materials policy

10. **Implement a two-track foreign policy** regarding raw materials security:
    - **promote *global governance* and multilateralism** with priority for food-related raw materials. In the current century, the tide has been unfavourable for multilateral agreements; witness the near-deadlock in the WTO and the energy that big players have invested in concluding regional and bilateral trade agreements.[28] Nevertheless, agreements on raw materials at the global level are indispensable to prevent outsiders from arising, with all the ensuing social and political risks;
    - **promote bilateral cooperation**. Instead of a race to the bottom for dwindling mineral reserves, commitments must be made for interdependence with both raw material *producing* countries and raw material *importing* countries. Concerning industrial raw materials, the EU has already made agreements with countries and organizations such as Japan (2010), the African Union (2010), the South

24 Much information about specific reserves is not publicly available or is accessible only after paying high fees.

25 *EU-USA Expert Workshop on Raw Material Flows & Data*, September 2012. http://ec.europa.eu/enterprise/newsroom/cf/itemdetail.cfm?item_id=6182&lang=nl

26 The IFDC emerged from the fertilizer industry but is now mainly funded by USAID (43%) and the Netherlands (34%).

27 This was recently advocated in the magazine of the Dutch employers' organisation VNO/NCW. http://www.vno-ncw.nl/publicaties/Forum/Pages/Gouden_bergen_afval_in_Nederland

28 When he took office, President Obama distanced himself from the unilateralism of his predecessor Bush. But when Syria deployed chemical weapons and Russia continued to support the regime, he threatened military intervention without a mandate from the Security Council. However, at the last minute in September 2013, he decided to cooperate with Russia and the Security Council. This gave another impulse to multilateralism. It is anything but certain whether this will be sustainable and will affect other areas of policy.

American Mercosur (2011) and Greenland (2012).[29] Where relevant, these agreements must be expanded to include raw materials for agriculture. In addition, cooperation on raw materials for agriculture is advisable with countries such as India and Brazil for recycling phosphate and other minerals. Where possible, other developing countries should also be involved. It is a shared interest to help these countries become more self-sufficient in raw materials and – to the extent that they export raw materials – benefit more from them. A specific point is cooperation with Morocco in the sustainable extraction of phosphate ore, based on mutual advantage. One possibility is a combination with the extraction of uranium, which is often a hazardous contaminant of mined phosphate and its waste products. Another aim is to prevent the phosphate duopoly from cutting the price to thwart recycling.

Circular economy

11. **Promote price stabilization of raw materials.** The development of a circular economy requires favourable governance conditions, such as stable prices; low and volatile prices for raw materials are detrimental.[30] *Low* prices can occur as a result of dumping, overproduction, price wars (exemplified by the recent problems on the potassium market) and excessive reserves. *Volatile* prices can occur due to small reserves and can lead to speculation that exacerbates price fluctuations. Price stabilization can be promoted with the following measures:
    - **conduct assertive policy against dumping of raw materials[31]** by third countries, despite the short-term advantages of dumping for companies that use or trade in those raw materials. This must also be a priority in bilateral trade associations with the USA and Morocco;[32]
    - **develop partnerships with raw material producing countries** with the following priorities: long-term delivery contracts with a wide **bandwidth for prices** in exchange for mutually beneficial forms of cooperation. However, note that this concerns not only the prevention of very *high prices* but especially the prevention of very *low and volatile* prices;

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29 For Greenland, this primarily concerns 6 of the 14 critical raw materials; others include zinc and molybdenum.

30 In 2012, food security expert Joachim von Braun presented a broader argument in favour of price stabilization: "*Commodity market volatility undermines investments (especially in small farm agriculture), sustainability, and food security: the whole range of actions to reduce volatility should be on the agenda (technology, productivity, market institutions, trade policy etc.)*". In: *Food and Agriculture: The future of sustainability*, 2012. Nevertheless, a recent report of the Rabobank, which makes a case for small farmers and cooperatives, devoted less than a single sentence to the scarcity of some critical nutrients. Integral thinking is still far from commonplace. https://www.rabobank.com/nl/images/framework-for-an-inclusive-food-strategy.pdf.

31 Paradoxically, *cartel forming*, to the extent it maintains high prices for raw materials, actually benefits efficiency, substitution and recycling. For example, the formation of OPEC encouraged oil-importing countries to take energy-saving measures.

32 The negotiations with Canada on the Comprehensive Economic Trade Agreement (CETA) were completed in October 2013 and presented to the European Council and the European Parliament. CETA includes reduced tariffs and relaxed import quotas for a wide range of products. As a result of this agreement, the EU would not necessarily acquire better access to the rich reserves of Canadian minerals, including potassium, since the EU already imposes low tariffs on raw materials.

- **consider the creation of public/private strategic reserves** of specific critical nutrients as a buffer and to stabilize prices if necessary.[33]

The previously mentioned **“compulsory blending”** of secondary raw materials can also contribute to price stabilization.

[33] The WTO is considering offering countries more room for maintaining food stocks. *Boerderij Vandaag* 20-3-13.

10. Recommendations to the Dutch government

Our general recommendation is to expand the fledgling raw materials policy along four tracks - national, European, bilateral and multilateral - while maintaining the following priorities:

- **Make the Netherlands less dependent on imports of nutrients by promoting a circular economy.**
- **Create partnerships, based on mutual advantage, with both raw material *im*porting countries and with raw material *ex*porting countries.
At the same time, aim for solutions that also benefit third countries.**

National raw materials policy

1. **Establish a Netherlands Raw Materials Agency** based on the example of the German *Rohstoffenagentur*. This agency would be given the task of mapping out the flows of primary and secondary raw materials (including nutrients), and the future need for them, and developing a strategy for each critical raw material. The first step has already been taken: the Raw Materials Monitor (Statistics Netherlands).

Circular economy

2. **Strongly promote the efficient use, recycling and substitution of nutrients**. The programme *Van Afval naar Grondstof* [From Waste to Resource], recently presented by State Secretary Mansveld (Infrastructure and the Environment), announces policy that focuses on a circular economy. Operational objectives include: addressing specific chains (including the food chain), focusing on sustainability from the design phase of products (ecodesign), and implementing market incentives (unspecified). The following market incentives should be explored:
   a. **internalize the environmental costs** in the prices of raw materials, including imported raw materials, thus creating a level playing field for primary and secondary raw materials. If that is not possible in the EU context, another option is to form a leading group of several Member States.
   b. as a variant of this approach: **introduce a variable, price stabilizing duty on raw materials**, that declines in a countercyclical fashion as market prices increase, and increases when they decline. This can create a beneficial investment climate for a circular economy.[34] For this purpose as well, a leading group of Member States can perhaps be established.

[34] One complication is that companies that have to compete on the international markets are disadvantaged. This complication can be avoided in two alternative ways: by exempting these companies from the duty, or by compensating them.

c. **integrate raw materials policy in the sustainable purchasing scheme of the national government.** For example, by selectively purchasing products that are manufactured with secondary raw materials.

3. **In the legislation on reuse and recycling of nutrients, give priority to essential uses**. Stated differently: apply **cascading**. This promotes operation according to a value pyramid, in which high-value uses have priority over low-value uses.[35] The primary emphasis is not on the financial-economic value, but on the value of the specific nutrient for agriculture and the food chain. This means the following: nutrients that become available are first used for the fertilization of farmland and for the human food chain, after which they can possibly be used for animal feed, then for composting (whereby the nutrients retain their value), and as a last resort for energy production. Finally, the nutrients can again be recycled.

4. **Deploy innovation policy** for utilizing the economic and export potentials of efficiency, recycling and substitution. The challenge is then to expand upon the current leading position in the **recycling of phosphate** with **potassium and micronutrients,** beginning with selenium and boron.

5. **Explore whether the phosphate stocks in Dutch farmland soils can be utilized as a strategic reserve.** This primarily concerns phosphate-saturated soils: can the phosphate at these locations remain fixed in an ecologically responsible manner, to be mobilized during times of scarcity, for example by using mycorrhizal fungi?

European raw materials policy

6. **Promote the inclusion of the food chain in the European raw materials policy, and the inclusion of raw material scarcity in agricultural policy,** as outlined above.

7. **Oppose the resource nationalism** of individual Member States.

8. **For micronutrients, link up with the idea of raw material "roundabouts".** The primary objective should not be a single European roundabout for all micronutrients, but multiple, specialist roundabouts in the European context. For the macronutrients phosphate and potassium, regional roundabouts should be given precedence due to the magnitude of the flows.

9. In the EU, seek **partners for a raw materials transition** (in German: *Rohstoffe-wende*).[36]

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35 This would link up with the comparable principle in the biobased economy.

36 www.wastematters.eu/.../The_Netherlands_as_materials_roundabout.pdf

Integrate raw materials in development policy

10. **Aim for coherence between raw materials policy and development policy.** This includes aspects such as:
    - supporting countries in establishing a transparent **land ownership register** with the aim of enabling the local population to benefit more from mining and land grabbing;
    - ensuring **transparency** in the actual trade in raw materials, for example by means of an EU directive that requires companies to determine the origin of their raw materials and limit negative impacts;[37]
    - modifying the **fiscal policy in the Netherlands regarding "letterbox companies"**, to ensure that more of the revenues from resource extraction remain in the countries of origin. During this process, make a critical examination of transfer pricing (the method for allocating taxes to various countries) which is used by multinationals to avoid taxation*;*
    - establishing **partnerships with nutrient *im*porting developing countries** focusing on greater self-sufficiency, for example by recycling nutrients from human urine (by means of eco-sanitation). In several countries, this is already taking place with phosphate. The Nutrient Platform seeks to close local nutrient cycles in Ghana, Zambia and/or China. Potassium is also worth considering;
    - establishing **partnerships with nutrient *ex*porting countries** based on mutual advantage. A recent example in the non-food sector concerns agreements with Bolivia, whereby Bolivia supplies lithium in exchange for Dutch expertise, also for the production of lithium batteries.[38] Similar cooperation could be possible with countries such as Morocco.

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[37] http://www.somo.nl/news-nl/somo-nieuws/nieuwe-eu-wetgeving-kan-bijdragen-aan-meer-verantwoorde-inkoop-van-grondstoffen

[38] http://www.rijksoverheid.nl/nieuws/2013/08/26/nederland-ondersteunt-bolivia-bij-benutten-lithium-voorraden.html

11. Recommendations for the private sector

Raw materials strategy

1. **Develop a comprehensive raw materials strategy with an important place for nutrients**. This is compatible with the trend whereby more and more sustainable activities that governments are unable to organize or compel are being implemented voluntarily by large companies as part of their risk management and Corporate Social Responsibility strategy – thus based on enlightened self-interest. Therefore, do not wait until the EU and the Dutch government have made the arrangements proposed above.

2. **In that strategy, give priority to reducing import dependence.**

3. Phosphate is already on the agenda of the committee of the VNO/NCW (employers association) which holds discussions about raw materials policy. **This agenda should also include potassium and critical micronutrients**. It is crucial that **non-food industries** also participate, because the best opportunities for substitution of micronutrients are available in that sector.

4. Specifically for the feed industry: **stop overdosing micronutrients (especially zinc, copper and selenium) in animal feed**.

Alliances

5. Seek **cooperation with other companies that use raw materials** in Europe, not only by forming purchasing alliances (such as the German *Rohstoffallianz*), but especially by taking steps towards a circular economy.

6. The Nutrient Platform now consists of 33 companies, organizations, universities and research institutes, and has already taken many market-oriented initiatives for recycling phosphate. It is time to take **comparable initiatives for other nutrients, such as potassium, selenium and boron,** within or without the Nutrient Platform. The ambition of the Dutch business sector should be to take the lead in this area.

Invest in cyclical processes

7. Specifically for banks, pension funds and other institutional investors: **invest in companies that focus on sustainable nutrient cycles,** including more efficient extraction and processing, more efficient use in agriculture, and recycling from manure, sewage sludge and ash from waste incineration, as well as (especially with micronutrients) substitution in industries, both in the EU and world-wide.

12. Recommendations for research and innovation

In line with the above recommendations, the following themes can be referred to for **technological** research and innovation:

1. System innovations in agriculture and industry, including ecodesign.

2. Substitution possibilities for macronutrients and micronutrients in various industries.

3. Recycling of macronutrients and micronutrients from sewage sludge, waste incineration and surface water.

4. Possibilities to treat soil phosphate as a strategic reserve and the possibilities to mobilize this reserve with mycorrhizal fungi.

5. Innovations in breeding and selection, cultivation and processing of European protein crops.

6. Possibilities for roundabouts for macro and micronutrients, both central and regional.

Regarding **policy-oriented** research and innovation, the following themes are important:

1. Options for a recycling obligation for nutrients.

2. Options for a blending obligation for nutrients.

3. Options for partnerships of the Netherlands and the EU with raw material *im*porting countries based on mutual advantage.

4. Options for partnership with raw material *ex*porting countries based on mutual advantage.

5. Options for variable, price-stabilizing levies on raw materials in the EU, the Netherlands or a leading group of Member States.

6. Options for multilateral raw materials policy.

7. Options for integrating raw materials supply risks in the CAP.

8. Options for integrating the food chain in the European raw materials policy.

In conclusion

Sooner or later, the Netherlands and the EU will have to deal with scarcity of macro-and micronutrients. This scarcity will not be caused initially by depletion of global reserves, but by market manipulation and resource nationalism. This could result in a “hard landing”, with severe consequences for European agriculture and food production. However, a soft landing is still possible if we change course promptly in the direction of reduced import dependency and a more circular economy.

The geopolitics of raw materials for agriculture and food production

Part B

Analysis

Drs. Wouter J. van der Weijden, Platform LIS

Dr Eric Hees, CLM Research and Advice

Dr Ton Bastein, TNO

Prof. dr Helias A. Udo de Haes, Platform LIS

1. Agriculture and raw materials: an emerging problem

Since the food crisis of 2007/2008, a world-wide debate on food security has been raging. The situation for developing countries is particularly worrying. It is generally assumed that food security in the EU is not threatened: after all, the EU is self-sufficient for the majority of basic foodstuffs, with the exception of protein-rich feed (soya meal being imported on a large scale from South America) and to lesser extent vegetable oils. Potential shortages are not considered to be worrying; the EU can always obtain what it needs due to its strong purchasing power.[39]

To test this optimistic assumption, in 2011 the Platform for Agriculture, Innovation and Society (Platform LIS) conducted a stress test of the European agriculture and food system.[40] The aim of this test was to determine the consequences of four types of calamities on food security: a large-scale and long lasting drought, a large volcanic eruption, a sudden collapse of soya imports and a large-scale animal disease epidemic. The test showed that food security was not seriously threatened by any of these calamities. However, severe price shocks would occur, and the livestock and meat sectors would be severely damaged. Moreover, the EU would have to restrict its exports of grain and increase its imports, which could cause problems for food-importing countries such as Egypt.

Nevertheless, the food security of the EU *itself* can be threatened in the long term by another problem: scarcity of raw materials. This primarily concerns the macronutrients phosphate and potassium and several micronutrients. This scarcity can be caused by:

- physical causes: depletion of regional reserves;
- economic causes: increasing prices for raw materials because the supply falls behind the increasing demand, or due to market manipulation;
- political or geopolitical causes: restriction of market access for protectionist or other political reasons. The confidence that the multilateral trade system will prevent such measures is fading.

Policy gaps

The European Commission is also concerned about potential scarcity of raw materials. In 2008 it launched the Raw Materials Initiative. However, this initiative pays attention primarily to raw materials for industry, largely ignoring raw materials for agriculture. On the other hand, the Common Agricultural Policy (CAP), including the recent reform,

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[39] Besides a debate on food *security*, another debate has been going on for decades concerning food *sovereignty*: proponents argue that countries must be able to decide for themselves about the degree to which they want to be self-sufficient or import-dependent, regardless of multilateral trade agreements. The WTO offers only very limited room for such policy, and for the American government this is a no go area. This was an important reason for the stalemate of the Doha Round. In December 2013, however, an agreement was reached in which developing countries were allowed more space to build up food stocks to feed the poor.

[40] http://www.platformlis.nl/rapporten/StresstestEUagrfoodsystem.pdf

pays hardly any attention to the potential scarcity of raw materials.[41] This is the case even though the CAP has traditionally sought to safeguard food security in the EU. These are two risky gaps in the European policy, even more so if we realize that although minerals can – to some extent – be substituted in industry, they cannot be substituted in agriculture and food.

Positioning
In recent years the Platform LIS has published two advisory memoranda: one on phosphate and one on micronutrients. These reports showed that agriculture in the EU is vulnerable due to its imports of phosphate and several micronutrients. In 2012, the Platform made several proposals to the European Parliament to give raw materials a clear position in the reform of the CAP. Phosphate scarcity also received attention in previous studies: Wageningen UR (2009), the Interdepartmental Project Group on Scarcity and Transition (2009), the Netherlands Environmental Assessment Agency (van den Berg et al. 2011) and The Hague Centre for Strategic Studies (HCSS), together with TNO and the CE (2011). The latter study also concerned soya and cocoa. A subsequent study of the HCSS (2012) focused extensively on geopolitics, but was entirely about phosphate, not potassium and micronutrients. A recent study of HCSS and LEI (2013) included the geopolitics of phosphate and soya, along with a number of food items, from the Dutch perspective. Micronutrients did receive detention in two recent Wageningen UR reports (Chardon & Oenema [2013] and Van Krimpen et al. [2013]), but the accent in these reports was on the Netherlands, and they paid little attention to geopolitics.[42] The present report integrates all these topics and fills several gaps.

Aim of this report
This report focuses on the geopolitics surrounding soya, phosphate, potassium and several micronutrients. The aim of this report is to analyse the risks, the major interests that are at stake, and the responsibilities for safeguarding these interests. This analysis can be relevant for policymakers in the Dutch Ministry of Economic Affairs (and indirectly other ministries, particularly Infrastructure and Environment, Foreign Affairs, Security and Justice), the European Union and private stakeholders who want to prepare for the supply risks that are impending for European raw materials security, agriculture and food supply.

Structure of this report
The report begins with a brief sketch of the history of trade, geopolitics and conflicts concerning raw materials and of current issues in that area. Then the following questions are addressed:

- what are “scarce” and “critical” raw materials?
- besides phosphate, which nutrients are critical for agriculture? How critical are they?
- what geopolitical risks are relevant?
- how vulnerable is the EU for such risks?

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[41] Action is being taken only with respect to protein-rich crops: ‘The possibility exists to provide protein-rich crops with 2% linked support’. And protein crops can be grown on the mandatory 5% *Ecological Focus Area (EFA)* on each farm. http://europa.eu/rapid/press-release_MEMO-13-621_en.htm

[42] Exact references to all these publications can be found in Appendix 2.

- what can the EU do, internally and externally, to prepare for such risks?
- during this process, how can the EU also take account of developing countries?

Method
This report is based on:

- a report by Dr Eric Hees, commissioned by the Platform for Agriculture, Innovation and Society, *Voedsel, grondstoffen en geopolitiek* [Food, raw materials and geopolitics]. That report is based in part on interviews with nine individuals from business, government and research institutes who are involved with the issue;
- our own literature and internet research;
- two workshops on geopolitics with experts on 4 September 2009 and 7 October 2010;
- bilateral discussions with the Rathenau Institute and The Hague Centre for Strategic Studies (HCSS).

Note that this advisory memorandum lists only a limited number of sources. For more extensive source references, please refer to the report by Dr Eric Hees.

2. Trade, geopolitics and conflicts surrounding raw materials

History
Traditionally, many raw materials for agricultural products are scarce in some regions, but abundant in other regions. The customary method to balance this situation was trade. Initially, this involved barter, but later on goods were traded for money. A classic example is the Silk Routes. In the 16th century, European countries introduced world trade, also in raw materials. During his first journey to America in 1492, Columbus was already looking for gold. The initial explorations were quickly followed by trade and the conquest of larger areas: colonialism. Frequently, trade monopolies were pursued, for example by the Dutch East India Company (VOC), and sometimes military means were used. That was nothing new; in ancient times the Romans conquered Asia Minor with the aim of obtaining more grain, and conducted trade wars with Carthage. Box 1 contains a number of examples, from the 19th century to today.

Geopolitical theory
Geopolitics is often defined as how states take account of geographical realities in their foreign policy: location, country profile, the presence or absence of sea routes, availability of fresh water, but also the presence of minerals. This report also looks in part at the policy of non-state actors, in particular companies.

The emergence of geopolitics as a political vision is usually placed at the end of the 19th century, a period of increasing competition between the most powerful states at the time: the United Kingdom, Germany and Russia. The founders were Mackinder (British), Ratzel (German) and Kjellén (Swedish). Mackinder established a school of thought with his Heartland theory, which focused on Eastern Europe and West Asia. He asserted that whoever controls that region would have the political power and capital to rule the world. This region contains some of the richest agricultural lands in the world and has large reserves of raw materials such as coal and iron ore.

In 1899, Kjellén coined the term “geopolitics”, which he defined as “the science of the conditioning of political processes by the earth.” He believed that states would grow organically as they became stronger. He brought a moral argument into play by arguing that a state with a more “advanced culture” also had a greater right to expand its “domain” or “territory”. With this argument, he elaborated on Ratzel, who referred to *Lebensraum*: superior cultures deserve more territory, because they also use the land better. The German Haushofer modified and popularized Kjellén’s theory, after which it was introduced into the Nazi regime by his student Rudolf Hess. As a result, the concept of geopolitics became associated with Nazism, which lasted until about 1990.

Box 1 Historical examples of geopolitical conflicts concerning natural resources

Oil and gas

- 1941-45: with operation Barbarossa, Nazi Germany attempted to conquer European Russia, partly to acquire access to the oil-rich region of the Caspian Sea. The advance stopped at Stalingrad.
- 1941: Japan attacks Pearl Harbor as part of its strategy to dominate Southeast Asia, after the US and the Netherlands halted exports of oil, aviation fuel and scrap iron.
- 1967-1970: Biafra war of independence against Nigeria, partly for ethnic reasons, partly for control of oil fields.
- from about 1970: tensions and occasional skirmishes between China and Japan, Vietnam, the Philippines, Taiwan and Malaysia over archipelagos in the South and East China Sea that are rich in oil and fish stocks.
- 1990: Iraq annexes Kuwait, partly to acquire control over oil reserves and indirectly to control the oil price.
- 1991: the USA leads a coalition of 34 countries to retake Kuwait, with a mandate from the UN. The formal motive is to undo the unlawful annexation of Kuwait, but oil is also mentioned as a motive.
- 2002: the USA and the UK invade Iraq, without a UN mandate, and occupy the country through 2011. The alleged motive is that Iraq possesses weapons of mass destruction, but this turns out to be incorrect. Oil appears to be at least as important as a motive.
- 2005-present: tensions between Russia and Ukraine about gas prices. In January 2006, Gazprom shuts off the gas supply for several days. This immediately impacts several Member States of the EU. After several days, an agreement is signed under pressure.
- 2013: Russia offers Ukrain price cuts for gas if it joins the European trade union of Russia, Belarus, Kazakhstan, Kyrgyzstan and Armenia rather than the European Union.

Land

- 1939-1945: Nazi Germany seeks *Lebensraum* in Eastern Europe, also in the form of agricultural land.
- 2009: month-long demonstrations in Madagascar lead to the resignation of the government, which had signed a contract with the South Korean company Daewoo to lease 1.3 million hectares of land for the production of maize.

Water

- Since the 19th century: tensions between Egypt/Sudan and Eastern European countries about sharing the water in the Nile. Recent tensions concern the construction of the Grand Ethiopian Renaissance Dam on the Blue Nile.
- 1967: Israel occupies the Golan Heights in Syria for security reasons, but also to safeguard its water supply. The Golan Heights supplies 30% of Israel's water and borders on the Sea of Galilee, Israel's most important water source.
- 1970-present: plans for 22 dams on the Tigris and Euphrates rivers lead to tensions between Turkey, Syria and Iraq.

Minerals

- 1960-63: the province of Katanga, rich in copper, gold and uranium mines, declares its in independence from the young Democratic Republic of the Congo. This attempt is supported by the Belgian army and business community, but is stopped by UN troops.
- 1998-present: regional wars in East Congo, partly with ethnic motives, partly for control of minerals (including coltan), diamonds and wood. Nine countries are involved in this “African world war”.
- 2010: China briefly restricts its exports to Japan of rare earth metals crucial for industry in retaliation for the arrest of a Chinese captain sailing near the controversial Diahoyu/Senkaku Islands.

Agricultural raw materials (fertilizers)

- 1836-39: war for guano islands between Peru/Bolivia and Spain.
- 1879-1883: saltpetre war between Peru/Bolivia and Chile.
- 1975: Morocco and Mauritania occupy two-thirds and one-third, respectively, of the Western Sahara.

Paradoxically enough, a comparable train of thought can be found in the work of Ayn Rand, who is seen as the spiritual mother of neoliberalism (Friedrich von Hayek is seen as the spiritual father). She believed that Europeans had every right to conquer America, because the Indians had produced too little with their natural resources.[43]

At the end of the World War II, the Western Allies decided that international trade must take place via the free market, within the rules of the multilateral trade system. This initially became the General Agreement on Tariffs and Trade (GATT), which was replaced in 1995 by the World Trade Organisation (WTO). The GATT provisions theoretically concerned all trade, but did offer possible exceptions for exhaustible natural resources among other things.[44] For that matter, agriculture was included in the system only during the Uruguay round (1986-1994). The system has had a regulating and pacifying effect, but could not prevent various resource-based regional conflicts, such as that in Eastern Congo.

After the Cold War, different visions emerged, such as that of Huntington; in his *Clash of Civilizations* (1993), he emphasized cultural conflicts. Others, such as Thomas Friedman in *The World Is Flat: A Brief History of the Twenty-first Century* predicted a level playing field for all world citizens due to the Internet, which would lead to increasing equality. Indeed, more and more people are acquiring free access to more and more global information thanks to the Internet. However, when it comes to energy and raw materials, things are different; in the words of Robert Kaplan in his book *The revenge of geography*, we have to make do with our place on the map. Armed conflicts for raw materials are not only a phenomenon of the past, but also of today. And such conflicts can be expected in the future.

Geopolitics versus free trade (1): raw materials

After the Berlin Wall fell, the dominant belief in the West was that global free trade between private companies would be the winning system. In today's multipolar world, this belief no longer appears to be tenable. Various developments point in a different direction.

First, in the mining of raw materials, state-related companies are not in decline but rather on the rise. These include companies in China, Morocco, Turkey, Belarus, Kazakhstan, Iraq and Saudi Arabia. Table 1 lists companies which are active in the mining of six raw materials that are important for agriculture.[45]

Furthermore, we see that more and more raw material producing countries, including China, Indonesia and the USA, are limiting the production and/or export of raw materials to protect their domestic buyers, to attract processing industries and sometimes to manipulate export prices upwards. In 2008/2009, China did so with an

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43 Quoted by Hans Achterhuis (2010) in *De utopie van de vrije markt* [The utopia of the free market]. Ayn Rand wanted to drastically reduce the role of the state in favour of talented individuals. Briefly summarized, we could say that Kjellén propagated the entitlement of the strongest, the Nazis propagated the entitlement of the Aryan race and Ayn Rand propagated the entitlement of the individual. But this is overly simplified.

44 Following its admission to the WTO in 2001, China used this exception to impose various duties on imports and exports of raw materials. But that was judged as improper use by the panels of the WTO.

45 In the *exploration* for many minerals, however, the most active companies are not the large private and state-related companies, but small “junior” companies (T. Bastein, TNO, in email 14-1-13).

export duty of 135% on raw materials such as phosphate and zinc, and with export quotas for rare earth metals. In 2012, the WTO ruled that China was in violation of trade rules, after which the government withdrew these measures. But in the first half of 2012, China cut zinc production with the aim of driving prices up – after several years of price declines due to a stagnating world economy. And in 2012, the Russian oligopoly Uralkali attempted to do the same for potassium, but was defeated by the combined purchasing power of China and India.

Box 2 Western Sahara: the geopolitics of phosphate

Recent history provides a striking example of geopolitics concerning an agricultural raw material: the phosphate-rich region of the Western Sahara.

Until 1975, this was a Spanish colony, where the Spanish foreign legion fought against the Polisario liberation movement. In 1975, based on old regional claims, Morocco organized a Green March to the border. Spain – in the last days of the Franco regime – offered no resistance and began negotiations, after which Morocco and Mauritania occupied the northern two-thirds and southern one-third of the region, respectively. In 1976, Spain transferred sovereignty to Morocco in exchange for fishing rights near the Moroccan coast. But in that same year, Polisario founded the Sahrawi Arab Democratic Republic, with the support of Algeria and Libya.
In 1979, Mauritania gave up its battle against Polisario, after which Morocco also annexed the southern part of the Western Sahara. In the following years, Morocco built a long defence wall from north to south. The 1/6 of the Western Sahara that remained behind the wall was left to Polisario.

Although the regional claims were never acknowledged by the International Court of Justice in The Hague, the occupation continues today. In the meantime, the broad international support for Polisario has crumbled. Algeria, which provided most of the support to Polisario, is also keeping quiet. Time is working to Morocco's advantage, and with its policy of *fait accompli*, the country is acquiring increasing control of the region and its phosphate reserves.

For that matter, only a small part of Moroccan phosphate mining takes place in the Western Sahara. The magnitude of the reserves is unknown. The UN has passed a resolution according to which phosphate exports can only take place if the local population benefits from them. Norway is boycotting phosphate from the region.

Source: http://nl.wikipedia.org/wiki/Westelijke_Sahara

On the other side of the equation, we see that raw material *importing* countries are signing long-term deals to safeguard their supply. For example, China is active with agricultural land and mining, and in return offers attractive deals such as investments in infrastructure.

Furthermore, the markets are becoming consolidated; as a result, raw materials are increasingly coming into the hands of a small group of big players. The biggest private players are BHP Billiton, Rio Tinto and Vale.[46] Other big players include the Canadian

[46] If we include oil, in 2012 the highest turnover in raw materials in the world was reported – surprisingly – by Vitol, a relatively unknown Dutch trading company, just ahead of Glencore (which

PotashCorp and the British/Swiss Xstrata, which trades in commodities such as copper and zinc. In May 2013, Xstrata was in turn taken over by the Swiss company Glencore, which thereby became the fourth largest raw materials company in the world. State-related buyers include the Moroccan OCP (phosphate), the Chinese Zijin Mining Group (zinc) and the Belarusian Belaruskali (potassium). Finally, the world market leader in nitrogen fertilizer, Yara, is partly owned (43% of the stock) by the Norwegian state.

Of strategic importance is also the fact that Hong Kong Exchanges and Clearing purchased the London Metal Exchange at the beginning of 2012. According to the Director of the Hong Kong Exchanges:

> "The acquisition of LME Holdings represents a unique opportunity for us to acquire in one stroke a position of global leadership in the commodities market."

Table 1 State involvement and consolidation in raw material extraction and production Source: Bastein, TNO.

Raw material	Countries holding reserves	State-related mining and/or production	Privately owned mining and/or production
Phosphate	Morocco China Iraq Algeria Saudi Arabia USA	OCP = *Office Chérifien des Phosphates* Yuntianhua Group SCPQIRAQ Sonatrach Ma'aden	Mosaic
Potassium	Canada Belarus Russia	Belaruskali	PotashCorp, Mosaic Uralkali: 5 Russian shareholders
Zinc	China Australia Peru	Zijin Mining Group	Xstrata (now GlencoreXstrata) Antamina (Billiton, Glencore and others)
Selenium	Chile Peru	Codelco	Southern Copper Corp
Molybdenum	China Chile	China Molybdenum Co. Codelco	
Boron	Turkey USA	EtiMaden	Rio Tinto, Searles Valley

had not yet merged with Xstrata) and Cargill. Vitol is relatively unknown partly because it is not a publicly listed company. It is owned by management and 330 employees. Source: *Grondstoffenhandelaren opereren in* stilte [Commodity traders work in silence] *NRC Handelsblad* 18-4-12. With an annual turnover of $223 billion, Vitol is the second biggest company in the Netherlands.

Due to the rising demand, in combination with increasing concentration in fewer hands and declining market access, the tensions surrounding raw materials are bound to increase. Raw materials nationalism (more broadly: resource nationalism) is increasing. Governments in various countries are increasingly hesitant to place the exploitation of raw materials into the hands of foreign companies. A few examples for agricultural raw materials:

- Canada has effectively halted the takeover of the potassium giant PotashCorp (Potash Corporation of Saskatchewan) by the British-Australian concern BHP Billiton.[47]
- Conversely, Israel has used its veto to block the takeover of fertilizer producer PotashCorp by ICL. Its aim: protection of its domestic phosphate reserves.
- Belarus blocked the privatization of the potassium company Belaruskali.
- In 2009, the Australian government prevented the Chinese aluminium manufacturer Chinalco from acquiring a minority stake (and two seats on the board) in the mining giant Rio Tinto.[48]
- China, the USA and South Africa are inclined to retain their phosphate reserves for domestic use.
- In 1999, Turkey withstood pressure from the IMF to privatize its boron mining.

Despite these developments, geopolitics is still not a priority on many agricultural agendas.[49]

Geopolitics versus free trade (2): Agriculture and food

Similar developments are taking place on the agricultural and food markets. In 2009, an uprising in Madagascar prevented the sale of 1.3 million hectares of agricultural land to the South Korean company Daewoo. Russia intends to become less dependent on food imports (with maximum imports of 15% for meat, 10% for milk and 5% for potatoes) and for this purpose is using measures such as a long-term import ban on American pork. Russia, together with the other Black Sea states Ukraine and Kazakhstan, intends to surpass the USA as the largest exporter of wheat.[50]

China has also become involved. For political reasons, the Chinese government wants to become less reliant on the USA for its growing imports of soya and feed maize.[51] For example, China has loaned €9 billion at beneficial terms to Ukraine, which will use the money to purchase Chinese agricultural machinery and fertilizers and invest in irrigation systems. With these investments, it will develop 3 million hectares of

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[47] Another consideration was the potential loss of tax revenues. This is because BHP Billiton wanted to put an end to the potassium export cartel, of which PotashCorp was a member. That would result in lower prices and lower tax revenues. Taylor, C.R. & D.L. Moss (2013). *The Fertilizer Oligopoly: The Case for Global Antitrust Enforcement.* AAI Working Paper no. 13-05. The Canadian government is thus – indirectly – a member of this cartel. The government also effectively halted the takeover of the ailing Blackberry by the Chinese company Lenovo, ostensibly for national security reasons. Source: *NRC Handelsblad* 13-11-13.

[48] *NRC Handelsblad* 30-7-13.

[49] This not only applies to the CAP. For example, in 2012 the report *Food and Agriculture: The future of sustainability* was published, based on interviews and panel discussions with many experts on food security. The report paid attention to *land grabbing*, but not to possible scarcities of potassium, phosphate and micronutrients, nor to the associated geopolitics.

[50] The formation of such a cartel is indeed forbidden by the rules of the WTO, but the three countries are still holding discussions. *Boerderij Vandaag* 18-9-12.

[51] *Boerderij Vandaag* 29-9-12.

farmland. The resulting products – primarily maize and pork – will be sold to China at fixed prices.[52] In addition, China is investing in agriculture and infrastructure in countries such as Argentina and Brazil.

However, the Chinese policy is also evoking resistance:

- In Australia, opposition is increasing against the purchase of farmland by foreign companies, especially Chinese state-owned companies. This apparently concerns 4.6 million hectares of land. In response, the government decided to map out foreign land investments.[53, 54]
- In New Zealand, the Supreme Court halted Chinese land purchases.[55]
- China is investing in new dairy farms in France, the Netherlands and New Zealand. It also wants to purchase shares in the New Zealand dairy cooperative Fonterra. This caused commotion among the members of the cooperative.
- The Chinese company Shuanghui wanted to take over the American Smithfield Foods, the largest meat company in the world. The USA was concerned about national security risks and had the takeover reviewed by the Committee on Foreign Investment in the United States. In September 2013, the Committee approved the purchase, and the stockholders agreed.

The debate is thus taking place in various countries; the decision is sometimes in favour of the foreign company, and sometimes against them.

Price manipulation

Both large state-owned companies and large privately owned companies can use their market power to manipulate prices. There are strong indications of global duopolies on the markets for phosphate and potassium (Box 3). On the phosphate market, a North American export association is cooperating with the Moroccan state-owned company OCP. And on the potassium market, another association is doing the same thing with the Belarusian state-owned company Belaruskali and the recently merged Russian companies Silvinit and Uralkali, which are formally privatized but still maintain close ties with the Kremlin.[56] These export associations are legal, so the Canadian and American governments facilitate the cartels.

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[52] *Boerderij Vandaag* 26-9-12 and rt.com/business/china-ukraine-agriculture-lease-267/ en

[53] *Boerderij Vandaag* 24-10-12.

[54] Mineral raw materials play a major role in Australian domestic politics. In 2010, the labour government imposed a 30% tax on iron ore and coal. But in September 2013, the liberal Tony Abbott was elected with a programme in which this tax was abolished. This is beneficial for the mining sector and for large buyers such as China. Abbot's campaign was supported financially by five mining companies. http://www.theguardian.com/environment/southern-crossroads/2013/sep/18/tony-abbott-abolish-carbon-price. However, Abbott was compelled to form a coalition government with the National Party, which is much more critical about foreign investors.

[55] *Boerderij Vandaag* 23-1-13.

[56] *NRC Handelsblad* 29-8-13.

Box 3 Cartel formation on the world markets for phosphate and potassium

The structure of the world's phosphorus and potash markets, while complex, may best be viewed as duopolies with small, high cost fringe firms.

The phosphorus duopoly is comprised of the U.S. export cartel, PhosChem, operating with limited antitrust immunity under Webb-Pomerene,[57] and the Moroccan monopoly OCP. There are presently only two members of PhosChem – PotashCorp and Mosaic. PhosChem members account for 52 percent of world phosphorus trade. PotashCorp's phosphorus sales volume traded by PhosChem averages 69 percent for fertilizer, 17 percent for industrial, and 14 percent for feed. The majority of Mosaic's phosphorus sales volume (85 percent) is fertilizer. PotashCorp's production of phosphate products is almost evenly split among liquid fertilizer, solid (dry) fertilizer, feed grade products and industrial, while OCP's sales are about equally split between liquid and solid phosphorus fertilizer. OCP controls 36 percent of the global raw phosphate market and 51 percent of the global phosphoric acid sales. PotashCorp and Agrium obtain phosphate rock from OCP.

The potash duopoly is comprised of the Canadian sanctioned export cartel, Canpotex, which markets potash from Saskatchewan, and a Russian cabal. The three owner-members of Canpotex are PotashCorp, Mosaic, and Agrium, each with a fixed market share of 54 percent, 37 percent and 9 percent of export sales, respectively. Canpotex accounts for 61 percent of world potash trade, including trade by other potash companies in which PotashCorp has significant ownership. The Russian cabal accounts for 32 percent of trade, with a high-cost, non-integrated fringe accounting for the remaining seven percent. There are three major producers of potash in the former Soviet Union – Belaruskali, Silvinit, and Uralkali. These three producers were tightly interlinked, arguably operating effectively as a cartel, and appeared to be morphing into a single firm, until an apparent breakup between Uralkali and Belaruskali in August 2013.

If these figures are correct, the phosphate duopoly controls 88% of the world market; and the potassium duopoly, until August 2013, controlled no less than 93% of the world market.

Source: Taylor, C.R. & D.L. Moss (2013). *The Fertilizer Oligopoly: The Case for Global Antitrust Enforcement.* AAI Working Paper no. 13-05.

A relatively recent phenomenon is the role of large American investment banks. By taking strategic positions in stocks of raw materials, they sometimes see an opportunity to manipulate prices with just a small market share (Box 4). This has little to do with geopolitics as such, but there are also hybrids between privately owned and state-owned companies. Privatized Chinese companies do not operate with full independence from the state. Remarkably, one such company, Shuanghui, has investors that include Rabobank, Crédit Agricole and GoldmanSachs. As a result, privately owned companies can also be dragged into geopolitics.

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57 The Webb-Pomerene Act was implemented in 1918 to give small American companies a stronger position on foreign markets. Consequently, their activities abroad are partly exempt from antitrust legislation and they are allowed to form associations, as long as they continue to compete on the domestic market. Six such associations are currently in existence, including the gigantic PhosChem. The Webb-Pomerene Act is now under attack by the American Antitrust Institute and buyers on the fertilizer market; they have filed a claim in the courts that PotashCorp, Uralkali and other parties are manipulating the import prices for fertilizer. http://www.bloomberg.com/news/2013-07-31/potash-s-20-billion-market-transformed-by-uralkali.html

Box 4 American banks manipulate raw material prices

Since 2003, it has been legal for American banks to invest in raw materials. In the meantime, the six largest banks own more than 14,000 subsidiaries that are not financial institutions. With these investments, they control crucial infrastructure such as ports, power stations, car parks and airports. The investment bank Goldman Sachs says that it is involved in the production, storage, transport, marketing and trade in various raw materials, including agricultural products and minerals.

The American Senate has held hearings to clarify whether banks are playing a dubious role and are able to manipulate prices. Investment bank JP Morgan has been accused by the Federal Energy Regulatory Commission of manipulating energy prices. And beer and soft drink companies are accusing Goldman Sachs of driving up aluminium prices. The bank owns few raw materials, but it does own a warehouse that stores aluminium and can thus control sales of this commodity.

Source: *NRC Handelsblad* 24-7-13.

Deterrence

An especially disturbing development is that the increasing competition for raw materials has begun to have a military aspect. Governments are beginning to worry about the availability of raw materials. China, India and Australia are expanding their naval fleets in the Indian Ocean. And in the new NATO Strategic Concept – prepared by a committee under the leadership of a former CEO of an oil and gas multinational (probably not coincidentally) – referred to the disruption of trade as a security threat.[58]

It has been claimed that the geopolitical tensions will focus on the Indian Ocean region. In 2010, naval vessels were sent to the region by 25 countries, in many cases not only to combat piracy, but also to build a military position. The Indian Ocean is indeed a roundabout for oil and gas, but much less for agricultural raw materials and products. For the latter commodities, other routes are of greater strategic importance:

- the route between China and the east coast of South America (Brazil and Argentina). This route proceeds via the Pacific and Atlantic. This also fits China's plans for a railway through Colombia and a canal through Nicaragua;
- the route between India and North and South America (soya and maize). This route does pass through the Indian Ocean and continues into the Atlantic Ocean;
- the route between India and Morocco (phosphate). This route does pass through the Indian Ocean, the Mediterranean and the Atlantic;
- the route between North and South America and Morocco (phosphate). This route also passes through the Atlantic.

In short, for agricultural raw materials and products, the Atlantic and Pacific appear to be no less important in strategic terms than the Indian Ocean.

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58 *Active Engagement, Modern Defence - Strategic Concept for the Defence and Security of the Members of the North Atlantic Treaty Organisation adopted by Heads of State and Government in Lisbon.* NATO, 2010. The chairperson was Jeroen van der Veer, former CEO of Shell.

3. Key concepts: resources, reserves, scarcity and criticality

There is some confusion about the concepts of resources, reserves, scarcity and criticality. Below is an attempt at clarification.

Resources and reserves

The terms “resources” and “reserves” are often confused with each other. Resources are the known quantities of raw materials that can potentially be extracted in the future. According to the simplest classification, reserves are defined as the portion of the resource stocks that can be feasibly exploited with current technology and at current prices. As a result, resources and reserves can differ greatly; with phosphate, for example, they can differ by a factor of 4. Over time, resources can increase due to continuing exploration. Reserves can also increase – sometimes very rapidly – due to new technologies or higher prices. Consequently, data on reserves are much more dynamic than data on resources.[59]

Scarcity

Scarcity is the basis of the market economy: without scarcity, there would be no production and trade. In the literature and in the public debate about scarce raw materials, we encounter several concepts of scarcity:

1. scarcity of nutrients in *agricultural soils, animal feed and foodstuffs*. These are often referred to as deficiencies;
2. physical scarcity: *mineral reserves - or even resources - become depleted* and are no longer adequate to satisfy the demand/need. Regional depletion will occur first, followed by global depletion;
3. economic scarcity: if supply falls behind demand, *prices will increase* sooner or later. Such scarcity can also be deliberately created by cartels;
4. politically-driven scarcity: *producing countries restrict access* to their raw materials using various means (ranging from export duties or quotas to full export bans).

A few comments on these definitions.

Deficiency

In this context, the term scarcity can be confusing, because scarcity in the soil, crop or foodstuff can occur only due to lack of knowledge, poor governance or inadequate purchasing power. This is why we prefer the term “deficiency” in this context.

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59 Until 2010, the U.S. Geological Survey (USGS) used four categories instead of two. One was the “reserve base”, which includes those resources that are currently economic (reserves), marginally economic (marginal reserves) and some of those that are currently subeconomic (subeconomic resources). This category is much more stable than “reserves” and a more solid basis for comparison between years and countries, but was dropped following budget cuts in 1995 which left insufficient capacity for the required research. Scholz, R.W. & F-W Wellmer 2013. Earth Syst. Dynam. Discuss., 4, C574-C598.

Physical scarcity
This concept of scarcity has been used by the Club of Rome and other groups. For phosphate, it is used by the Australian researcher Dana Cordell and colleagues. Analogous to *Peak Oil* - which King Hubbert (1949) predicted would occur as early as the 1950s - Cordell (2008) predicted that *Peak Phosphorus* would occur in 2033. However, absolute physical scarcity of raw materials does not exist. In contrast to energy, mineral raw materials are not lost after being consumed. They remain somewhere in the biosphere, even if that is at the bottom of the ocean. However, during their use they are often diluted, certainly if used in agriculture and food production, and leakage occurs almost always. And the greater the dilution, the more energy and money is required to recover the minerals. In that sense, all physical scarcity is relative, and is in fact economic and energy scarcity.

However, easily accessible, high quality reserves, characterized by high concentrations of the mineral and low levels of contamination, *can* become depleted. Extracting the remaining, lower-grade reserves requires more energy, water and money, and produces more waste.[60] Moreover, purification can lead to water and/or soil pollution.

Depletion will always begin in certain regions. For example, consider copper in Western countries. Despite increasing investments in exploration after 2000, the known recoverable reserves have only become smaller. This suggests regional physical scarcity.

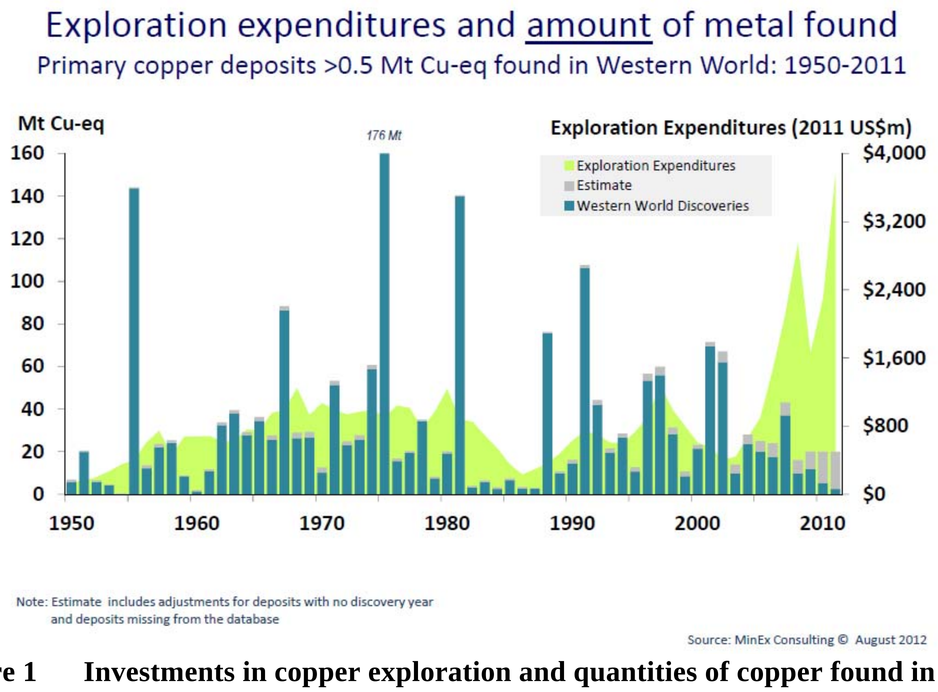

Figure 1 Investments in copper exploration and quantities of copper found in the Western world.

But a qualification is required here as well, because new exploration technologies could discover reserves that are currently unknown. And new mining technologies could make it possible to exploit resources that are currently inaccessible. This has been shown with shale gas and shale oil; at some locations production is possible even at *lower* prices, at

60 Declining grades of ores have been reported with many minerals, but despite many discussions this has not yet been reported with phosphate (Van Kauwenbergh, cited in HCSS 2013).

least if the environmental costs are not included. But with mineral raw materials, experience shows that the production costs of new reserves are usually higher, for the following reasons:

- the easily recoverable reserves become depleted;
- the ore grade is lower, so more energy and water are necessary for extraction;
- the concentration of toxic contaminants (such as cadmium) is higher.

Moreover, increasingly strict environmental measures are being applied, and the costs of labour, logistics and taxes have all risen.[61]

R/P ratio

There is broad interest for the question "how long will world stocks last?" For this purpose, the R/P ratio is often used, where:
R = magnitude of global reserves
P = current production per year.
The R/P ratio is then expressed in x number of years[62].

One problem with this ratio is that although a reasonable value for P is usually known, the data for R are less reliable. No one knows exactly how big the global reserves are. This is partly because exploration is expensive and the owners (privately owned and state-owned companies) usually begin exploration only if they expect profit; it is also because public disclosure is not in their interest.[63] For convenience, many authors use the USGS data, but this information is sometimes poorly supported and may vary greatly from year to year, without a clear reason being reported. What is known is that the USGS has fallen behind for a number of years, due in part to drastic budget cuts in 1995.[64]

Apart from that, the R/P ratio does not indicate how fast the reserves will be depleted. For that matter, P will increase in the future due to rising demand; as a result, depletion could occur much sooner. However, R can also increase as a result of exploration, technological innovations and rising prices. This will also come to an end, but nobody knows exactly when.

Economic scarcity

Economic scarcity that results in high prices for raw materials is especially a problem for countries and farmers with little purchasing power. They can be faced with declining agricultural production and food insecurity. In rich countries, the effect is often limited to inflation. However, for producers, high prices for raw materials are a powerful stimulus to begin searching for new reserves and to begin exploiting more of the known

[61] T. Bastein, TNO, in email 14-1-13.

[62] One variant is the reserve/consumption ratio. However, when calculated over many years, consumption will not deviate much from production.

[63] Asteroids are a bizarre new potential source of metals. Serious plans have been made to travel to asteroids with rockets to extract platinum. Other metals from the platinum group are also referred to, and even a few micronutrients such as iron and cobalt.
http://www.planetaryresources.com/asteroids/composition/
But even if that becomes technically feasible, it will only be profitable for extremely valuable metals.

[64] Van Kauwenbergh, S.J., M. Stewart & R. Mikkelsen (2013). *World Resources of Phosphate Rock…a Dynamic and Unfolding Story*. Better Crops 97 (3): 18-20.

reserves.[65] For users, they are a stimulus to use these raw materials more efficiently, recycle waste and look for potential substitutes. Substitution of nutrients is impossible in agriculture and the food chain, but is often feasible in industry.

Economic scarcity can also be *created* by monopolists or oligopolists. Although this is forbidden in countries with strict anti-cartel legislation, in the EU and world-wide under the WTO regime, it still happens and is not always demonstrable. Legal export cartels exist even in the USA and Canada (Box 3). Speculators can legally amplify a price increase (a price decline as well), but they can usually do that effectively only in the short term; sooner or later, they will have to sell the raw materials they have bought. But it is clear that economic scarcity can occur *long before* world reserves are depleted.

Political scarcity
Political scarcity can be created by raw-material producing countries, with the following aims:

- protectionism: give domestic buyers preference and save reserves to safeguard future raw material security. China is doing this with raw materials such as bauxite, fluorspar, silicon metal, magnesium, manganese, phosphorus and zinc.[66] The USA is doing it with phosphate;
- forcing higher prices. This is usually effective only if multiple producing countries with a large collective market share do this in a coordinated fashion. OPEC was able to do that in 1973 and subsequent years.[67] For the phosphate and potassium export cartels, see Box 3.
- applying political pressure. In 2010, China used export restrictions on rare earth metals to apply political pressure in a conflict with Japan over the Diahoyu/Senkaku islands.

Like economic scarcity, political scarcity can also occur *long before* global reserves are depleted.

Criticality
Besides the term “scarcity”, the term “criticality” is often used in government policies of the EU and the USA with respect to raw materials. This refers to raw materials that are potentially scarce and could result in serious problems. The European Commission applies two criteria:

1. economic importance;
2. the supply risk during the next 10 years as a result of political instability, concentration of reserves, limited substitution and recycling possibilities and/or environmental policy.[68]

More specifically, in the literature we encountered no fewer than nine criteria:

- the importance of the raw material for the economy;
- the degree of geographical concentration of the reserves and the expected risks for the supply;

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65 For example, since 1979 the curve for copper exploration costs has been essentially parallel to the curve for copper prices. T. Bastein, TNO, in email 14-1-13.
66 www.wto.org/english/tratop_e/dispu_e/cases_e/ds394_e.htm
67 Taylor, C.R. & D.L. Moss (2013). *The Fertilizer Oligopoly: The Case for Global Antitrust Enforcement.* AAI Working Paper no. 13-05.
68 The known global reserve relative to the annual use (R/P ratio) is therefore **not** a criterion.

- the concentration of mining companies and producers (corporate concentration) and the corresponding risks of market manipulation;
- R/P ratio: the magnitude of the known global reserves (R) in proportion to the current annual production (P);
- (for agriculture) the extent to which the mineral is present in soils throughout the world;
- the price development: stable, rising or fluctuating? The latter two cases, may indicate scarcity – or speculation on scarcity;
- substitutability: the degree to which the raw material can be replaced by another raw material that is considered less critical;
- recyclability: the extent to which recycling (or increased recycling) is considered feasible;
- the risk that the country will take environmental measures which could limit the supply.

In this field, several studies have been conducted or are in progress, including studies by the European Commission, several German studies, the US Department of Energy and a new study commissioned by the Directorate-General for Enterprise and Industry of the EU. The latter study[69] used criterion 1 and a combination of criteria 2, 7, 8 and 9 (supply risk). The EU is also working together with USA on a shared database.[70] The factor of greatest concern for most parties involved is not the price, but the supply risk.[71]

Although there is no consensus about the definition of "criticality", it should be clear that this definition depends on the context: what is critical for the security of a state does not have to be critical for a company, and *vice versa*; large differences exist between individual companies and states; the political stability or reliability of a producing country can be assessed in various ways; the practical possibilities for substitution are not the same for each country, etc.

In this report, the Platform LIS uses the following criteria for the selection of "critical" raw materials for agriculture: the R/P ratio, the natural prevalence of the mineral in agricultural soils, the import dependence of the EU, the geographical concentration, geopolitical risks, the concentration of companies concerned, the nature of these companies (privately owned or state-related) and the recyclability and substitutability of the raw material. Note that the raw materials described in this report *cannot* be substituted in agriculture, but can be substituted to a certain extent in industry.
Based on these considerations, the Platform LIS has selected seven raw materials:

- **the macronutrients phosphate and potassium;**
- **the micronutrients zinc, selenium, molybdenum and boron;**
- **soya.**

Although soya is indeed interchangeable with other protein-rich crops, it has been included because intensive livestock production in Europe, and especially in the Netherlands, is highly dependent on imported soya.

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69 *Critical raw materials for the EU – Report of the Ad-hoc Working Group defining raw materials*. 2010. http://ec.europa.eu/enterprise/policies/raw-materials/critical/

70 *www.state.gov/p/eur/rls/or/2012/197847.htm*

71 T. Bastein, TNO, in email 14-1-13.

4. Soya

Since the 1960s, the EU – especially the Netherlands – has imported soya on an increasing scale. Initially, this primarily concerned imports from the USA, later on especially imports from Brazil and Argentina. This mainly refers to soya meal,[72] which serves as an ingredient for animal feed due to its beneficial amino acid composition.

In 2012, the world production of soybeans amounted to 269 million tonnes. The largest producers are the USA and Brazil, each responsible for more than 80 million tonnes. Brazil has continued to grow steadily as a producer and exporter, while the production in the USA has declined (Figure 3). Soybeans are processed (crushed) to produce two main products, oil and soya meal. This processing takes place either in the country of origin or the country of export. The largest importer of whole soybeans is China (60 million tonnes in 2012); China and India are the largest importers of soybean oil (1.4 and 1.1 million tonnes, respectively); and the EU is the largest importer of soya meal (Figures 2 and 3). In 2012, the EU-27 imported 11 million tonnes of whole soybeans, 21 million tonnes of soya meal and 500,000 tonnes soybean oil.

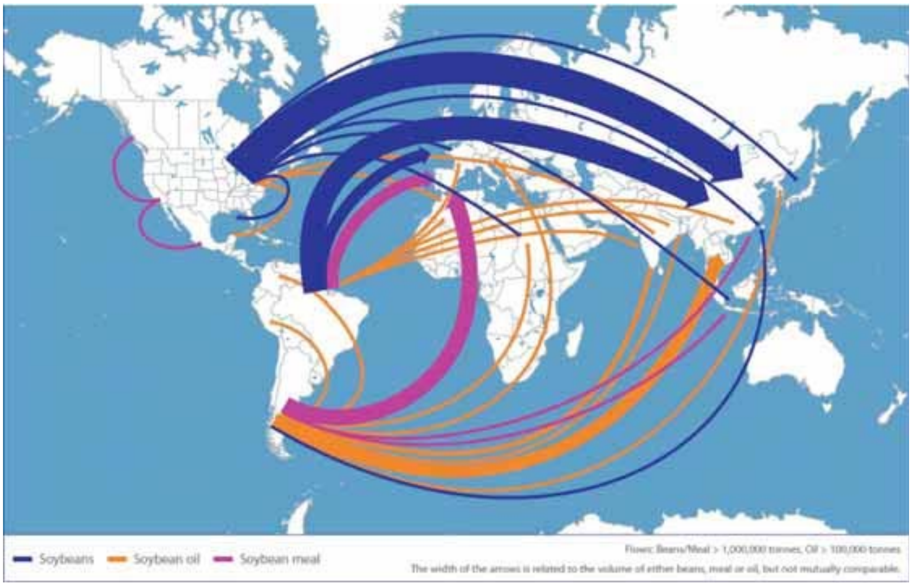

Figure 2 Global trade flows of soya products. Source: Rabobank Group (2010).

[72] Soya*meal* is the product that remains following extraction of soybean oil; it is a high-quality animal feed and is sometimes more valuable than the oil.

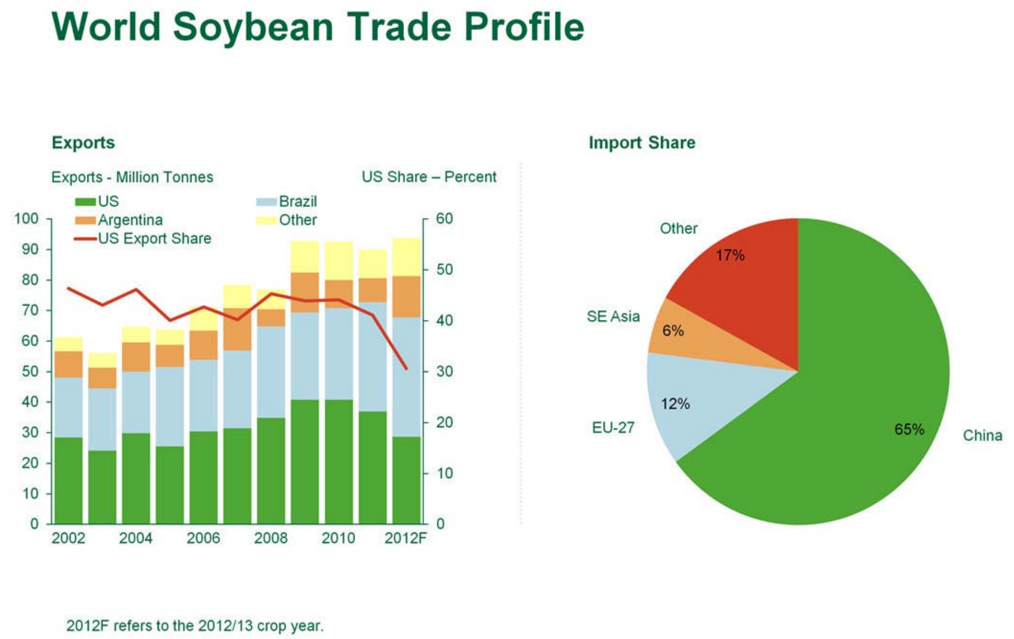

Figure 3 World trade in soybeans. Source: USDA.

Soya can be replaced by alternative protein sources, but due to its special amino acid composition, high demands are placed on substitutes. For example, meat-and-bone meal is highly suitable, but rapeseed meal is much less suitable. Missing amino acids can be supplemented, but that is expensive. A report from Wageningen UR compared oil seeds, legume seeds, alfalfa, grass, beet leaf, aquatic proteins (algae, seaweeds, duckweed), insects, oats and quinoa.[73] Products with high moisture content – such as alfalfa, foliage crops and aquatic proteins – have a low score for the time being due to the high energy costs for dehydration. Of the oilseeds, forage peas currently score the best, but over the longer term soya scores better. For that matter, soya is already grown on a limited scale in the EU, especially in Italy and Romania. In 2007 in Romania, 140,000 ha of soybeans were already being grown, but because this was a transgenic crop the country was forced to stop when it entered the EU. In the Danube region, soya could potentially be grown on 2.4 million hectares, in countries such as Croatia and Serbia.[74] This is equivalent to 2.4% of the current global soya acreage.

In principle, the production capacity for soya is enormous. Production can be increased by raising the production per hectare and/or by expanding the production area. However, various sustainability issues are involved, especially the loss (direct or indirect) of tropical rain forest and savannah (*Cerrado*), the position of farm workers,

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[73] In Dutch dairy farming, the farm network *Eigen eiwit eerst* [Grow your own protein] is experimenting with three methods to replace soya: summer barn feeding, cultivation of winter wheat and a grass mixture with red clover. And Wageningen UR is conducting research into small-scale refining of grass and maize. According to Prof. Johan Sanders "…Brazil is no longer needed as a feed supplier for Dutch livestock". *Boerderij Vandaag* 9-7-13. That is very optimistic when it comes to all the livestock in the country, but certainly appears to be feasible for dairy farming.

[74] Claim of the *Danube Soy Association*, which is setting up a soya production and processing chain. Remarkably enough, the World Wildlife Fund also belongs to this Association. *Boerderij Vandaag* 15-5-13

the use of genetically modified herbicide-tolerant soya, and health problems related to the herbicide glyphosate (used with the genetically modified variety – residues of this herbicide are sometimes found in the soya meal).

China devours more and more supply…..

One geopolitical risk in the context of the availability of soya is related to the rapidly increasing demand for soybeans from China. Today China is not only the largest importer by far (65%), but also the largest crusher in the world. As a result, the country is earning more and more on processing soybeans into oil and meal. This is even more the case because the crushers "play" with the price by repeatedly making orders and then cancelling them.

For that matter, imports negatively impact domestic Chinese production of soybeans. During the past four years, this production has fallen from 15.5 million tonnes to 12.6 million tonnes (USDA, 2013). One of the causes of this declining production is that China forbids the production of GM soya, but permits its import. Chinese growers, with the support of Solidaridad, are now going to export GM-free soya to the Netherlands. Another cause is the scarcity of land and water. Maize produces more food/feed per hectare with less water. China views its soya imports as imports of land and water.[75]

….with risks for the EU, the Netherlands and developing countries

In West European livestock production, especially the production in the Netherlands, imported soya holds a key position. Approximately 50% of pig feed consists of soya meal; and for poultry, this is almost 100%. And although cattle feed contains relatively less soya, in absolute terms it is still a very large quantity. For its own use in 2011, the Netherlands imported 3.3 million tonnes of soybeans, 5.4 million tonnes of soya meal and 0.08 million tonnes of soybean oil. Of total imports, 75% originated from Brazil and Argentina. The percentage of soybeans has declined because steadily fewer beans are being crushed in the Netherlands. Nevertheless, the Netherlands is still the world's second largest importer of soybeans (although far behind China). The imported soya products used in Dutch livestock production require more than 700,000 ha for their cultivation.[76]

In addition, Dutch ports play an important role in soya imports into Europe.[77] Of the 8.7 million tonnes of soya products imported into the Netherlands, 5.5 million tonnes (more than 63%) are transhipped to other European countries, especially Germany and Belgium. Moreover, animal products are an important Dutch export: approximately half of the production in the Netherlands is destined for export. As a result, a collapse of soya imports would have a greater impact on the Dutch economy than on other Western European countries.

The fact that most of the soya comes from only two countries and is destined for only a few countries makes the EU and the Netherlands especially vulnerable. Firstly, this applies to natural disasters in South America (such as plant diseases/insect infestations and long lasting droughts); secondly, it applies to geopolitical shifts. For example, Brazil wants to invest in its own dairy and meat sector, and can therefore start using

75 Source: interview with Denggao Liu – China Soybean Association.

76 Source: *Productschap MVO.*

77 *Kamervragen Grondstoffennotitie* [Government reply to parliamentary questions] 10 January 2012.

more of its own soya meal. Furthermore, it could start using the resulting manure (which contains phosphate) on its own farmlands, thereby reducing its phosphate imports (it is unknown whether this consideration is already playing a role). If this occurs gradually, the EU can make the required adaptations. The situation would be much different, however, if China faced a sudden surge in domestic meat prices. In that case, the government could give orders to purchase all available soya on the world market at “any” price. And if the EU has started to import GMO-free soya from China at that point, China could buy all this soya as well. This would cause a crisis in the intensive livestock-farming sector in Europe.

One of the responses that could be expected in the EU is restricting the exports of grain and increasing the imports. This could drive up the grain price on the world market, which would especially affect poor population groups in grain-importing countries. Such countries are located, for example, in North Africa and the Middle East, which have already been affected by political instability in recent years. This could be a severe social and political risk.

….and therefore risk management is needed

Dutch companies also refer to the collapse of soya imports as one of their most important operational risks.[78] As measures to *manage* the risks as much as possible, companies most frequently refer to: alliances with suppliers, spread purchasing and increasing their stocks.

In geopolitical terms, soya is an example of how sustainability is "used" as a means to limit the risk of supply collapse. The Round Table on Responsible Soy (RTRS) labels and simultaneously safeguards raw material flows.[79] Via the *Initiatief Duurzame Handel* (Sustainable Trade Initiative – IDH) the Dutch government – as part of a co-funding agreement with business – also invests public money in sustainability targets, which indirectly may help safeguard the long-term supply.

But this does not provide hard guarantees for continuity of supply. Therefore, several feed companies from the Netherlands and other countries in the EU are working on substituting imported soya with European-grown protein crops. Agrifirm has begun experimental soybean production and launched a company in Drenthe that focuses on soybean selection and breeding.[80] Another factor is the pressure exerted by NGOs, especially Friends of the Earth Netherlands and Greenpeace, which are critical of the RTRS because it does not exclude GM soya.

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78 Hugo Stam, CEO of Cefetra, wholesale trader in raw materials, on the feed, food and fuel sector: “Geopolitical considerations will determine a large component of raw material prices in the years to come. (…) A battle is taking place to safeguard food security for the population.” *Agrarische Grondstoffenmarkt*, ABN AMRO Agrarische Bedrijven, 2012. abnamro.nl/sectoragrarisch.

79 Companies such as Nutreco and Unilever explicitly refer to this as a motive to participate in the IDH.

80 The soya yield per hectare was immediately equivalent to average yields in the USA and South America. *NRC Handelsblad* 25-10-13. But the revenue of €1800 per ha cannot yet compete with that of wheat. *Boerderij Vandaag* 29-11-13. The experiment will be expanded to 200-300 ha. *Boerderij Vandaag* 22-11-13.

Conclusions on soya

1. The EU, and especially the Netherlands, are highly dependent on soya meal, most of which comes from two countries: Brazil and Argentina.
2. That makes the EU, and especially the Netherlands, vulnerable to natural disasters in South America and to geopolitics. The intensive livestock sector is the most vulnerable.
3. However, soya is replaceable. Initially, the EU could limit the damage by restricting grain exports and increasing grain imports. But this could increase grain prices on the world market and cause scarcity and political unrest in grain importing regions such as North Africa and the Middle East.
4. At the same time, the EU could gradually replace part of the grain production acreage with protein crops such as lupine, legumes and soybeans and by permitting the use of meat and bone meal in animal feed.[81] Due to both measures, the potential shocks could be muted within four years.[82] However, price shocks for meat and eggs will occur, and afterwards the prices would be structurally higher. After approximately 11 years, soya imports could even be replaced entirely by European protein crops, *without* expanding the current acreage for grain.[83] Due to the continuous productivity increase in grain production, every year a certain acreage becomes "available" for other crops.
5. These developments will be linked to a certain shift of the intensive livestock sector from the Netherlands to arable farming areas elsewhere in the EU. For that matter, such a shift could have advantages from the perspective of the environment (nitrate, ammonia and phosphate emissions), animal health (infection pressure) and consequently for risk management as well.
6. All in all, the dependence on soya imports is a serious risk to the EU in the short and medium term, but not for the long term. However, for livestock farming in the Netherlands, the situation is different.

The subsequent chapters show that with nutrient scarcity, it's the other way round: it is an important risk for the long term.

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[81] Depending on how strict the requirements are, meat-and-bone meal could replace between 4% and 11% of soya meal imports. Source: Platform Agriculture, Innovation and Society (2011). *The vulnerability of the European agriculture and food system for calamities and geopolitics – A stress test*, p. 76 (http://www.platformlis.nl/rapporten/StresstestEUagrfoodsystem.pdf). Recently, another protein source has come into the picture: potatoes. For decades, starch potatoes have been selected for higher starch content and lower protein content. Potato protein was often considered to be a waste product, which for many years was dumped into the Wadden Sea. But that protein can also be used for higher value applications in food and feed. www.dutchbiorefinerycluster.nl/nieuws/

[82] Stress test Platform LIS, p. 76.

[83] Stress test Platform LIS, p.78

5. Phosphate

Phosphate is an essential element for all life on earth. It is contained in all cells in DNA and in ATP, an important energy carrier. In animals, phosphate is also contained in enzymes that are involved in energy balance and in bones. Plants also need phosphate for photosynthesis, where sunlight is used to produce sugars. Lack of phosphate slows plant growth and leads to poor utilization of nitrogen and other nutrients.

Phosphorus is present in many compounds; the most important ones for agriculture are listed in Table 2.

Table 2 Phosphorus in agriculture-relevant compounds

Name	Chemical formula
Phosphorus	P
Phosphate	P_2O_5
Phosphoric acid	H_3PO_4
DAP = diammonium phosphate	$(NH_4)_2HPO_4$
Superphosphate	Chemical fertilizer with 17, 18 or 20% P_2O_5
White (= yellow) phosphorus	P_4
Struvite	$Mg(NH_4)PO_4.6(H_2O)$

In plant cultivation, phosphorus is often a limiting factor; therefore phosphate is a component of most types of chemical fertilizer. The increasing global demand for food, in particular animal products, creates an increasing demand for chemical fertilizer, including phosphate fertilizer. The increasing demand for biofuels is an additional factor. For the sake of brevity, we refer to a previous report of the Platform LIS.[84]

Uses

Approximately 90% of the phosphate ore that is extracted world-wide is used for chemical fertilizer production, and 6% as a feed additive. In industry, phosphate is used in products such as detergents, plasticizers, flame retardants and pesticides. In these products, phosphate is theoretically replaceable. In agriculture it is not, but it is recyclable from crop residues, manure, slaughterhouse waste (especially bones), food waste, wastewater and waste incineration.

Resources, reserves and depletion

Unlike nitrogen and carbon, phosphate does not have a natural cycle, at least not at the human timescale. It is a finite raw material, most of which was formed over 10 to 15 million years on the ocean floor by sediment from dead plants and animals.

84 Udo de Haes, H.A., J.L.A. Jansen, W.J. van der Weijden & A.L. Smit (2009) *Phosphate – from surplus to shortage.* Steering Committee for Technology Assessment.

Box 5 The phosphate yo-yo of the *U.S. Geological Survey*

There is great confusion about the magnitude of global phosphate reserves and about the number of years that reserves will be depleted. In 2010, the USGS estimated global reserves at 16,000 Mt of phosphate ore; in 2011 the estimate was suddenly raised to 65,000 Mt. At the same time, the USGS raised the estimated reserves in Iraq to a level higher than those in China and the USA combined. However, a year later it reduced this estimated reserves to almost zero. The increased estimate for Morocco was based partly on a publication of Van Kauwenberg, senior scientist at the International Fertilizer Development Center (IFDC), which revalued the reserves from 5,700 to 51,000 Mt. According to Van Kauwenbergh, the low USGS figures were not up to date.

Recently a thorough analysis of the background of these yo-yo estimates was published. The most important results:

- The increased estimates were based on one publication from one Moroccan researcher in 1988. In this publication, however, many resources were incorrectly classified as reserves.
- Moreover, the IFDC confused phosphate ore with concentrated phosphate. The USGS did not explicitly state whether it expressed the reserves in terms of phosphate ore (in which the phosphorus concentration can vary between 2% to 30%) or in concentrated phosphate as used in trade (with a phosphorus concentration of approximately 30%).
- The figures for Iraq were also based on upgrading resources to reserves. Nevertheless, the USGS referred to “discoveries”. However, a year later the discoveries were quietly reduced to almost zero.
- The IFDC simplified the USGS classifications of P occurrences from four categories to two. As a result, the figures for Morocco could not be compared with those for many other countries.
- The IFDC raised the global R/P ratio from 75 years to 300-400 years. This assumed a global annual production (P) of 160 Mt, although this had previously been raised in 2011 to 198 Mt. As a result of this change alone, the R/P ratio was overestimated by 24%. In the future, P will increase even more, and the R/P ratio can consequently decline even further.

Some of these criticisms had been voiced in 2010 by the *Global Phosphorus Research Initiative*, which also noted that the IFDC did not mention the market price on which the reserves were based. Rosemarin et al. (2011) stated that production and consumption were higher than assumed by the IFDC, and would probably rise much further.

All this criticism was somewhat embarrassing for the IFDC and the USGS. Apparently, their data does not provide a solid basis for policy.

Some of this criticism was refuted by Scholz & Wellmer (2013) in a somewhat jumbled paper. They correctly argued that the R/P ratio is not a good measure of the lifespan of phosphate reserves, since many deposits have poorly been explored. The USGS does not even publish the R/P ratio. In addition, they argued that the fluctuating USGS reserve figures are unstable because they depend on the personal judgments of experts in many countries. The USGS does not measure reserves directly, it only collects information. This argument confirms the limited usefulness of USGS figures for policy making.

Sources:

Van Kauwenbergh, S. (2010) *World Phosphate Rock Reserves and Resources.* International Fertilizer Development Center, Alabama.

Global Phosphorus Research Initiative. *GPRI Statement on Global Phosphorus Scarcity.* http://phosphorusfutures.net/files/GPRI_Statement_responseIFDC_final.pdf

Rosemarin, A., Schroder, J.J., Dagerskog, L., Cordell, D. & Smit, A.L. (2011) *Future supply of phosphorus in agriculture and the need to maximise efficiency of use and reuse*. In: Proceedings of the International Fertiliser Society – 685.

Edixhoven J. D., J. Gupta, & H. H. G. Savenije (2013) *Recent revisions of phosphate rock reserves and resources: reassuring or misleading? An in-depth literature review of global estimates of phosphate rock reserves and resources.* Earth Syst. Dynam. Discuss. 4: 1005-1034.

Scholz, R.W. & F-W Wellmer 2013. Earth Syst. Dynam. Discuss. 4, C574-C598.

Resources may be as high as 300 billion tonnes and are located in North Africa, the Middle East, China, the USA, Brazil, Canada, Russia, South Africa, Finland and some other regions. But there are also resources on continental shelves and in shallow sea floors in the Atlantic and Pacific. In some countries, reserves are rapidly becoming depleted.

Box 6 Peak Phosphorus

Long before the global reserves of a raw material become depleted, scarcity and price increases can occur. In 1949, King Hubbert coined the term Peak Oil, i.e. the year in which the supply of oil, as it becomes depleted, falls behind the demand. He calculated the years based on the national oil reserves, the moment of their depletion and the depletion rate.

In 2009, the Australian researcher Dana Cordell and colleagues presented an equivalent concept for phosphate: Peak Phosphorus. The calculation was based partly on figures for national reserves as reported by the USGS, and partly on the expected growth in demand as a result of population growth, changing diets, increasing use of biofuels, soil improvement and increasing agricultural efficiency. As a result, she predicted that peak phosphate would occur between 2030 in 2040, with 2033 as the most probable estimate.
In 2011, when the IFDC and in its wake the USGS, sharply increased the estimated reserves – especially for Morocco – these dates appeared to be obsolete. Peak phosphorus would have to be pushed far into the future. However, Rosemarin et al. (2011) stated that production and consumption were higher than assumed by the IFDC, and would probably rise even more rapidly. Due to population growth alone, the R/P ratio would decline from 300 to 400 years to 172 years. If Africa develops its agriculture, the ratio would decline further to 126 years; and if 10% of the global energy supply were supplied by biofuels, it would fall to 48 years.

Therefore, Neset and Cordell assumed that Peak Phosphorus could still occur in this century. A recent model study by Mohr & Evans (2013) in which the dynamics/flexibility of both supply and demand were included, provided 2090 as a best estimate for the year of peak phosphorus. But they emphasized – correctly – the large bandwidth that results from uncertainties.

Sources:
Cordell, D., J. Drangert & S. White (2009) *The story of phosphorus: Global food security and food for thought.* Global Environmental Change19: 292-305.
Mohr, S. & Evans, G. (2013). *Projections of Future Phosphorus Production.* PHILICA.COM Article number 380.
Neset, T-S. S. & D. Cordell (2012) *Global phosphorus scarcity: identifying synergy for a sustainable future*. J. Sci. Food Agric. 92: 2-6.
Rosemarin, A., Schroder, J.J., Dagerskog, L., Cordell, D. & Smit, A.L. (2011) *Future supply of phosphorus in agriculture and the need to maximise efficiency of use and reuse*. In: Proceedings of the International Fertiliser Society – 685.

In recent years, a debate has raged among experts about the question of whether we will reach Peak Phosphorus in this century, after which supply will remain permanently behind demand, resulting in rising prices for phosphate and food, and ultimately leading to food shortages. Early 2011, the USGS drastically increased its estimate of global phosphate reserves from 16 to 65 billion tonnes (based partly on a IFDC study); and in 2012 raised the estimate even further to 71 billion tonnes, 50 billion (70%) of which located in Morocco and the Western Sahara. Assuming an annual production of about 180 million tonnes, the R/P ratio was then estimated to be 370 years. But these figures,

especially those for Morocco and Iraq, resulted in extensive, well-founded and even somewhat embarrassing criticism. Some but not all of this criticism was refuted (Box 5).

Phosphate mining, similar to the mining of many mineral raw materials, has an intrinsic inertia: developing a new phosphate mine takes at least 10 years. Moreover, experience with various minerals has shown that the quality of the ore often declines over the years due to lower mineral concentrations in the ore and/or higher concentrations of contaminants. With phosphate, this primarily concerns heavy metals, especially cadmium and uranium. Cadmium is toxic for people and animals and is costly to remove from the ore. Uranium from chemical fertilizer is increasingly being found in groundwater and drinking water in Germany. The uranium standard is already exceeded in the drinking water of more than 1 million Germans.[85] The European Commission is preparing a Fertilizers Regulation, which includes agricultural and environmental criteria; it is intended to replace various types of national legislation on fertilizers and the trade in fertilizers.

Geography

Phosphate reserves are highly concentrated geographically in a small number of countries. According to the most recent figures of the USGS, Morocco (which also controls the Western Sahara) holds no less than 74% of the reserves, followed at a great distance by China (5%), Algeria (3%), Syria (2.5%), South Africa (2%), the USA (2%) and Russia (2%). However, the reliability of these estimates is questionable (see Box 5).

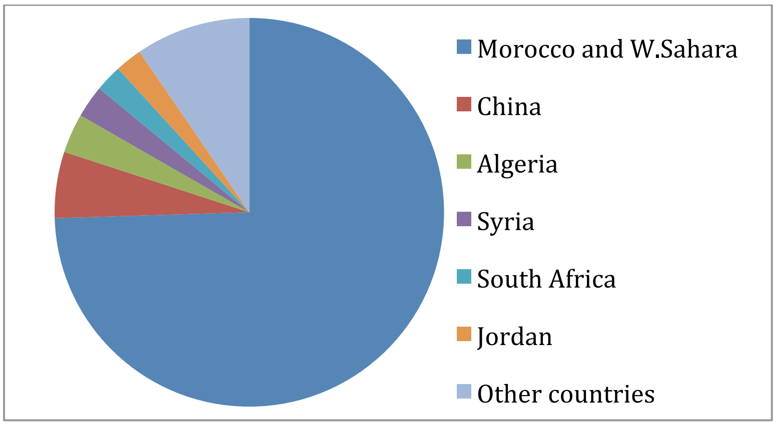

Figure 4 Distribution of global phosphate reserves. Source: USGS, 2013.

China holds a special position. As a producer of phosphate, after decades of intensive, partly excessive use of phosphate in agriculture, the country now faces accumulation in agricultural soils. In the Netherlands as well, agricultural soils have accumulated significant stocks of phosphate as a result of excessive application of animal manure from intensive livestock farming. This also applies to some other farm acreage in the EU.

Of great importance is the fact that the quality of the reserves differs greatly. Phosphate in igneous rocks, as mined in Russia, contains little cadmium, whereas phosphate from sedimentary rock often contains higher or excessive levels of cadmium. The majority of

85 http://umweltinstitut.org/radioaktivitat/messungen/uran-im-dunger-981.html

the reserves, including those in Morocco, consist of sedimentary rock, the contamination of which can be seen as a global environmental and food safety problem.

Price development and supply concentration

The phosphate price on the world market is kept high by a *de facto* duopoly between the legal export association PhosChem (consisting of the Canadian companies PotashCorp and Agrium and the American company Mosaic) and the Moroccan state-owned company *Office Chérifien des Phosphates* (OCP), which control 52% and 36% of the market, respectively, hence as much as 88% combined. In 2007/2008, when food prices rose, the phosphate price rose sharply. And when China – to protect its own agriculture and food supply – subsequently imposed a 135% export duty on phosphate, the price even peaked at 800% of the previous level.[86] Under pressure from the WTO, the export duty was quickly withdrawn, after which the price fell rapidly, to again rise gradually (Figure 5).[87] It is possible that the duopoly again controlled the price. The steepness of the price fluctuations can be caused in part by well-capitalized speculators.

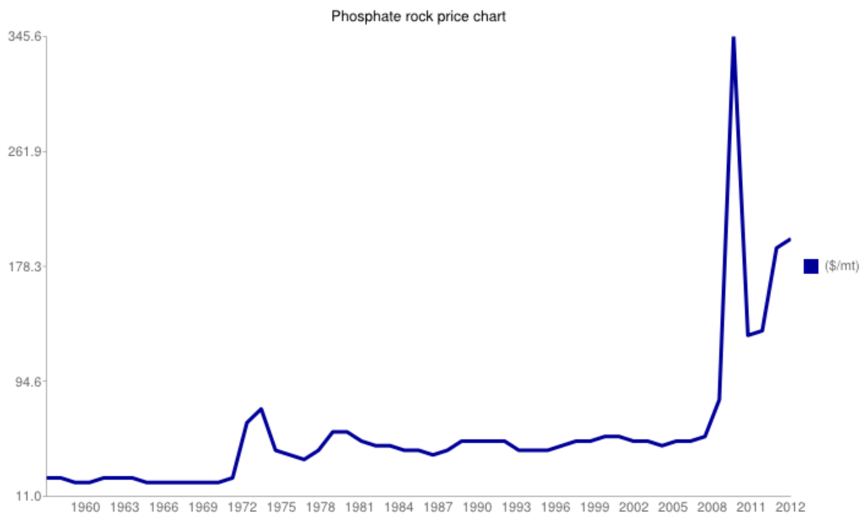

Figure 5 Price development of phosphate ore on the world market. Source: mongabay.com.

For many years, phosphate ore was relatively cheap. Since the prices have risen to a structurally higher level, mining and exploration have been given a new impulse, and the reserves have increased. Furthermore, reserves that are more difficult to extract in countries such as Mali, Saudi Arabia, Kazakhstan and Australia have come more into the picture. Not only are large privately owned mining companies involved, for example companies from Canada and New Zealand, but also state-owned companies such as the Saudi Ma'aden.

86 For that matter, the prices were largely "virtual" because trade had come to an almost complete halt.

87 China had also imposed export restrictions on aluminium, copper, chrome, iron, magnesium, manganese, molybdenum and nickel. Currently, China still maintains an export duty of 110% for part of the year to prevent internal prices from rising too quickly.

Geopolitics

Given their geostrategic position, how do countries and companies deal with phosphate?

Many countries holding reserves still limit themselves to the mining and export of raw phosphate ore, while others have devoted themselves to processing phosphate ore into phosphoric acid or still further into higher value products, such as phosphate fertilizer. One example is Israel Chemicals Ltd (ICL), a privatized company, in which the state of Israel still holds a "golden share" with veto rights. For decades, ICL – operating in the Netherlands and other countries – has produced phosphate fertilizer based on phosphate ore from the Negev desert. Such forward integration is becoming increasingly important for many countries and companies.

The Moroccan state-owned company OCP also supplies raw material to the West European feed industry, but this has already been processed into phosphoric acid – the required chemical form for this industrial application. This trade channel may be small, but for the phosphate suppliers it is still interesting because it pays higher prices. During the production of this phosphoric acid, large amounts of contaminated gypsum are released; this is why phosphoric acid production has virtually disappeared from Europe. Until recently, phosphoric acid was produced – from pure phosphorus – by Thermphos in Vlissingen in the Netherlands.

Morocco is an awakening superpower on the phosphate market, and the investment plans of OCP are ambitious, although legal and humanitarian issues continue to be a problem due to the occupation of the Western Sahara. The domestic instability in several phosphate-rich countries also entails uncertainties. Until now, the Arab spring has largely bypassed Morocco. But in Tunisia, the unrest was accompanied by a sharp decline in exports. And in Syria, the unrest starting in March 2011 became a full-scale civil war that goes on today.[88]

China is the largest producer of phosphate and by 2006 had developed from a net importer to a net exporter of phosphate fertilizer. However, since then exports have declined sharply, partly due to the increasing supply on the world market, but especially due to government policy to restrict exports of this commodity. Another aspect is that China has closed many phosphate mines due to illegal practices and accidents, including landslides. China has labelled phosphate as its third most important natural resource.[89] China has once again become a net importer, and that will probably continue, assuming we can base predictions on the most recent USGS figures in which China's share in phosphate reserves (5.5%) is much smaller than its share of consumption (39%). This high level of consumption will continue to put the phosphate market under pressure.[90] In

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88 Morocco and other countries in North Africa and the Middle East are faced with water scarcity. Phosphate mining and processing requires a great deal of water, and therefore competes with agriculture for water. Although freshwater can be extracted from seawater, this requires much energy. Consequently, there are four mutually competing resources: raw materials, water, energy and food. Due to such competing claims, phosphate mining can become an additional source of social and political unrest in the region.

89 HCSS (2012) p. 44.

90 HCSS (2012). However, China also takes account of the export interest of its fertilizer industry. In December 2012, the export duty was again reduced to support this industry. http://eshare.cnchemicals.com/publishing/home/2013/02/05/133/china-loosens-export-of-phosphate-

contrast, the Saudi phosphate producer Ma'aden, with exports of approximately 1.5 million tonnes of DAP (diammonium phosphate), continues to operate far below its capacity.

Import dependence
The EU, India, Japan and Brazil rely almost entirely on imports of phosphate ore for their phosphate supply. India is the world's largest importer of phosphate products, primarily from Morocco. Most other countries in Asia, Latin America and Africa are also dependent on phosphate imports. In the long term, this also applies to the USA, which according to the USGS possesses only 2% of global phosphate reserves. Consequently, the USA restricts phosphate exports. Some phosphate importing countries still produce much phosphate *fertilizer*, but exporting countries are taking over a larger part of the chain. For example, Morocco's OCP announced that it is going to double its production of phosphate ore and simultaneously triple its production of phosphate fertilizer

Many importing countries with the required financial possibilities are busy with long-term safeguards. Exploration is taking place in 17 countries,[91] especially by Australian and Canadian companies.[92] For example, New Zealand recently began offshore mining of phosphate ore up to 400 m deep. One of the partners in this project is the Dutch company BosKalis. Other wealthy and emerging countries (India and Brazil) as well are attempting to safeguard their supply, which can threaten the market access of poorer countries. Many developing countries depend on aid programmes, for example from the IFDC, which was founded in 1974 and has roots in the fertilizer industry and devotes itself to improving seed, chemical fertilizer and pesticides.

Of all regions, the EU has the greatest imbalance between import and production. In the EU, only Finland possesses notable reserves (23 million t), but this is less than 0.5% of the global total. Estonia still has unexploited reserves. In addition, phosphorus is still obtained as a by-product of the steel industry during the purification of iron ore from France and Luxembourg.[93] In 2010, the Platform LIS therefore suggested that the self-sufficiency of the EU is an illusion in the long-term. And in 2013, the HCSS suggested:

> "… European food security and the agricultural sector, for which phosphate is an essential resource, are at risk."[94]

An additional complication in this regard is the contamination of phosphate ore referred to previously. Phosphate ores from Russia, Finland and Syria are relatively clean, but exports from Syria have been halted, and reserves in Russia and Finland are limited. As

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fertilizer.html. The policy is therefore erratic, but it is difficult to say whether China merely exploits the price movements on the world market or whether it also tries to influence these movements. For that matter, the EU implements a somewhat comparable policy on the grain market. When the internal grain prices are deemed too high, the Commission attempts to bring them down by imposing temporary export duties or expanding the import quota for specific countries. These measures push prices down.

91 HCSS (2012).
92 HCSS (2013), p. 62.
93 HCSS (2012).
94 HCSS (2013).

a result, the EU will have to turn more often to cadmium and uranium contaminated phosphate ore, phosphoric acid and phosphate fertilizer from Morocco.

Recycling

In the past, phosphate from food was often returned to the land with municipal waste, and re-entered the cycle. As cities grew and chemical fertilizer came onto the market, that land-based system was replaced by a water-based system. In that system, phosphate largely ends up in surface water, and ultimately on the seafloor, where it can no longer be recycled. In this way, we have moved from a more or less circular system to a linear system, "from mine to mouth". Phosphate is lost at every step in the chain: mining, processing, chemical fertilizer production, spreading on the land, harvest, food production, food consumption and waste processing. Of the total quantity of phosphate that is mined world-wide, only an estimated 12% to 20% ends up in food.[95]

These losses can be limited. In the EU, that is possible only in the final links of the chain. We can also recover that part of the phosphate that we consume, excrete and dispose of via wastewater or waste incineration. In this way, we could partly close the phosphate cycle. In many countries, relatively small-scale initiatives are ongoing to recover phosphate from human urine, including initiatives in South Africa, China, Vietnam, Mexico, Scandinavia, Germany and the Netherlands.

On paper, recycling from wastewater has great potential. In the EU, 40% of wastewater is currently used without purification in agriculture (which is forbidden in the Netherlands and other countries). Wageningen researchers have calculated that if the EU were to recycle all phosphate from this source, it could replace approximately 34% of its phosphate imports.[96] Of course, in that case purification would be required before application.

This makes the fate of Thermphos in Vlissingen even more painful. That company – together with *Slibverwerking Noord Brabant* (sludge treatment plant) – had developed a technology to recycle phosphorus from waste flows, in this case from the ash of incinerated sewage sludge. But at the end of 2012, the company went bankrupt. One of the causes was the company's need for capital in order to comply with environmental and safety requirements. The company had exceeded the environmental standards for heavy metals and dioxins, and was required to remediate the factory complex that had been contaminated with uranium. Another cause was the dumping of cheap phosphorus from Kazakhstan. This is remarkable because from 2003 to 2010, Thermphos had participated in a joint venture with Kazphosphate LL.[97] In those years, Kazphosphate seized the opportunity to transfer much expertise about the production process to its home country.

As stated previously, phosphate in industry is replaceable, but that only concerns 4% of total consumption, so it would have little impact.

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95 These figures do not include wasted food. Source: M.A. Sutton et al. 2013. *Our Nutrient World: The challenge to produce more food and energy with less pollution.* www.unep.org

96 A. Rosemarin et al. (2010), cited in HCSS (2013).

97 In 2010 the Kazakhstan share in Thermphos was purchased by an Italian-Israeli investment company.

Box 7 Thermphos vs Kazakhstan and Germany

In 2011, at the request of Thermphos, the European Commission considered initiating an anti-dumping procedure against imports of white phosphorus from Kazakhstan. However, under pressure from Germany, the Commission halted the procedure.

According to EU legislation, before anti-dumping measures can be implemented, at least three conditions have to be met:
- Damage must be ascertained.
- There must be a causal connection between damage and dumping.
- The implementation of anti-dumping measures must not be in conflict with the general interest of the European Union.

The Commission acknowledged that the dumping by Kazakhstan had a demonstrably negative effect on industry. It also acknowledged that a European white phosphorus producing industry could contribute to the raw material security of the EU. But antidumping measures could actually harm the interests of phosphorus-*using* industries. According to Commissioner de Gucht, "The termination of this study was based on the assessment of the negative effects of possible rights on the users of white phosphorus and on a thorough investigation during which the standpoints of all stakeholders were taken into account. Under these conditions, it was ascertained that it is clearly not in the interests of the European Union to impose antidumping measures, and in accordance with legal provisions, no antidumping measures will be imposed."

The Commission gave greater weight to the interests of the phosphorus-using industry than the interests of the phosphorus-producing industry. The commission added that the future of Thermphos was uncertain, even if antidumping measures would be imposed. That is not illogical reasoning, but what is lacking in the justification is the long-term environmental and strategic interest of a European recycling industry. For Germany as well, that apparently did not have sufficient impact.

Sources:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:043:0038:0058:EN:PDF
http://www.publicserviceeurope.com/article/2547/germany-dismisses-eu-partners-in-favour-of-kazakhstan#ixzz29Hhc9CzH

In summary, for the EU phosphate is not extremely critical in terms of recyclability. But it remains unclear how long global reserves will last and when a supply peak will be reached. And phosphate is extremely critical anyway in terms of geographical concentration, geopolitics and substitutability.

Phosphate in the Netherlands

With respect to phosphate, the Netherlands holds an unusual position:

1. Our country imports most (59%) of the phosphate in organic form: as soya for animal feed. The share of inorganic phosphate (chemical fertilizer, feed additives) is only 35%. Relatively speaking, our phosphate supply is therefore highly dependent on soya imports, with all their associated risks.

2. Phosphate is also *used* primarily in organic form: animal manure. This concerns no less than 90% of phosphate use. [98]

[98] CBS Statline: In 2012, the total phosphate production in manure in the Netherlands was 165 million

3. European environmental regulations are increasingly limiting the use of phosphate; in the near future, this will even be limited to balanced fertilization (input =output). Since the early 1980s, phosphate use has declined by 47% due to low-phosphate animal feed, reduced use of phosphate fertilizer and reduced phosphate in detergents.

4. In the soil, in particular on maize fields on higher sandy soils, which are the most heavily fertilized, a large quantity of phosphate has accumulated: an estimated 1.9 million tonnes. This phosphate is largely immobile, bound to iron, but utilization appears possible in at least two ways: a) planting crops with specific root fungi (mycorrhizae)[99] and b) temporarily flooding the parcel, after which the phosphate dissolves and can be taken up by algae or duckweed *(Azolla)*.[100] The Netherlands could consider leaving this phosphate temporarily in the soil as a strategic reserve. It would be enough for at least 10 years of phosphate use.[101]

5. The Netherlands has pioneered phosphate recycling and is the first country that wants to close the phosphate cycle.[102] This is logical considering the high densities of both people and livestock, which result in enormous volumes of surplus manure and phosphate, sewage sludge and residues from waste incineration. Recycling phosphate from pig manure was initiated by Ecoson, a subsidiary of Vion Ingredients.[103] With sewage sludge, extensive progress in phosphate recycling has already been made. Several years ago, agreements were made about phosphate recycling in the *Ketenakkoord Fosfaatkringloop* [Chain Agreement on the Phosphate Cycle] – which is a so-called Green Deal. This agreement attracted international interest, also from China and the USA.[104] Phosphates from incinerated sludge, including that from *Slibverwerking Noord Brabant*, are shipped, among other destinations, to ICL Fertilizer in Amsterdam. An Amsterdam wastewater purification plant is also going to supply struvite to ICL. By 2020, ICL wants to operate entirely on recycled phosphate for its production of phosphate fertilizer. This company is therefore of strategic importance for the Netherlands, but is vulnerable for price fluctuations of phosphate and potassium. The *Waterschap* [Water Board] *Vallei en Veluwe* prepares to convert the wastewater treatment plant. Apeldoorn into an energy production and fertilizer plant.

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kg. This was not used entirely on farmland in the Netherlands. There was also import, export and processing, but that concerns only a small fraction. Via chemical fertilizers, 7 million kg P = 7*2,29 = 16 million kg phosphate was used. Rounded off: 90% of the phosphate in the Netherlands was used via animal manure.

99 Prof. em. P.J.C. Kuiper in a letter published in *NRC Handelsblad* 1-12-12.

100 *NRC Handelsblad* 20-2-13.

101 http://www.kennisakker.nl/kenniscentrum/document/benutten-van-de-fosfaatvoorraad-akkerbouwgronden. Agricultural soils in the Netherlands contain between 1.5 to 15 tonnes of phosphate per hectare. Depending on the crop, during cultivation 40-100 kg P2O5/ha is withdrawn from the soil. That is enough for at least 10 years. But withdrawal of phosphate from the soil is not always a simple task. In 2012 a study was launched into possibilities to better utilize phosphate reserves in the soil: http://www.wageningenur.nl/nl/show/Zonder-fosfaat-geen-voedsel.htm

102 Since 2007, commercial recovery has also taken place in Japan, the USA and Canada.

103 In October 2013, Vion sold Vion Ingredients to the American company Darling International.

104 *Nieuwsbrief Nutrient Platform* - July 2013 www.nutrientplatform.org

6. Potassium

Potassium is one of the macronutrients that are essential for the life; it is present in all cells of all plants and animals. In animals, potassium also plays a role in the cellular electrochemical balance as part of the cell membranes and impulse conduction system in nerves. In plants, it is also essential for the uptake of water by the cells.

Uses, reserves, depletion and geography
Due to its high reactivity, potassium occurs in nature only in the form of salts. More than 90% of mined potassium is used for fertilizers in the form of potassium oxide, potassium sulphate, potassium nitrate or potassium chloride. Industrial uses primarily involve chemical applications, for example as a base in acid-base reactions. Potassium carbonate is an important catalyst in charcoal and is used for the production of glass. Potassium nitrate is frequently used in the manufacture of soap and glass, but also in explosives and in products such as matches.

The USGS estimates the R/P ratio at 288 years. Since 1900, the price of potassium has been relatively constant, apart from an extreme peak during World War I (Figure 7). However, the graph shows that prices started to rise after 2000, with a small peak in 2008, but in 2012 they fell again

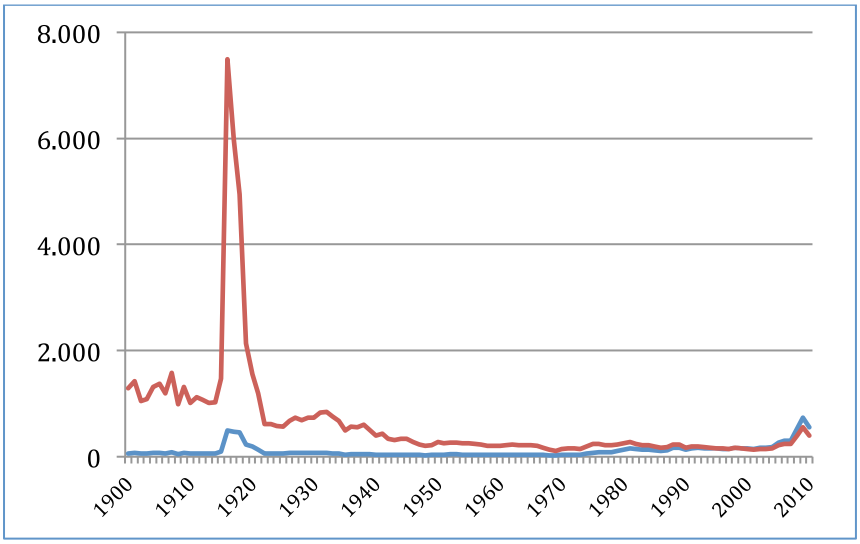

Figure 6 Potassium prices between 1900 and 2010 (dollars/tonne) (USMarkets.nl).

Current prices **Constant prices (1998)**

The global reserves of potassium are nearly as concentrated geographically as those of phosphate. Between 75% and 80% of the reserves are located in only two countries: Canada and Russia. Other potassium sources are located in Belarus, Brazil and several other countries. Although China also has potassium reserves, the country is a net importer of this nutrient.

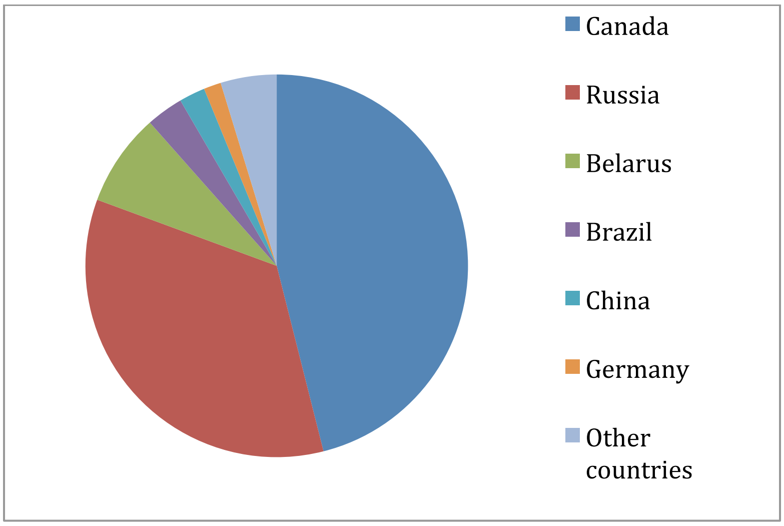

Figure 7 Distribution of global potassium reserves. Source: USGS, 2013.

Import dependence, supply concentration and geopolitics
The biggest concerns about the availability of potassium have to do with the market structure. The production and consumption of potassium are widely separated geographically. This sometimes results in some countries being very dependent on others, which is the case for the EU, China and especially India.

Mining companies and Canada, Russia and Belarus dominate the supply and until recently were able to largely determine the market price. In 2012, 80% of the market was controlled by only six companies: Uralkali, PotashCorp, Belaruskali, Mosaic, ICL and the European market leader K+S (Table 3).[105] Moreover, PotashCorp, Mosaic and Agrium are members of legal export associations in Canada (Canpotex) and the USA (the Phosphate Chemicals Export Association– PhosChem – which also trades in phosphate). For many years, until 1 August 2013, the Belarusian company Belaruskali and the Russian companies Uralkali and Silvinit formed the export cartel BPC. Together, these two cartels formed a global duopoly that controlled no less than 93% of the export market (Boxes 3 and 8).

The potassium sector has a strong tendency towards consolidation. For example, the Canadian potassium giant PotashCorp has attempted for years to take over its Israeli rival ICL. The Israeli government has used its "golden share" – with veto rights – in ICL (which also trades in phosphate) to protect the domestic phosphate reserves.

After the food crisis of 2007/2008, and the subsequent high prices for fertilizer, plans were made to expand production capacity in various countries, including Canada, Argentina, Belarus Brazil, the Congo and the UK. However, due to the price cuts by Uralkali, these plans were called into question. The share prices for PotashCorp, Mosaic and K+S collapsed, but because several large producers cut their production, the price

[105] *Boerderij Vandaag* 7-11-12.

decline for potassium has remained limited so far. Nevertheless, the price war threatens the independent existence of the European K+S[106] and the Israeli ICL.

Table 3 Most important countries and companies in potassium production.

Most important countries	**Important companies**	**Type of company**	**Annual production (million tonnes KCl)***
Canada	PotashCorp	Privately owned	13
	Mosaic, located in the USA	Privately owned	11
	Agrium Inc	Privately owned	2
Russia	Uralkali, until 1-8-2013 member of export cartel with Belaruskali	Privately owned	12.5
Belarus	Belaruskali	State-owned	10
Germany	K + S	Privately owned	6
Most important countries	**Important companies**	**Type of company**	**Annual production (million tonnes KCl)***
Israel	ICL group	Privately owned, but state has veto rights	7
Australia	BHP Billiton Group	Privately owned	
UK	Rio Tinto plc	Privately owned	

* Source: http://www.potashcorp.com/overview/upload/introduction/overview/01-OV_Worlds-10-Largest-Fertilizer-Companies.jpg – update June 2013

ICL fears a flood of cheap potassium and claimed:

> “It is has become a political question. Do we want to retain production in Europe for strategic reasons?” [107]

Relevant for the present report is that an eventual closure of the Dutch branch of ICL, following the bankruptcy of Thermphos, would mean a second setback for the recently launched phosphate-recycling programme.

For that matter, the Eastern European cartel did not collapse only as a result of global overproduction, but also due to *power play* of two giants on the demand side. India and China have both established strategic potassium stockpiles, not only to safeguard their supply, but also to compel lower prices on the market. This proved successful in January 2014, when Uralkali agreed to supply potassium to China at a price that was 24% lower than before it pulled out of the cartel. However, this strategy will have less effect if production remains behind demand and there is a shift from a buyers’ market to

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[106] On 6 November, Moody’s lowered the credit rating of K+S to “junk” status. *Boerderij Vandaag* 7-11-13. A week later, K+S announced cost-cutting measures of €500 million, where layoffs were not excluded. As an explanation, the company referred to a price decline in the third quarter from $400 to $300 per tonne of potassium and “remarkable uncertainty about future sales volumes and prices”. *Boerderij Vandaag* 15-11-13.

[107] *Boerderij Vandaag* 1-8-13.

a sellers' market. The global demand for potassium is growing by approximately 4% per year. In particular, Chinese imports have risen in recent years, but so have Indian and South American imports. In China, the increased prices for crops that need large amounts of potassium, such as fruit, vegetables and grain, play a role, and in South America the expansion of farmland has also increased the demand for potassium.

Box 8 The Eastern European potassium cartel

For several years, the privatized Russian potassium companies Uralkali and Silvinit – which merged in 2011 – were part of a cartel with the Belarusian state-owned company Belaruskali. The main stakeholder of Uralkali was the Russian billionaire Suleiman Kerimov. In 2011 he made an attempt to acquire a majority stake in Belaruskali, which would create the world's largest potash company. However, he found the price too high.
On July 29 2013, a fascinating poker play started. Uralkali left the cartel arguing it was unhappy that Belaruskali sold potassium to China at low prices outside the cartel. It announced price cuts and increased production. This was an attempt to increase its market share and market power as well as to gain access to major contracts with China. An additional reason for the price cuts may have been that Kerimov was attempting to push the price of Belaruskali stocks down.

The Belarusian government expected that it would experience a loss of 1 billion dollars. To enable Belaruskali to continue being competitive, the company was given a tax exemption. Furthermore, the government made a bizarre attempt to restore the cartel. The prime minister invited the CEO of Uralkali, Vladislav Baumgertner, to Minsk for a discussion. When the CEO refused to cooperate, he was arrested at the airport for alleged misuse of power in public office. In retaliation, Russia halted pork imports.
In November, Belarus extradited Baumgertner to Russia on the condition that he would not return to his position as CEO. Another condition was that Kerimov would give up his 21.75% stake in Uralkali. In December, the billionaire investor Prokhorov purchased Kerimov's stake plus an additional 5.34% stake. Another billionaire, the Belarus-born Mazepin, bought a 20% stake, bringing their combined stake to 47%. Baumgertner was replaced by a director of Uralchem, which is owned by Mazepin. This increased the likelihood that the cartel will be restored.

However, countervailing forces are at work. A Chinese state investment company has also purchased a stake in Uralkali, presumably to ensure supply at competitive prices. In addition, the Russian company Eurochem has reported that it wants to increase potassium production over the next 10 years from zero to 8 million tonnes, approximately half of the current production of Uralkali. Meanwhile, in Chicago a lawsuit has been filed against PotashCorp and Uralkali for manipulating the import prices of potassium, but this appears to have been superseded for Uralkali. On balance, the future of the Eastern European cartel is hard to predict. In January 2014, a major contract was signed with China at a price 24% below the previous cartel prices. So if the cartel is restored, it will probably charge lower prices.

Sources: http://rbth.ru/business/2013/08/01/worlds_largest_potash_fertilizer_cartel_dissolves_28579.html
NRC Handelsblad 29-8-13.
Boerderij Vandaag 10-9-13 en 25-10-13.
http://en.ria.ru/business/20131224/185870481/Uralkali-Replaces-Baumgertner-as-CEO.html
http://en.ria.ru/business/20131220/185770446/Onexim-Mazepin-Funds-Complete-47-Uralkali-Stake-Deal-.html
https://www.google.nl/#q=Uralkali+china+potash

Moreover, India is entirely reliant on imports to supply its growing need for potassium. Indian Potash Limited – a large public-private company – imports approximately 60% of domestic demand, while privately owned companies import the remainder.
For potassium, the EU is less dependent on imports than for phosphate, at least for the time being. Potassium mining takes place in Germany by the German company K+S, which has processing facilities in several European countries. It is the sixth largest producer in the world. However in the long term, the picture in the EU is less positive. Germany, Spain and the UK together hold 182,000 tonnes of potassium reserves – only 2% of the global reserves. Consequently, it is logical that K+S also wants to start mining potassium in Canada. In any case, it is clear that the EU will become increasingly dependent on third countries. And this is an even greater political risk, because state-related companies play an important role in this market: on the supply side, these are companies in Belarus and to a certain extent in Russia, and on the supply side, these are companies in China and India.

For the sake of completeness, we can report an interesting initiative of the British company Sirius Minerals in Yorkshire: mining of polyhalite. This is a mineral that, in addition to potassium, contains three other nutrients: sulphur, magnesium and calcium. For this purpose, Sirius has signed a supply contract with the Chinese company Yunnan TCT Yong Zhe.[108] But this tends to reduce the raw material security of the EU rather than increase it, because the products will probably be sold to China.

Substitution and recycling
For many purposes (salts) potassium can be replaced by sodium and other elements. Possibilities for recycling are also available, but these have technical and financial hurdles.[109] Because most potassium salts are soluble in water, recovery is difficult. Membrane technology is one option, but is very costly. Similar to phosphate, struvite technology is also available for potassium, but that process is difficult to control and requires the use of costly chemicals. In any case, it is important to keep potassium as concentrated as possible. This can be done for example by separate collection of urine, of both people and animals (barn design). But for the time being, potassium recovery is financially uninteresting, and is being done almost nowhere. In the Netherlands, experiments are ongoing,[110] but unlike phosphate and nitrogen, a clear stimulus in environmental policy is lacking: there are no environmental standards for potassium leaching and run-off. And the recent price decline for potassium does not promote recycling either.

In summary, for the EU potassium is not extremely critical in terms of global depletion, but it is critical in terms of geographical concentration, geopolitics and possibilities for substitution and recycling. This would appear to be sufficient justification for the EU to make itself less dependent on imports.

108 *Boerderij Vandaag* 3-7-13.
109 Source: dr.*ir* Jan Weijma, LeAF.
110 For example, potato starch industry Avebe has a patent on potassium recovery from wet waste streams.

7. Micronutrients, general

The prefix "micro" means that micronutrients are needed in very small amounts, but this does not make them any less essential than other nutrients. There are two basic types of micronutrients: organic micronutrients (such as vitamins) and mineral micronutrients (such as zinc and selenium). The present report is limited to the mineral micronutrients.[111] They enable plants and/or animals and people to make enzymes, hormones and other growth substances. Table 4 contains a list of these essential nutrients.[112] For plants, animals and humans, the following micronutrients are essential: zinc, copper, iron, manganese, molybdenum and boron.[113] Specifically for humans and animals: chlorine, silicon, sodium, iodine, cobalt and selenium.

Table 4 Essential nutrients for crops, and for humans and livestock, ranked according to concentrations in crops.

Nutrient	Crop [1)]	Humans/ livestock [2)]	Nutrient	Crop	Humans/ livestock
Nitrogen	+	+	Chlorine	±	+
Potassium	+	+	Silicon	±	+
Calcium	+	+	Sodium	±	+
Sulphur	+	+	Iodine	-	+
Magnesium	+	+	Nickel	±	(+)
Phosphorus	+	+	Chrome	-	+
Manganese	+	+	Cobalt	±	+
Iron	+	+	Selenium	±	+
Zinc	+	+			
Boron	+	+[3)]			
Copper	+	+			
Molybdenum	+	+			

1) + essential; - nonessential; ± necessity not demonstrated, but assumed to be beneficial
2) + essential; - nonessential; (+) necessity not demonstrated, but not excluded
3) Acknowledged as essential for humans and poultry only around 1980.

For the present report, the following aspects are of primary importance: the magnitude

111 There is some overlap: the essential component of vitamin B12 is cobalt. For that matter, vitamin K has nothing to do with the chemical symbol (K) for potassium.

112 Sources: Nubé, M. & R.L. Voortman, *Simultaneously addressing micronutrient deficiencies in soils, crops, animal and human nutrition: opportunities for higher yields and better health*. Centre for World Food Studies, Amsterdam, 2006. For boron with humans and livestock: M.M. van Krimpen et al. (2103). *Behoefte en verbruik van micronutriënten in de diervoeding*. [Need for and use of micronutrients in animal nutrition] Wageningen.

113 For plants such as soya, which can bind nitrogen from the air in symbiosis with rhizobia bacteria, *vanadium* is also essential. For that trace element, the USGS has estimated an R/P ratio of only 22 years, and the reserves are strongly concentrated in China (35%), Russia (35%) and South Africa (25%). But according to Chardon & Oenema (2013), this mineral is abundant in most agricultural soils, so no scarcity is expected. So there seem to be more risks for industry than for agriculture. We will not address vanadium any further in this report.

of mineral reserves in proportion to the annual production (R/P) and the geographical concentration of these reserves. Manganese, chlorine, silicon, sodium and iodine are abundantly available on the earth and are therefore not relevant to the present report. In contrast, the R/P ratios of zinc, iron, molybdenum, copper, selenium and boron are less than 50 years (thus substantially shorter than the ratios for phosphate and potassium).[114] The reserves of copper and iron are widely distributed in geographic terms, and therefore scarcely a risk from the perspective of geopolitics; moreover, iron is abundantly present in agricultural soils. Therefore, these micronutrients will not be addressed either. The remaining micronutrients are zinc, selenium, molybdenum and boron. These will be addressed in more detail in the present report.

Table 5 Four mineral micronutrients and their characteristics.*

	Zinc	Selenium	Molybdenum	Boron
Reserve (R) in 1,000 t	250,000	98	11,000	210,000
Production (P) in 1000 t/y	13,000	2	250	4,600
R/P in years	19	49	44	46
% R in EU	3%	0%? **	0%	0%
Share in production of marketable product	China 31%	Germany + Japan 64%	USA + China 63%	Turkey 50%
Uses	Metal products for automotive industry, construction and chemistry. Galvanization, alloys, bronze	Electrolytic manganese, glass, plastic, electronics, ceramics, photovoltaic cells etc.	61% in iron, steel and superalloys	Glass, ceramics, fertilizers, cleaning products, soap, ferro boron
By-product	Yes	Yes	Often, not always	No
Recycling rate	>50%	< 1%	25-50%	< 1%
Substitution	In galvanizing, by aluminium and plastics	By silicon, cerium, tellurium and other elements	By chromium, boron, cadmium, neodymium, nickel, tantalum and other elements	Partly possible, with sodium, potassium, phosphate, cellulose and other substances
% consumption in agriculture incl. livestock farming	<1%	10%	<1%	12%

* Sources: the most recent update of the *USGS Minerals Commodities Database*, *Recycling Rates of Metals – A Status Report*, UNEP (2011) en Chardon & Oenema (2013).

** The EU holds 5% of the global copper reserves, but we were unable to find corresponding data for selenium.

[114] According to the most recent USGS figures, cobalt (with a ratio of 68 years) is not far above these other micronutrients. The reserves of this mineral are strongly concentrated in the Congo (45%), followed by Australia (16%). Smaller reserves are located in countries such as Cuba, New Caledonia, Zambia, Russia and Canada. Europe is hardly mentioned. And more than 50% of production takes place in the Congo. This substance is therefore included in the European list of raw materials critical for industry. We will not address the substance any further in this report.

Many complex interactions with nutrients take place in the soil and in plants and in animals, for example, between phosphate and iron, phosphate and zinc, calcium and zinc, and between zinc and copper. For these – often crucial – interactions, we refer for the sake of brevity to Bussink (2012), Voortman (2012) and Van Krimpen (2013).

Deficiencies of micronutrients in the soil occur on large areas of farmland, but are rare in the Netherlands. This is the result of decades of fertilization (partly over-fertilization) with animal manure. But now that over-fertilization has been greatly reduced under pressure from environmental policy, soil nutrient deficiencies are becoming more frequent. One mechanism that plays a role in this process is the following: if less nitrate is available to plants, their uptake of zinc, copper, iron, silicon and selenium also declines. As a result, farmers should start using fertilizer enriched with micronutrients.[115]

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115 *BLGG: tekort nutriënten in bodem neemt toe.*[BLGG: soil nutrient deficiencies on the rise] *Boerderij Vandaag* 14-11-13.

8. Zinc

Zinc is an essential micronutrient for both plants and animals. It plays a role in approximately 200 enzymes and in other proteins that have a function in metabolism, including synthesis of proteins, DNA and RNA. Zinc deficiency results in discolouration of the foliage and growth abnormalities, such as a drastic reduction in leaf area and necrosis of upper foliage. This leads to lower production or even to plant death. With livestock, deficiency symptoms include skin disorders, immune suppression and growth retardation.

Uses
Of the annual production of metallic zinc (12 million tonnes), 99% is used by industry and less than 1% in agriculture. Zinc has many industrial applications. It is primarily used for galvanizing, in metal products for the automotive industry, construction and chemistry, and in alloys such as bronze and brass. Other applications include automobile tyres, batteries and pigments in paints.

In agriculture, zinc *oxide* is added to fertilizer to compensate for potential zinc deficiencies in the soil and/or poor availability due to the composition of the soil. Zinc oxide is also used in composite animal feeds and mineral pre-mixes (customized feed supplements). In human nutrition, zinc is often used as a supplement, although in very small quantities

Deficiencies
Zinc deficiency in food is a major problem world-wide. It occurs on vast areas of farmland, including land in the demographic giants China and India, the agricultural giant Brazil and Africa (Figure 8).

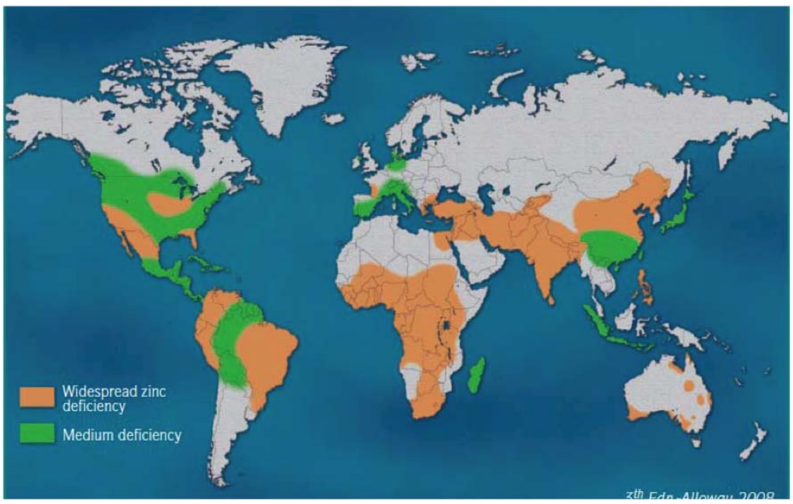

Figure 8 Zinc deficiency in the soil world-wide. Source: Alloway, 2008.

Zinc deficiency in the soil leads to deficiency diseases in humans, especially in large parts of Asia, Africa and South America. Approximately one-third of the world population is at risk for zinc deficiency. World-wide, approximately 800,000 people die every year from the consequences of zinc deficiency, which is comparable to the mortality from malaria.

Causes of zinc deficiency in the soil include:

- naturally low levels of zinc in the soil (from the parent material of the earth);
- specific soil conditions, such as organic soils or water-saturated soils (characteristic of rice cultivation).

The sense of urgency to do something about zinc deficiency in food and soil is increasing rapidly. In Turkey, spectacular yield increases have been realized in arable farming through fertilization with zinc. In Africa, programmes have been initiated to supplement food with zinc. Since 2012, the Chinese Ministry of agriculture has advised including zinc in the national fertilization recommendations. In China, as many as 400,000 agricultural extension agents provide these recommendations.

Assuming that 50% of the arable farmland in China has a zinc deficiency, then implementation of these recommendations would lead to approximately 300,000 tonnes of added zinc consumption per year. India and Brazil have comparable plans, with 100,000 and 60,000 tonnes of added zinc consumption per year, respectively. Transposed to the global level: assuming that half of the farmland world-wide is deficient in zinc, and that a one-time application of 10 kg zinc per hectare is required, then there would be a one-time need for 25 million tonnes of zinc. This is equivalent to two times the current annual production of zinc. Assuming further that an annual application of 0.15 kg zinc per ha is needed to maintain a crop yield of 5 tonnes per ha per year, then 750,000 tonnes of zinc per year would be required; this would amount to 6% of current world production. In comparison: only 1% is now used in agriculture. Such suppletions could force the prices of zinc sharply upwards. Even more important is the question of how long zinc reserves will last.

Geography, reserves and depletion

The USGS estimates global resources of zinc at 1.9 billion tonnes, of which approximately 250 million tonnes are reserves. The annual production is about 12 million tonnes, which means that the R/P ratio is only 19 years![116]

But that is perhaps less alarming than it appears. After all, zinc reserves can remain stable due to new exploration and mining. In 1994, the first year for which the USGS provides data, the zinc reserve was only 20 years. Since then, that figure has remained more or less constant because new resources are continuously moved to the domain of recoverable reserves.

The price of zinc is rather erratic. During World War I, there was an extreme price peak, but the price also peaked during the commodities boom in 2007-2008 (Figure 10). This indicates temporary scarcity – or speculation on scarcity.

[116] Assuming a very optimistic case that consumption will not increase and that all known resources can be converted into reserves, then the R/P ratio would still be only 144 years.

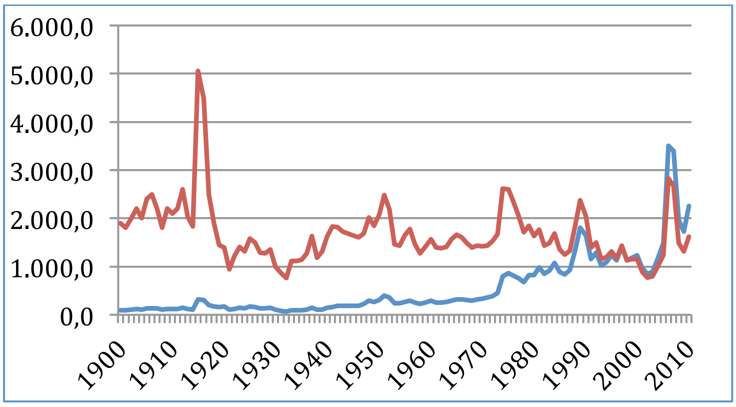

Figure 10 The price of zinc between 1900 and 2010 (euros/tonne). (USMarkets.nl)

Current prices **Constant prices (1998)**

Zinc is mined in more than 50 countries, so it is widely distributed across the world. The most important countries are Australia and China (Figure 9). Zinc mining is primarily in the hands of Canadian and Australian companies.

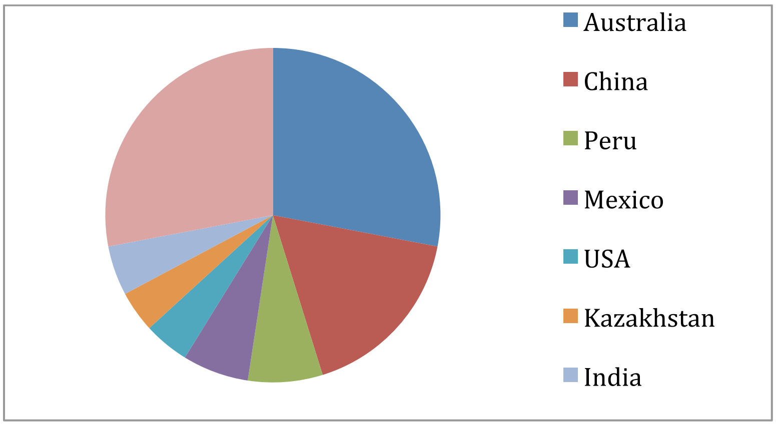

Figure 9 Distribution of global zinc reserves. Source: USGS (2013).

The demand for zinc is growing most rapidly in Brazil, China and India. At the same time, new mines are being opened in countries such as China, India, Mexico and Russia. The short-term expectation is that production will expand even faster than consumption, partly due to slower economic growth. This could result in falling prices.

Price increases have occurred previously with zinc *oxides*, 95% of which originate from secondary sources (recycling and scrap: pre-consumer waste from the zinc/galvanizing industry). Buyers compete fiercely for zinc oxides. North American buyers for the fertilizer industry scour this market. If the price increases substantially, this could damage food production both quantitatively and qualitatively, especially in countries where farmers have little purchasing power.

Import dependence, supply concentration and geopolitics

The EU has zinc mines in countries such as Sweden, Spain, Portugal and Ireland. Europe is responsible for almost one-third of global consumption, but has only 3% of

the global reserves. As a result, import dependence is bound to increase. However, the geopolitical vulnerability is less, due to the wide geographical spread of the reserves.

Zinc mining and production is dominated by a handful of Western companies: Glencore, Nyrstar and Xstrata, followed by the Vedanta subsidiary Hindustan Zinc Ltd (in which the Indian state holds a minority stake) and several Chinese state-owned companies. In 2013, Glencore took over Xstrata, thus increasing its market share. Consequently, there is certainly a risk of market manipulation by both state-related and privately owned companies.

Recycling and substitution

Recycling of zinc is possible with many uses. Of the total amount of zinc consumed, approximately 50% originates from recycling, and this proportion is expected to increase to 80%. The competition for secondary zinc is certainly a strong impulse for recycling. Moreover, for most industrial applications, especially galvanizing, substitutes are available such as aluminium and plastics. This tempers the urgency of the alarmingly short R/P ratio of 19 years.

In summary, zinc is a critical nutrient for the EU with respect to import dependence, but is less critical in terms of geographical concentration, geopolitics and possibilities for recycling and substitution. It is unclear how quickly the reserves will become depleted.

9. Selenium

Selenium has various biological functions. It is a cofactor for several enzymes and supports the immune system. Selenium deficiency, depending on the animal species, can lead to problems such as breakdown of muscles (including the heart muscle), liver disorders, skin damage, oedema and impairment of growth, fertility and resistance to infection.

Uses

World-wide, 90% of selenium is used in industry and 10% in the food chain. As a result, selenium – together with boron – is the only micronutrient for which the food chain uses a significant proportion of total consumption.

The most important industrial applications are in the metal and glass industries. Addition of selenium can provide a red colour to glass, and can also compensate for possible discolouration due to contamination with other substances. In China it is used for electrolysis to produce manganese. Moreover, due to its photovoltaic properties (transformation of light into electricity), selenium has electronic applications in photocopy machines, solar cells and other devices.

In the food chain, selenium is used primarily in feed and as a nutritional supplement, but is sometimes added to chemical fertilizer. In the feed industry, selenium has only been used for several decades (since the emergence of intensive livestock farming).

Deficiency

Selenium deficiency in soil has come into the picture fairly recently. This deficiency is widespread and is present in China, Russia and New Zealand, among other countries. In China, selenium-poor regions – not coincidentally – have relatively sparse populations.

In Europe, Finland has a low selenium concentration in the soil. As a result, Finns have a low selenium concentration in their blood, approximately the lowest in the world. In 1984 the government decided to add selenium to chemical fertilizer. In 1990, it was determined that the concentration in the food chain had risen to such an extent that selenium supplementation could be limited to 10 mg per kg of fertilizer.[117] The uptake by livestock also increased.

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[117] http://www.fertilizer.org/ifa/HomePage/Case-studies/Selenium-in-Finland. In the Netherlands, the addition of selenium to fertilizers was also considered, but the Netherlands Food and Consumer Product Safety Authority (NVWA) discouraged this suppletion because no selenium deficiencies occur in the Netherlands, high doses can be harmful and it is forbidden to add any substances to the soil that could accumulate. NVWA (2012) *Advies over het toevoegen van selenium aan mest*. The fact that selenium deficiencies in the Netherlands are rare is logical considering the intensive application of animal manure on farmland.

Since the health effects of selenium have become more well-known, its use in chemical fertilizer, feed and nutritional supplements has increased. This can happen only as long as the reserves are adequate.

Geography, reserves and depletion

Selenium is extracted from the mud that is a by-product of copper refining, and to a lesser extent of nickel, gold, lead and zinc refining.[118] The supply therefore depends on the demand for copper. In copper ore, selenium is present in an average proportion of 1 to 650.

The USGS estimates global selenium reserves at only 98,000 tonnes. It estimates annual selenium production at approximately 2,000 tonnes. As a result, the R/P ratio is 49 years. Generally speaking, the market for selenium is tight, and is under constant pressure due to the wide-ranging applications. In recent years, prices have been extremely volatile, with a very high peak at the end of 2011 of more than 154 dollars per kg (Figure 12). This suggested scarcity – or speculation on scarcity.

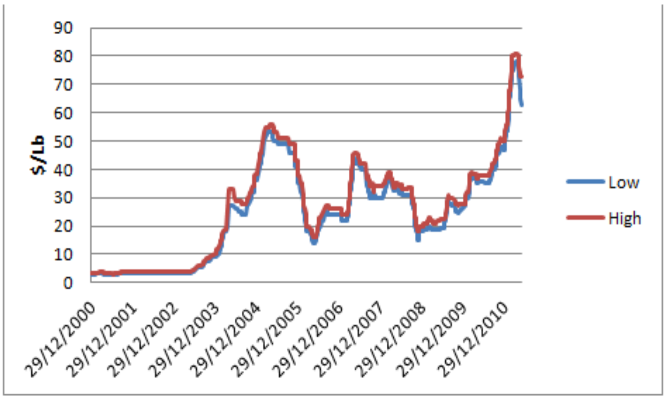

Figure 12 Price of selenium 2000-2012. Low and high indicate the margins of the trend prices. Source: Minor Metals Trade Association.

Approximately 75% of the reserves are concentrated in five countries: Chile (25%), Russia (20%), Peru (13%), the USA (10%) and Canada (6%) (Figure 11).

[118] Selenium can also be extracted from coal, but that process is currently not economically feasible.

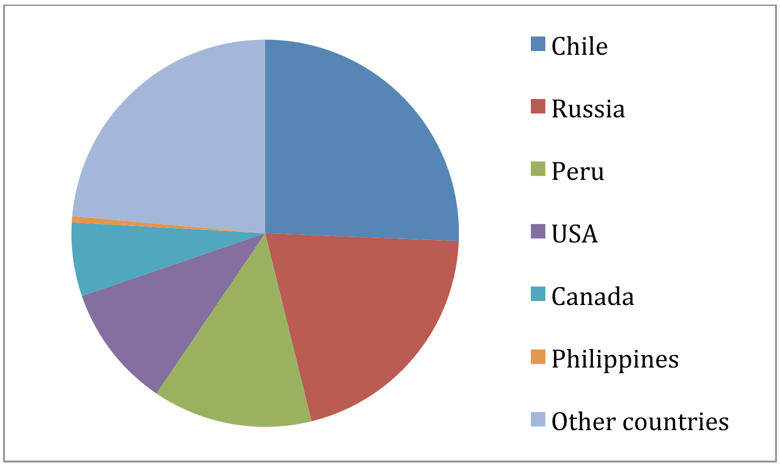

Figure 11 Distribution of global selenium reserves. Source: USGS (2013).

The future availability of selenium depends on many factors, some of which are conflicting. For example, it is unlikely that it will soon be possible to extract selenium separately from copper processing. Although copper production is expected to increase in the coming decades – among other things due to the transition to wind and solar energy – this does not necessarily mean that proportionally more selenium will also become available.

Chinese industry is the biggest user by far, and is responsible for 40%-50% of the consumption of extracted selenium. Nevertheless, selenium is scarcely used in China as a feed supplement. Although the demand from China for the electrolytic production of manganese is expected to decline, the use of selenium in the production of glass will increase world-wide. And if the demand from the Chinese and Indian feed industry also begins to increase, the competition for selenium between industrial applications and applications in food chains would increase world-wide. This could be even more problematic because the feed sector is not a minor user of selenium.

In Germany, this tension has been a point of concern for some time. The demand for selenium from the feed industry is still modest, and the profit margins for selenium producers are relatively small. But the legal standards for selenium in feed are much higher than those for other uses. Considering these requirements, the German feed industry is actually paying too little for selenium. If the demand for selenium increases, competition will increase and profit margins will also increase.

Import dependence, supply concentration and geopolitics

According to the USGS, the EU has virtually no selenium reserves. The EU does have approximately 5% of world copper reserves, but we were unable to find reliable information on the selenium concentration of these reserves.

Most of the *production* capacity for selenium is still located in Japan, Germany and Belgium (together 75%). In Europe, the German company Retorte (in Nuremberg) is market leader. But a shift to the countries where mining takes place – and these are primarily countries with large copper reserves such as Chile, Peru and Russia – seems to be a matter of time. As a result, import dependence will increase greatly. And the EU

will also encounter more geopolitical risks, although – due to the geographical spread – these risks are lower than those associated with phosphate and potassium.

Recycling and substitution
Selenium is scarcely recycled, due to the low concentrations in which it is present in products. But the Umicore company in Antwerp has started urban mining: recovery of selenium from urban waste

For substitution, various possibilities are available in industry, but some substitutes, such as cerium and tellurium, have an even lower R/P ratio than selenium itself.[119]

In summary, selenium is not extremely critical for the EU with respect to geopolitical risks, but it is critical in terms of tight global reserves, the unpredictable possibilities for extracting the mineral, import dependence and the limited possibilities for recycling and substitution. In agriculture, the risk is limited to livestock farming. The Netherlands, with its relatively large livestock sector, is particularly vulnerable.

[119] W.J. Chardon & O. Oenema, *Verkenning mogelijke schaarste aan micronutriënten in het voedselsysteem* [Exploration of possible micronutrient scarcity in the food system], Wageningen, 2013. In the report, the selenium substitutes in Table 9 do not correspond with the text, in which iron is not mentioned.

10. Molybdenum

Molybdenum is an essential nutrient for both plants and animals. In plants, it plays a role in the transmission of electrons, especially in nitrogen metabolism. It plays an additional role in leguminous plants and several other groups of plants, which can bind nitrogen from the air in symbiosis with Rhizobium bacteria in the soil. These plants include soya, lupine, peas and beans. Along with iron, molybdenum is a building block of the enzyme nitrogenase, which converts atmospheric nitrogen into ammonia. For animals and people, molybdenum is also an essential trace element for the functioning of the nervous system and the kidneys. In addition, it plays a role in energy production at the cell level.

Deficiencies occur in acidic, iron-rich soils. Molybdenum deficiency in sheep can lead to renal calculi and with goats and chickens to fertility problems and embryo mortality. However, because humans and animals need only very small amounts of molybdenum, and the element is present in many types of food, deficiencies occur only sporadically.

Uses
World-wide, 99% of molybdenum is used in industry and less than 1% in agriculture. It is one of the few metals that are highly resistant to heating and wear. Therefore, it is also an important component of green technology. It makes the steel in vehicles lighter, stronger, safer and more energy-efficient. It also allows oil to be processed at a higher temperature, leading to reduced CO_2 emission. Molybdate is included in fertilizer formulations, especially for the production of leguminous plants. In the Netherlands, no fertilization recommendations are made for molybdenum. For most livestock species, no molybdenum standards have been established, and to our knowledge it is never added to feed.

Reserves and geography
Molybdenum reserves are found primarily in North and South America and Asia. The most important ore is molybdenite, with concentrations of molybdenum ranging between 0.01% and 0.25%. The ore is extracted at two different types of mines: primary mines and by-product mines. The latter are usually copper/molybdenum mines, which are located primarily in North and South America. African copper mines generate little molybdenum as a by-product.

According to the USGS, global molybdenum reserves are estimated at 10 million tonnes. World production totals 260,000 tonnes. Ergo: the R/P ratio is only 44 years. Moreover, 82% of the reserves are geographically concentrated in only three countries: China (43%), the USA (27%) and Chile (12%).

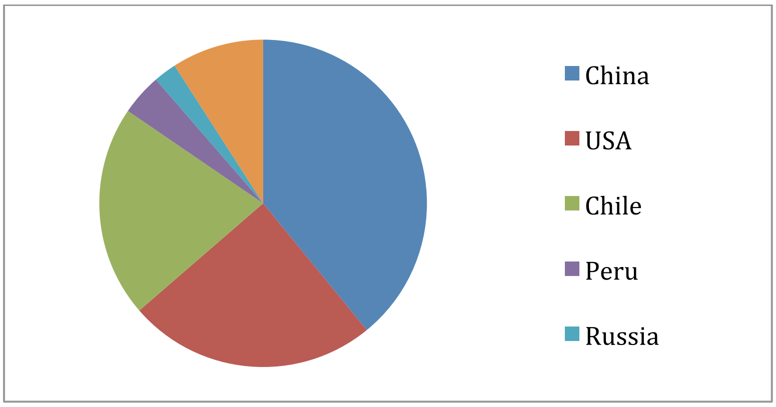

Figure 13 Distribution of global molybdenum reserves. Source: USGS (2013).

Between 1940 and 1970, the price of molybdenum remained fairly constant (Figure 14), but then the price peaked in 1979 and again between 2007 and 2009. The price increase in 1979 was caused by a greatly increased need for heat and rust-resistant steel for the oil industry, which felt compelled by the Iranian revolution to accelerate oil exploration and production. Shortly thereafter, the price fell just as quickly. This was a result of the economic crisis that began in 1980 and of the replacement of molybdenum by the cheaper metal vanadium. In 2007, prices rose sharply again after the demand from the Chinese steel industry increased rapidly and China imposed export restrictions on molybdenum. All these price fluctuations were probably amplified by speculation. Because molybdenum, like selenium, is primarily obtained as a by-product of copper, the price is also affected by the demand for copper.

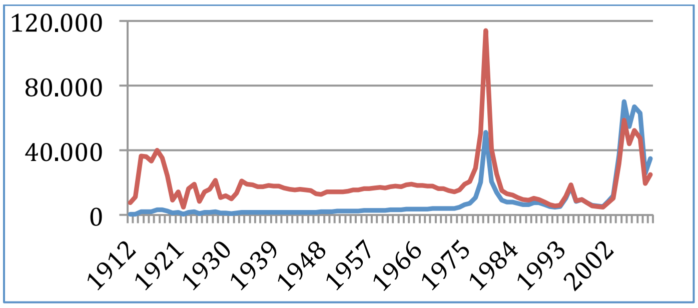

Figure 14 Price development of molybdenum from 1912 to 2010 (euros/tonne) (USMarkets.nl)

Current prices Constant prices (1998)

Import dependence, supply concentration and geopolitics
Molybdenum is not only concentrated geographically, but the market is also concentrated. The five largest companies, often active in copper mining, produce together nearly 50% of the molybdenum. Two of these companies are state-owned. However, the number of players on the molybdenum market is increasing because primary mining is increasing more rapidly than by-product mining.

Table 6 Important countries and companies in the molybdenum sector. Source: Bastein, TNO.

Most important countries	Important companies	Type of company	Production	Remarks
China	China Molybdenum Co., also known as Luoyang Luanchuan Molybdenum Co.	State-owned	Approximately 33,000 t of molybdenum and about 30,000 t FeMo (2011)	Export quota of 40,862 t in 2012
USA	Freeport-McMoran Copper & Gold Inc. (FCX)	Privately owned		
	Thompson Creek Metals Company Inc.	Privately owned		
Chile	Corporación Nacional del Cobre de Chile (Codelco)	State-owned	23,000 t molybdenum in 2011	
	Antofagasta plc (VK)	Privately owned		
UK	Rio Tinto plc	Privately owned	Also operates in the USA	

Unlike selenium and other micronutrients, the production of molybdenum takes place in essentially the same countries in which the reserves are located. China is not only the largest producer but also the largest consumer, although the Chinese figures are not very transparent. China imposes export restrictions to safeguard its reserves and support its domestic buyers. The use of molybdenum as a tool for political pressure is not excluded.

Due to the rapid growth of green technology, during the next few years the demand for molybdenum is more likely to increase than decrease.

The EU has no molybdenum reserves and produces no molybdenum, and is therefore entirely dependent on the world market. This explains why the EU filed a complaint with the WTO in 2012 about the Chinese export restrictions. This complaint was supported by a previous WTO ruling against China, which concerned zinc and yellow phosphate, among other minerals.

Recycling and substitution

Molybdenum is recycled on a small scale: occasionally in pure form from scrap, more often in alloys. In the USA, 30% of the molybdenum alloys used originate from recycling. Possibilities for substitution are also available, but many of these are minerals that could quickly become scarce themselves, especially boron, cadmium, neodymium, nickel and tantalum.

In summary, molybdenum is not a critical nutrient for the EU in terms of recyclability, but it is critical in terms of global reserves, import dependence, geographical concentration, geopolitics and possibilities for substitution.

11. Boron

Boron is an essential trace element for plants, animals and humans. In plants, it plays a role in cell wall strength and the energy supply. Moreover, boron deficiency reduces the efficiency of phosphate utilization. In beetroot, boron deficiency results in internal brown rot and in maize in smaller ears. Other crops are also susceptible to boron deficiencies: cauliflower, chicory, potatoes, tulips, peas, pear and apple.

Boron was acknowledged as an essential trace element for humans and poultry only around 1980. It probably plays a role in the functioning of cell membranes. Boron deficiency in livestock is rare. No dietary standards are known, and to the best of our knowledge boron is never added to animal feed or fish feed.

Uses
World-wide, 12% of boron is used in agriculture and 88% in industry.
Boron is used in industry for the production of ceramics, alloys and glass, among other products. For a metal, it is remarkably light, and is therefore used in aircraft. Furthermore, boron has a range of useful chemical properties and is used in magnets and as a catalyst. In agriculture, it is used in the form of boronic acid (BO), and corresponding salts, as a fertilizer supplement. In the form of boric acid (H_3BO_3), it is also used as an insecticide.

Deficiencies
Boron is a relatively rare element in the earth's crust. Boron shortages occur in farm soils on every continent, resulting in loss of yield and quality. Supplementary boron fertilization is then required. The recommended application rate for boron deficient soils can be as high as 1.5 kg boron per hectare per year.

It is generally assumed that soils with high levels of organic matter contain sufficient boron. In the Netherlands, boron deficiency occurs primarily on sandy soils with low organic matter content. Deficiency is increased by a reduction in organic matter, declining use of organic fertilizers and increasing precipitation intensity.

Geography, reserves and depletion
The annual world-wide production of boron is approximately 4.6 million tonnes, and the USGS estimates the R/P ratio at 46 years. Since 1910, the inflation-corrected price development has been relatively stable, and even after 2007 there was no peak (Figure 16). As yet, there appears to be no question of scarcity.

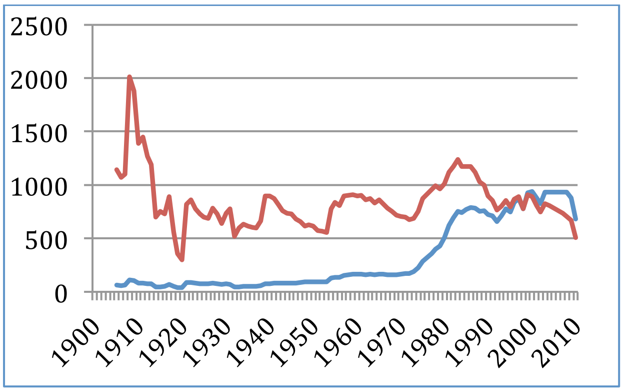

Figure 15 Price development of boron from 1900 to 2010 (euros/tonne)

Current prices Constant prices (1998)

According to expectations, the world-wide growth of agriculture and industry will lead to a rapid increase in the demand for boron. In agriculture, the increasing use of fertilizer in China and America is especially important.

Boron does not occur in the earth's crust in pure form, but in the form of borates. These are naturally occurring minerals that contain boron. The reserves are estimated at 210 million tonnes and occur in three zones:

- the Mojave Desert in the Southwest of the United States, with US Borax as the most important producer;
- the south-central Asian mountain zone that runs from Turkey to Kazakhstan, and from Northeast Russia to the adjacent region in China;
- the South American Andes zone.

More than 95% of the reserves are found in only five countries: Turkey (29%), the USA (19%), Russia (19%), Chile (17%) and China (15%). These figures will in reality be somewhat lower, since Bolivia and Kazakhstan also have reserves of unknown magnitude.

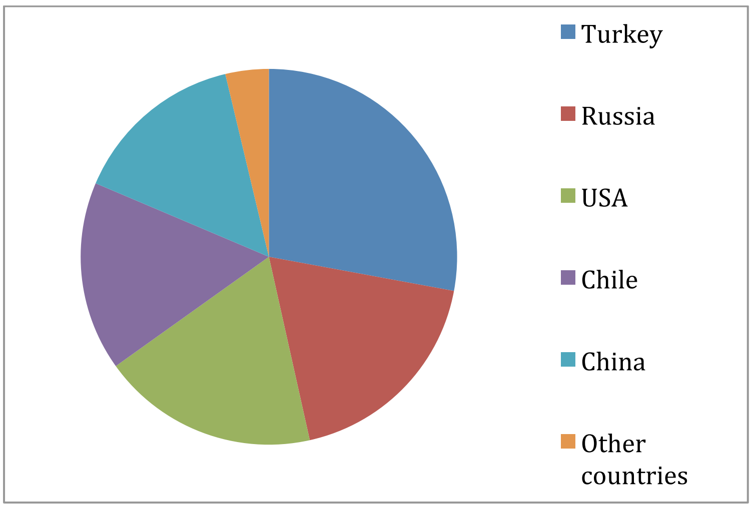

Figure 16 Distribution of global boron reserves. Source: USGS, 2013.

Table 7 Most important countries and companies in boron production. Source: Bastein, TNO.

Most important countries	Important companies	Type of company	Remarks
Turkey	Eti Maden AS	State-owned	
USA	Rio Tinto Borax Inc.	Privately owned	The British/Australian multinational Rio Tinto Minerals is a major global player, and also owns boron mines in Argentina
	Searles Valley Minerals, Inc. (SVM)	Privately owned	

Turkey and the USA are the leading producers of boron. If we disregard the figures from the USA (which are unknown due to confidentiality of two companies), then 54% of the global production takes place in Turkey. This is followed by Argentina, Chile, Russia, and Peru – of which only Russia and Chile hold large reserves. China also holds large reserves, but these are generally low-grade and therefore production is small. It is expected that in the years to come China will increase its imports from Chile, Russia, Turkey and the USA.

Import dependence, supply concentration and geopolitics

The EU has virtually no boron reserves. Import dependence is increasing due to the growing production of fibreglass, which in turn is caused by the increased insulation requirements in the construction sector. Increased use of boron is driven by increased quality demands in glass production. Boron needed for chemical fertilizers is supplied by the above-mentioned Turkish-Finnish joint venture.

Turkey could become a geopolitical risk. The country is the largest exporter of boron and – according to the USGS (2013) – holds 29% of global boron reserves. The state-owned company also has ambitions to increase production (Box 9). With this position, the country appears to be capable of manipulating the market for economic and/or political purposes. Whereas sustained market manipulation appears to be unlikely with a share of only 29%, Turkey could make market agreements with countries such as Russia or China. For that matter, Turkish sources such as the National Boron Research Institute, basing their predictions on proven *plus probable* reserves, arrive at a figure of 72%. In that case, over the long term Turkey could acquire a dominant position on the boron market comparable to that of Morocco on the phosphate market.

Box 9 Boron and Turkey

According to the USGS (2013), Turkey holds 29% of global boron reserves and is the largest exporter. Production is in the hands of a state-owned company. Production is concentrated in the Western part of the country, and mining activities have taken place since 1935 under the auspices of *Eti Mine Works G.M*. That company produces a wide range of boron products, including fertilizers, borax and sodium tetraborate.
In 1982, Eti and the Finnish mining group *Outokumpu* formed a joint venture, *Ab Etiproducts Oy*, to sell the products on the Scandinavian market. Since then, due to expansions and takeovers, the market for the products has not only expanded to Western Europe, but also to Central and Eastern Europe and the Caucasus region.
Turkey is fully aware of the geopolitical importance of its large boron reserves. Until 1978, exploitation was still in the hands of foreign companies, but following the nationalization, all mining rights were transferred to the Etibank. In 1999, the IMF tried to compel Turkey to privatize the boron mines, but that attempt was blocked by the resistance of political parties, trade unions, NGOs and others.
The Turkish nationalist politician Mustafa Gecer stated recently in a column:
"Boron reserves will exhaust upon procession. (….) We must protect our boron. Even when the mines would close without ever being processed, the boron mines would take the second place as strategic resource after nuclear minerals such as uranium in the future. 60 years later the boron resources in other countries will become exhausted and Turkey will become the world authority".

Recycling and substitution
In industry, boron can easily be substituted, for example with sodium, potassium, phosphorus, cellulose or rock wool. However, boron recycling is virtually impossible because it is present in extremely low concentrations in products.

In summary: boron is not a critical nutrient for the EU in terms of substitution possibilities in industry, but it is critical in terms of global reserves, import dependence, geographical concentration, geopolitical risks and recyclability. The Netherlands, with its relatively large poultry sector, is particularly vulnerable.

12. Nutrient prices and their consequences

Nutrients enter the food chain primarily via chemical fertilizer (and to a lesser extent via livestock feed). In the sections above, we have illustrated how the inflation-adjusted prices for mineral raw materials have been affected by specific circumstances, sometimes rather suddenly, as in 2008. Figure 17 shows that the price development of chemical fertilizer is more or less in parallel to the prices of energy and agricultural products. That is logical, because high energy prices increase the cost of making fertilizer and agricultural products, while high prices of agricultural commodities in turn raise the demand for fertilizer, and all of these prices are subject to the activities of investors and speculators who may have fled stock and bond markets. During the last 17 years, the price trend has been upwards for chemical fertilizer, energy and agricultural commodities. Recent declines in the price of grain and fertilizer have been observed, but these appear to be only temporary, because the growth in agricultural production in most regions remains behind the expected demand.[120]

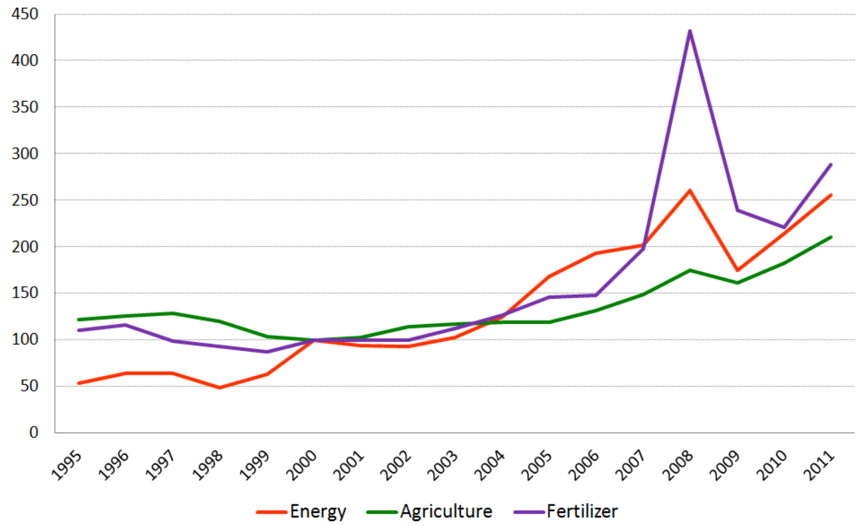

Figure 17 Price development of fertilizer, energy and agricultural commodities between 1995 and 2011. Source: World Bank. (Relative price changes in constant US dollars; 100 = year 2000).

[120] http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0066428

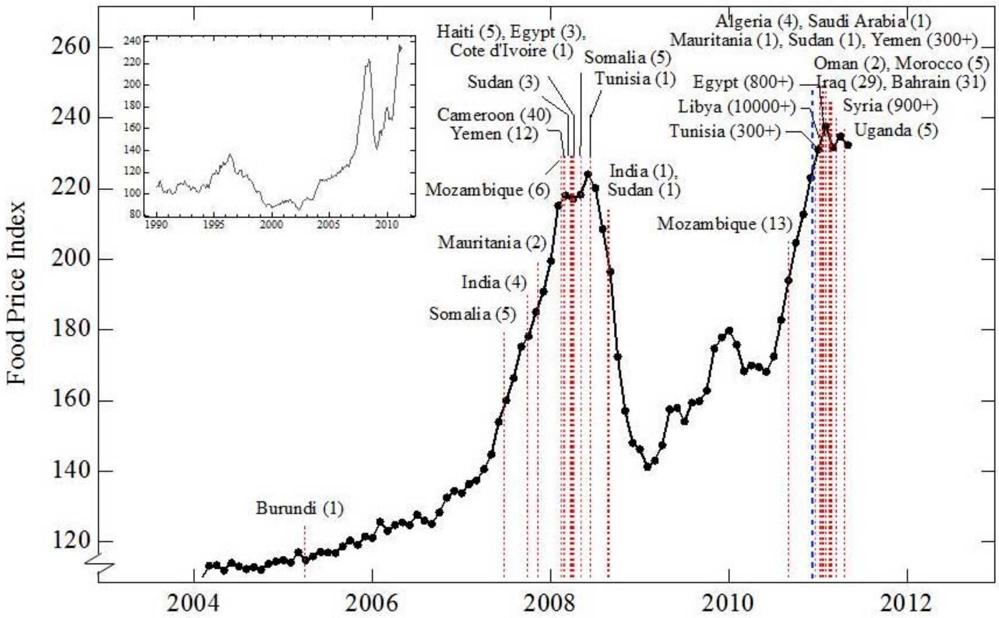

Figure 18 Starting dates of food riots and protests in relation to the FAO food price index. In brackets, the number of deaths caused by the riots. Source: FAO.

In many cases, increasing prices of agricultural commodities result in higher food prices for consumers, which in turn can lead to social and political unrest. Figure 18 illustrates the correlation between high food prices and food riots/protests. Although high food prices are seldom the *only* source of unrest, they can certainly be a powerful trigger.

Scarcity of macronutrients and/or micronutrients affects agricultural production with a lag, so the resulting price increases would tend to be gradual rather than steep. Nevertheless, shortages of nutrients can lead to unrest on the market, including panic buying of fertilizer and large-scale speculation. In that case, severe price fluctuations as shown in Figure 18, with accompanying social unrest, are certainly possible.

13. Conclusions: nutrients

1. More than 90% of the macronutrients phosphate and potassium are used in agriculture (including livestock farming). For the micronutrients discussed here, this proportion is reversed: 12% of the boron is used in agriculture, 10% of the selenium and less than 1% of the zinc and molybdenum.

2. For potassium, there is no threat of global depletion of reserves in the present century, but for phosphate that is not yet clear. For zinc, selenium, molybdenum and boron, the global reserves relative to the annual consumption are small, sometimes sufficient for only a few decades. However, it is unclear how much value we should assign to these figures. For zinc, the R/P ratio is only 19 years, but in 1995 was only 20 years. Apparently, the easily recoverable reserves are still adequate. The situation for selenium appears to be of greater concern, because this mineral is not mined or extracted by itself, but is almost always a by-product of copper refining, while the need for selenium in industry and the food chain is increasing

3. The EU has only a small share of the mineral reserves of the nutrients addressed in this report. For zinc that is 3%, for potassium 2% and for the other nutrients less than 1%. Consequently, the EU is extremely dependent on imports. Although the EU does control a substantial proportion of the production of concentrated potassium, zinc and selenium, for the latter mineral this production is almost entirely based on mining that takes place outside the EU.

4. In the production of potassium, zinc and molybdenum, there is a consolidation trend; as a result, the production is being dominated by a small group of large companies. These are taking a position in which they can manipulate the market with the aim of compelling higher prices. Or to force prices down temporarily, which they might do for example if import-dependent countries – and that includes most countries – attempt to reduce their dependence by recycling, as Kazakhstan did with white phosphorus. In the cases of phosphate, potassium and boron, state-related companies play an important role. Besides commercial objectives, they can also have a political agenda, which entails other types of supply risks.

5. The supply of all the nutrients addressed in this report, except for zinc, is susceptible to three geopolitical risks.
   Firstly, reserves are concentrated in a limited number of countries. For selenium, molybdenum and boron, the concentration is fairly strong, for potassium it is strong (with more than 75% of the reserves in two countries, Russia and Canada) and for phosphate it is extremely strong (with according to the USGS 74% of the reserves in Morocco including the Western Sahara, although that figure is controversial). Countries with a large share of the reserves can use export as a political pressure tool. And this becomes even more feasible as they control a larger part of the entire value chain.

Secondly, importing countries are becoming more dependent on the political stability of the exporting country. That has been demonstrated clearly with phosphate. The Moroccan annexation of the Western Sahara is contested. Some of the other reserves are located in less stable countries, such as Tunisia and Syria. Thirdly, many countries that are rich in raw materials have the logical tendency to use these reserves primarily for their own agriculture and industry. This applies not only to China, but also to countries such as the USA.

6. Of the two demographic giants China and India, China is both a mega-consumer and a mega-producer of nutrients. However, China is highly dependent on imports for at least two mineral nutrients: potassium and selenium. This import dependence comes on top of the increasing need of the country for food and feed, which results in rapidly growing imports of soya, the takeover of foreign companies (such as the huge American meat company Smithfield) and investments in farmland *(land grabbing)* overseas.[121] India is a mega-consumer as well, but that country is also dependent on imports for *all* the nutrients addressed in this report – with the exception of zinc. Very similar to the EU, India is thus subject to more geopolitical risks than China.

7. The two agricultural giants – the USA and Brazil – are also anything but autonomous in terms of nutrients. According to USGS figures, the USA possesses only 2% of phosphate reserves, 1.4% of potassium reserves and 4.5% of zinc reserves. Brazil holds only 0.4% of the phosphate reserves, 3% of the potassium reserves and negligible percentages of the zinc, selenium, molybdenum and boron reserves. Consequently, these countries are also structurally import dependent, although less than the EU. These countries will also compete with India and China on the nutrient market.

8. Despite the import dependence of the EU, there is still little interest for substitution and recycling of nutrients. Substitution is often possible in industry, but not in agriculture. Because more than 90% of phosphate and potassium is used in agriculture, few options are available besides recycling. In this context, it is a positive development that – with the Netherlands as a leader – recycling of phosphate from sewage sludge has begun.

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[121] China is also active in the EU with land grabbing, specifically in Bulgaria. China sees that country as a test for access to the EU. In that case it could even benefit from farm payments based on the Common Agricultural Policy. Qatar, Kuwait, Saudi Arabia, Israel and the UAE are also active there. Source: *Boerderij Vandaag* 15-8-12. For that matter, China is not the biggest land buyer. Most of the land (until now 33.9 million ha world-wide) has been purchased by Western companies, and local land buyers are also playing an increasingly important role. *Boerderij Vandaag* 2-8-13.

14. Position and policies of the EU and the Netherlands

This chapter provides a summary of the policies of the European Union and the Netherlands on raw materials. Conflicts of interest between the Member States appear to be a problem.

14.1 Position and policy of the European Union

Import dependence
Europe is a major net importer of raw materials, including raw materials for agriculture. Table 8 shows the current level of import dependence for several raw materials that are relevant or partly relevant for agriculture.

Table 8 Current import dependence of the EU for raw materials. Source: European Commission (2008) The Raw Materials Initiative. Source soya figure: European Commission 2009. *Prospects for agricultural markets and income 2008-2015.*

Raw material	Import dependence
Soya	92%
Phosphate	98%
Potassium	Unknown
Zinc	64%
Selenium	Unknown
Molybdenum	100%
Boron	100%

The situation over the long term primarily involves the distribution of the global *reserves*. The EU holds only a very small proportion of these reserves. The strong import dependence for soya is not structural, because if imports were to collapse, then the EU could compensate for the situation within approximately 5 years by exporting less grain and growing more protein crops, including soya. However, mineral raw materials are essential for high levels of agricultural production. Consequently, the much vaunted self-sufficiency of the EU is a fiction. Viewed from a long-term perspective, the EU appears to be an agricultural giant with feet of clay.

Common Agricultural Policy and Raw Materials Initiative
Even stranger is that the Common Agricultural Policy still has little regard for possible shortages of raw materials for agriculture. DG Agriculture and the Agriculture Committee of the European Parliament have obviously fallen behind. They seem to be unaware of the import dependence of the EU or they still rely heavily on supply security

through the free market.

When it comes to raw materials for industry, however, the confidence of the EU in the free market is declining. In 2008, the EU published a *Raw Materials Initiative,* with three pillars:

1) ensure access to raw materials from international markets under the same conditions as other industrial competitors. This pillar is compatible with a form of ‘raw material diplomacy’ which utilizes strategic partnerships and policy dialogues and pays explicit attention to the interests of developing countries;
2) set the right framework conditions within the EU in order to foster sustainable supply of raw materials from European sources;
3) boost overall resource efficiency and promote recycling to reduce the EU’s consumption of primary raw materials and decrease the relative import dependence.

Specific plans were made to monitor a list of raw materials identified as critical (every 3 years). However, harmonization of the foreign raw materials policies of the various Member States was lacking.

Critical raw materials

In 2010, the European Commission published the report *Critical raw materials for the EU* in which raw materials were classified as critical or less critical/non-critical. That distinction was based on two criteria:

a) economic importance;
b) the supply risk in the coming 10 years as a result of political instability, concentration of production, export restrictions by countries that supply raw materials, substitution and recycling possibilities and/or environmental policy.[122]

A weak point in this report was that it looked at the current concentration of *production,* not the concentration of the *reserves*. This is not surprising in view of the time horizon of only 10 years. Partly as a result, of the 41 raw materials examined in the study, only 14 were defined as critical. Of this group of critical raw materials, only two (magnesium and cobalt) are relevant for the food chain, but that is coincidental because the food chain was outside the scope of this study. Magnesium was defined as critical due to the concentration in China; and cobalt was defined as critical due to the concentration in the Democratic Republic of the Congo.

In the update of the Raw Materials Initiative in 2011, the above-mentioned principles were reaffirmed. Specific interim results consisted of the following: (a) promotion of good governance, (b) complaint procedures at the WTO and other institutions against protectionist measures, in particular measures taken by China, (c) much consultation with African countries about European aid for "sustainable mining". In this context, the term "sustainable" has two meanings: long-term access and responsible mining/processing (i.e. a combination of salesman and preacher).

New plans concerned increased joint monitoring of the mining activities in the EU and providing an incentive for innovative reuse of raw materials. As icing on the cake, in 2012 the European Commission launched a proposal for an internal *European Innovation Partnership on Raw Materials*.

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[122] The known global reserve relative to the annual use (R/P) is therefore **not** a criterion.

More controversial were the plans to obligate and maximize the public disclosure of the trading positions of investors and traders on the markets for raw materials. The aim of this measure was to counteract speculation and price manipulation regarding raw materials. This was in response to the food crisis of 2007-2008 and the financial crisis (which was caused in part by commodity derivatives) and American legislation (the Dodd-Frank Act).

With respect to mining in third countries, it is relevant that the EU is preparing a new *Transparency & Accounting Directive*. This will impose the same reporting obligations on European mining companies as US companies now have based on the Dodd-Frank Act. Canada, with its huge mining industry, is preparing similar legislation.

In her book *Winner take all – China's race for resources and what it means for the world* (2012), the Zimbabwean economist Dambisa Moyo argued that the EU is not standing up for its own interests in raw materials. In the meantime, the EU has initiated bilateral agreements on mining raw materials, with Greenland and some other countries. In Africa, the apparent strategy of the EU is to thwart the Chinese with sustainable mining. But it is very doubtful whether this strategy can compete with the enormous material compensation that China sometimes offers in exchange for mining rights.

Notable aspects of the above are the short time horizon of the EU and the fact that little or nothing is being done about food-related raw materials. A comprehensive, long-term vision was entirely lacking. But it appears that the EU has started to catch up.

Nutrients
In 2011, the Commission published a *Roadmap to a Resource Efficient Europe* and established a public-private *Resource Efficiency Platform*.[123] The Roadmap referred to a single agricultural raw material (phosphate), but did not mention geopolitics. In October 2013, the Commission made €40 million available for 14 research projects on research efficiency. Three of these projects concern the food chain.[124] In 2012 the Joint Research Centre of the European Commission published a report on possible future scarcity of three macronutrients: nitrogen, phosphate and potassium.

In October 2013, the Directorate-General for the Environment published a report from the University of the West of England, Bristol: *Science for Environment Policy - In-depth Report: Sustainable Phosphorus Use.* This provides an impressive and clear summary of the phosphate issue, including drivers, environmental pressure, geographical concentration, geopolitics, social risks, technological possibilities and policy options. It is not yet clear what parts of the report the Commission is going apply in its own policy. However, the Directorate-General for Enterprise and Industry announced that it was going to add phosphate to the list of critical materials.

Relevant to the private sector is the report by McKinsey *Towards the Circular Economy* from 2012. This report stated that Europe, by transitioning to a circular economy, can realize savings on materials as high as 340 to 630 billion dollars per year. It dealt with

123 Members include the Dutch citizens Gerben-Jan Gerbrandy (EP), Paul Polman (Unilever) and Peter Bakker (World Business Council for Sustainable Development).
124 http://europa.eu/rapid/press-release_MEMO-13-944_en.htm

only one agricultural raw material – phosphate – but the analysis was extensive (including geopolitical supply risks).

Conflicting interests between Member States

The establishment of an EU raw materials policy is complicated by conflicting interests between Member States. More specifically:

- Member States that maintain independent relationships with raw material-supplying countries, versus States that do not have such relationships. These conflicting interests became obvious in 2013 as part of a dispute with China about the dumping of solar panels, during which China played Members States against each other (Box 10);
- the agro-industry (fertilizer, feed) versus other industry. The competition between these sectors is already being felt with respect to selenium;
- industries that use primary raw materials versus industries that use secondary raw materials. These conflicting interests recently became apparent when Germany organized a minority of Member States to prevent the European Commission from taking measures against alleged dumping of white phosphorus by a Kazakh company. That contributed to the bankruptcy of the Dutch company Thermphos, which had developed technology to extract white phosphorus from sewage sludge (Box 7);
- trade versus domestic industry. Trade focuses on lucrative deals, even at the expense of the domestic industry. In many European countries, the ministries of Foreign Affairs often pay more attention to the strategic interest of industries; consequently, they frequently have conflicts with the ministries of Economic Affairs.

Box 10 Chinese power play in the EU on solar panels

China exports large numbers of solar panels to the EU. According to the European solar panel industry, these panels were actually being dumped on the European market. The European Commission agreed, and prepared to impose an import duty. China responded by threatening sanctions against Germany, France and other countries.
According to Simon Evenett, Swiss professor of international trade, Denmark, Sweden, Germany and Finland often take the easiest way out of such trade conflicts, while Portugal, France, Greece and Spain often refuse to yield. In this case, the Netherlands also gave in.
In comparison: China previously dumped solar panels in the USA. In response, the Americans imposed a 250% import duty. The Chinese immediately fell quiet.
The EU decided to withdraw the duty in exchange for the promise that Chinese suppliers would maintain minimum prices for solar panels. However, according to the *Financieele Dagblad*, these prices are scarcely higher than the previous "dump" prices, and the Chinese market share is not expected to fall below 70% (currently 80%).

For the EU it is therefore crucial to draw a single line with respect to powerful trading partners. This applies in equal measure to raw materials.

Source: C. de Gruyter, *De tektonische platen van de wereldhandel laten los*. [The tectonic plates of world trade are shifting]. *NRC Handelsblad* 7-6-2013.

In the Netherlands, the national and European interests are often seen automatically as being mutually compatible. This is naïve. When it comes to raw materials, the current situation in the EU appears to be “every man for himself”. Germany, France, the UK and the Netherlands each have their own raw materials policy. Germany and France – where industrial politics are much more important than in the Netherlands – increasingly transpose their need for raw material security into bilateral rather than European agreements.[125]

To this end, France is negotiating with the Central African Republic, among other potential partners. Germany has taken an assertive position. The *Rohstoffallianz* is an alliance of industries that cooperate to secure the supply of critical raw materials by several measure, including the development of and participation in exploration projects.[126] It is negotiating with China, Kazakhstan and Mongolia about raw material partnerships (Box 11). The recent coalition agreement of CDU/CSU an SPD announces support for such attempts, adding, however, that they do not replace EU or WTO policies but rather supplements them.

The fact that German industry strives for supply certainty is totally understandable, but the intended long-term contracts can actually cause supply *un*certainty for companies in other Member States. And if antidumping measures are blocked, this can frustrate recycling, as shown by the case of Thermphos. This development could elicit the following question: in the area of raw materials, is Germany starting to disregard the motto *Kein deutscher Sonderweg* of Konrad Adenauer, and starting an *Alleingang*? Strictly speaking, there is no *Alleingang*, because Germany always seeks at least one ally,[127] and for a blocking minority it needs multiple allies. But for such a big and powerful country, such allies can usually be found (see also Box 12).[128] And industries in other countries have little chance against the combined bargaining power of German industry. If this becomes the German policy with respect to raw materials, the EU could be threatened with disintegration in this area. And in the long term, that could even impact food security – a primal motive of the EU.

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[125] Federal Ministry of Economics and Technology (BMWi) (2010). *The German Government’s raw materials strategy. Safeguarding a sustainable supply of non-energy mineral resources for Germany*. Berlin. With the above, we must certainly not forget that the Netherlands has conducted a relatively nationalistic policy for many years with respect to natural gas, for example by making bilateral deals with the Russian Gazprom.

[126] The aim of the alliance is "to safeguard the supply of critical raw materials for the participating companies (..), in particular through the development of and participation in exploration projects and other measures to promote the preferential access of companies to critical raw materials." The term “preferential access” does not sound very reassuring for other companies. http://de.wikipedia.org/wiki/RA_Rohstoffallianz

[127] Marnix Krop, former Dutch ambassador in Berlin, reported that when its relationship with France became more difficult (France had been weakened by the European crisis), Germany needed a new partner. Germany did not want to become isolated. “No *alleingang*. That is a golden rule in German politics. The Netherlands, with its strict policies, began to play that role.” *NRC Handelsblad* 20-9-2013. The Netherlands would use this position in Berlin to address the *Sonderweg* regarding raw materials.

[128] NRC journalist Caroline de Gruyter reported that if a Member State wants to achieve something in European forums, they do not send lobbyists to Brussels, but more and more frequently to Berlin. *NRC Handelsblad* 15-9-2013

Box 11 *Deutscher Sonderweg?* (1): raw materials

"For a country like Germany, whose economy relies heavily on exports, the relationship with China is obviously of paramount importance.
The problem is that Germany seems to be willing to protect this relationship with or without the backing of Brussels – and sometimes even against the interests of its European partners. It is actually becoming normal for the country to take unilateral action to pursue its objectives when it deems it necessary. The last German-Chinese cabinet meeting in June brought about a number of bilateral trade deals which will improve Berlin's privileged relationship with Beijing, but are not necessarily in line with the overall EU trade policy towards China.

The EU is trying to address the issue with a comprehensive approach aimed at making the European position stronger at the negotiating table. "If we agree on a common list of priority rare earths, we can better manage to meet the interests of all European countries," explains a European Commission official who works in the sector. Despite this official line, Germany has often played this delicate game alone and not only when it comes to China. When Beijing reduced the export of rare earths in 2010, Germany turned to other countries. To date, Berlin has sealed bilateral agreements with Mongolia and Kazakhstan enabling privileged access to their precious resources. "These deals are certainly not in line with the EU approach," says the official. Instead of having comprehensive European deals, Germany negotiated alone."

Source: Francesco Guarascio, Italian journalist at PublicServiceEurope,
29 August 2012. http://www.publicserviceeurope.com/article/2379/germanys-growing-unilateralism-is-bad-news-for-europe#ixzz29HjDpc2w

14.2 Position and policy of the Netherlands

"The Netherlands does not have a raw materials strategy", concluded researchers of HCSS, TNO and CE in 2011. And the Netherlands Environmental Assessment Agency argued that year:

> "A geopolitical situation in which national interests in resource policies would become dominant would be the least desirable outcome for the EU and the Netherlands, as their ability to act in such a situation might be limited, compared to other main geopolitical players."

Stated differently: the Netherlands and the EU are relatively vulnerable.

The Netherlands is even more vulnerable because it has become an important transport hub for raw materials, and has the ambition to expand this role, as witnessed by the plans for a so-called Raw Materials Roundabout. Generally speaking, the focus of Dutch government and business is still on the short term (5-10 years) and on continued advocacy of free trade, market forces and multilateralism.

Recently, the Dutch government – under the influence of international developments and pressure from business – has shown more interest in the raw materials question. As a result, the traditional, virtually blind trust in free trade and global governance appears to be gradually crumbling. Below is a historical summary.

Box 12 *Deutscher Sonderweg?* (2): automotive industry and energy

The German *Sonderweg* in the **automotive industry** also has disadvantages for other Member States. As with the white phosphorus dispute, in October 2013 Germany managed to organize a blocking minority against the intention of the EU to tighten the CO_2 emission standards for automobiles. Compliance with these tighter standards is more difficult for the luxury models of Mercedes and BMW. A rather strange aspect was that the German position did not benefit national income. For example, one study had shown that Germany would save €9 billion per year on oil imports with the proposed standards. However, shortly after the proposed standards were blocked, it became known that BMW had donated a large amount to the CDU political party (and much smaller amounts to the other parties CSU, SPD en FDP). BMW and CDU denied any connection between the donation and policy. According to *Der Spiegel*, Germany had appeased the UK with concessions on the reform of European banking oversight.

In **energy policy** as well, especially electricity, Germany takes its own course, but that seems to be less harmful for other Member States. The *Energiewende* focuses on reducing emissions of CO_2, promoting sustainable energy production and cutting energy consumption in half without harming the economy. Nuclear energy will also be discontinued.
One important policy instrument is an energy tax on households, which is used to reimburse energy producers, including regular citizens, for supplying sustainable energy to the network.
In contrast to the raw materials policy, this energy policy does not result in other Member States having less access to natural resources, in this case coal, oil and gas. Quite the opposite, these resources have actually become cheaper for them. And on days with abundant sun and/or wind in Germany, electricity users in neighbouring countries can also benefit from the cheap sustainable energy. Of course the system does reduce the profits of those energy companies operating on fossil energy, but to some extent that is the intention of the policy. Energy companies in the Netherlands are also disadvantaged by this policy. On the other hand, all Member States can benefit from German technological innovations and the transition to a different energy system. In the long term the *Energiewende* appears not to be unfavourable for neighbouring countries.

Source automotive industry: *NRC Handelsblad* 15-10-13 and 17-10-13.
Source energy: http://www.carbonbrief.org/blog/2013/07/the-energiewende-an-introductory-look-at-germany%E2%80%99s-energy-transformation

In 2008 the fourth coalition government led by Jan Peter Balkenende, in response to the global food crisis and questions from the Senate, established an interdepartmental working group on Scarcity and Transition with the aim of

> "exploring the development of scarcity of food, water, energy and minerals in the context of climate change, biodiversity loss and changing political relations."

In 2009, one of the conclusions of the workgroup was the following:

> "…there are increasing signs that indicate a rise in protectionism and 'resource nationalism' of large and growing economies in the world. Under these circumstances, it is not a simple task to make global agreements. Therefore, it is wise to think about alternative strategies, forming alliances aimed at linking the self-interests of states and non-state actors that eventually achieve the same final result. [….]

> The global geopolitical developments concerning raw materials, as described above, increase the pressure on the European Union to arrive at a more effective common foreign policy. Otherwise, Europe could soon be side-lined, and China and the USA would largely determine how scarce raw materials will be allocated in the world."

This report established the basis for a *Grondstoffennotitie* [Memorandum on Raw Materials] (2011) in which the emphasis was on the interests of industry and on the short term. A Special Envoy on Natural Resources was also appointed, in the person of Prince Jaime de Bourbon de Parme.

In 2010, in its annual National Risk Assessment, the Ministry of Security and Justice paid attention to the possible consequences for the Netherlands of the collapse of soya imports.

In September 2011, the Rabobank warned about serious uncertainties as a result of supply risks of agricultural raw materials. At the request of the second chamber of Parliament, the cabinet published a response (*Kabinetsbrief* 18 January 2012), which included the following:

> "During periods of relative scarcity, the markets for agricultural raw materials can be put under pressure, where governments tend to prioritize their resource security. Such behaviour can have a negative effect on the economies of developing countries. This can also threaten the Dutch economy if imports of raw materials that are crucial to the Netherlands are hampered. […] The Netherlands devotes itself to sustainable development, projects that are mutually attractive in economic terms and to strategic partnerships with producing countries to improve the resource security for the Netherlands."

Notably, nothing was said about the possibilities of reducing import dependence through recycling and substitution.

In his speech to parliament in March 2012, Minister Bleker of Agriculture and Foreign Trade speculated as follows:

> "Is our food production not already too dependent on imports of proteins from other parts of the world? We must certainly determine whether we can become self-sufficient in that area".

At a conference in August 2012, Minister Rosenthal of Foreign Affairs even made a militant statement:

> "Countries with a monopoly on raw materials, like Russia and China, use this power for political ends. […..] The battle for raw materials is not some distant future scenario. It's already happening now."

Here, however, the Minister referred primarily to industrial minerals, not minerals related to agriculture and food.

The coalition agreement *Bruggen Slaan* [Building Bridges] of the new Rutte-Ascher cabinet in 2012 contains several passages on raw materials:

> "The cabinet aims for a **circular economy** and wants to promote the European market for sustainable raw materials and reuse of scarce materials."

And:

> "We choose for a realistic, ambitious green growth strategy, in which space and security are anchored. (…) This development is essential from the perspective of climate change and limited raw materials, and is also a challenge for innovative companies. A large number of highly promising 'biobased' initiatives have been launched in recent years. This biobased economy can form one of the cornerstones for green growth. With broad support in Parliament and society, we want to implement a stable and ambitious policy for the long term. In an international context we will attempt to involve as many countries as possible in this pursuit, also to improve the opportunities for Dutch business."

This all sounds very promising, but the word "geopolitics" is entirely absent.

Such a reference was also absent in a letter to Parliament from Wilma Mansveld, State Secretary for Infrastructure and the Environment (20 June 2013). In her letter, she referred to operational objectives for the programme *Van Afval naar Grondstof* [From Waste to Raw Material], which is intended to help the Netherlands achieve a circular economy. She referred to green growth as a motive and supply security as an additional benefit, but without explicit reference to geopolitical risks.

Similarly, Henk Kamp (Minister of Economic Affairs) did not refer to geopolitical risks in his answer to a question from Member of Parliament Van Veldhoven about raw materials security (20 September 2013).[129] However, he did state that the government:

> "…initiated a study to determine where critical metals and minerals are used in the Dutch economy, what the vulnerabilities are, and which behavioural perspectives can alleviate vulnerabilities."

In this document he referred to both biotic and abiotic raw materials. But it is still unclear whether geopolitical vulnerabilities will also be addressed.

In the meantime, the Netherlands is exploring the possibilities for a strategic partnership with Germany. In its recent work programme, the Dutch *Adviesraad Internationale Vraagstukken* [Advisory Council on International Affairs] referred to the conflicting interests of both countries and the resulting dilemmas for Dutch diplomacy (Box 13).

In 2011, Member of Parliament Van Veldhoven suggested a role for the Netherlands as *raw materials roundabout*, where waste streams would "enter" the roundabout and, following processing, would "exit" when they were again manufactured into products. Rotterdam would have a pivotal role in this process.[130] This idea appears to be feasible for high-value industrial raw materials such as silver and gold, and perhaps for several micronutrients, but is less feasible for the macronutrients phosphate and potassium. These are less valuable can better be recycled locally and regionally. Global transport is hardly compatible with a circular economy. In a more general sense, it therefore appears to be preferable to aim for multiple, specialized roundabouts in the European or national context.

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[129] Kamerbrief 20 September 2013.

[130] Moreover, the Belgian company Umicore and the Port of Antwerp are already active with recycling of gold and other high-value minerals from discarded electronics.

Box 13 Raw materials diplomacy

"In recent years Germany has established bilateral partnerships with countries rich in natural resources, including Kazakhstan and Mongolia. Germany's aim here is to share expertise and generally to strengthen ties with these countries in the hope of securing orders for German businesses. France has done the same, with the Central African Republic for example. No trade agreements have been concluded because they fall within the exclusive competence of the EU.

The Netherlands is currently working on a strategic partnership with Germany, as part of which Germany is being given the opportunity to discuss the 'raw materials roundabout' concept, in which the Port of Rotterdam plays a key role. At the same time, Dutch businesses are being invited to join the *Rohstoffallianz*, a joint raw materials purchasing initiative run by several major German companies. The Netherlands and Germany are also examining the possibilities for joint multilateral intervention.

Should the Netherlands also enter into bilateral partnerships with countries rich in natural resources? And what other like-minded consuming countries (besides Germany) could potentially be important to the Netherlands as partners in raw materials diplomacy? How could such partnerships take shape? Would the Netherlands be better off joining in on existing partnerships? Or should it push for a common European approach?

It is interesting to note that the major new players in the raw materials market (primarily the BRICS countries) have placed much of their focus on Africa in recent years. With this in mind, are the Netherlands and Europe paying sufficient attention to Africa in their raw materials policy or should they step up their African activities in the years ahead?"

Source: *Adviesraad Internationale Vraagstukken* [Advisory Council on International Affairs] (2012) Work Programme 2013.

Here the TNO report *Kansen voor een circulaire economie in Nederland* [Opportunities for a circular economy in the Netherlands] (2013) is worth mentioning. In this report it is argued that the transition to a circular economy could provide the Netherlands with €7.3 billion of savings and other benefits per year. Residues from the food chain would be good for €1 billion per year. The report does not refer to geopolitical supply risks.

14.3 Strategies

For both the EU and the Netherlands it is time to take the concerns about agriculture and food security in the long term more seriously. We previously quoted Robert Kaplan:

> "We have to make do with our place on the world map".

For the EU and for the Netherlands, that place offers little security when it comes to reserves of mineral raw materials for the food chain. Moreover, in the competition for raw materials, agriculture often draws the short straw. The world market also offers little security because it is disrupted by cartels and geopolitics.

The role of state capitalism in all its forms is increasing. The British expert David Humphreys warned emphatically for this problem in his book *Transatlantic mining corporations in the age of resource nationalism* (2012):

> "… the tide of state capitalism and the tendencies that have been described here appear set for the long term. This has implications for the supply of minerals to the transatlantic community. The alternative to acknowledging the issues and engaging in them constructively may simply be to walk blindly into a situation such as that which confronted, and decimated, the Western oil industry 40 years ago."

Many developments indicate that the biggest threat is not world-wide physical scarcity, but a form of *manipulated* scarcity created by an increasingly select and consequently more powerful group of privately owned and state-owned companies.

Firstly, states that have many more reserves than they could possibly use domestically, such as Morocco in the case of phosphate, attempt to form cartels to ensure high prices. Big privately-owned companies tend to do the same.

Secondly, due to the high costs of raw material extraction (exploration, mining, environmental costs, use of space, etc.) and the long time lag involved, exploring for new reserves or exploiting known reserves becomes interesting only if the price of the raw material at stake is high. As a result, dominant exporting parties can frustrate the global drive for exploration through market and price manipulation. We have recently seen an example of this due to the falling prices on the potassium market that were unleashed by Uralkali. Such parties can also actively discourage or frustrate initiatives for substitution or recycling of raw materials. For example, Morocco's OCP has sufficient market power – if worried that its sales were threatened by successful recycling – to unleash a price war that would be disastrous world-wide for both phosphate mining and recycling programmes, including the Dutch *Ketenakkoord Fosfaatkringloop* [Chain Agreement on Phosphate Recycling].[131] All OCP would need to do is develop a certain surplus mining and processing `capacity and temporarily increase its production. After recycling had been frustrated, OCP could reduce production and thereby raise prices again. Morocco is potentially more powerful in the phosphate market than Saudi Arabia is in the oil market.

Thirdly, countries such as China, which have large amounts of raw materials but also consume large amounts, the concern about resource security leads them to retain their raw materials for domestic use. They also attempt to buy shares in foreign mining companies.

Finally, for countries such as India and Brazil, which consume large amounts of raw materials, but have few reserves, the concern about resource security leads them to sign long-term bilateral trade agreements.

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[131] That risk was acknowledged by the signatories to the chain agreement. They entered into negotiations with Morocco to achieve a type of cooperation. "We are talking with Morocco about how they see phosphate consumption in the world, and how we can work together to make phosphate ore mining more sustainable. Morocco is faced with a chronic water shortage, and there are competing claims between water for mining, agriculture and drinking water," says Arnoud Passenier in an interview in *De Lichtkogel* 20-8-13. For that matter, Morocco is not expected to take risky initiatives as long as its claim on the Western Sahara has not been acknowledged more broadly.

Considering these conflicting interests, a strong case can be made for concepts such as global governance and a level playing field. But global governance is most needed to prevent poor countries with few raw materials from being excluded.

We are faced with the following fundamental choices:

- Should the Netherlands continue to focus on the scenario of a free market for raw materials based on the principle (the mantra) that the Dutch economy is benefited the most by open borders? Or should we also take account of other scenarios, in which state-owned companies acquire more influence on the market, a so-called managed trade scenario? Or should we choose the safe middle ground of a no-regret policy?
- Should we safeguard our raw materials interests in a strictly national context ("every Member State for itself"), or through bilateral partnerships with other Member States (such as Germany), or through the EU or through multilateral cooperation? Or by combining these four options?
- During this process are we prepared to also take account of the interests of developing countries? If yes, then should we only take actions that benefit both countries (reciprocity), or should we still take account of these other interests in cases where we have no clear national interest?

The HCSS (2012) referred to four scenarios: *Multilateral, Multipolar, Fragmentation* and *Network*. The scenarios differ in terms of the role of the state and the level of cooperation. Considering the unpredictability of the future, the HCSS argues in favour of a robust no-regret strategy with two tracks:

1) reducing import dependence
2) making partnerships with raw material-producing countries.
   This is a correct prioritization, but partnerships are also required with raw material *importing* countries which, like the Netherlands and the EU, aim to reduce their import.

Options
Below is a summary of 4 strategies and 18 options (Table 9) that enable companies and governments to anticipate geopolitical and other risks to the supply of raw materials. This table was derived from Hees (2013). The table focuses on phosphate, but similar assessments can be made for the other raw materials.

The four strategies are:

A. increasing the control over the supply
B. strengthening the market position
C. reducing demand
D. structuring global markets for raw materials.

In the cited report, all these strategies and options are worked out in more detail. We will only characterize these briefly here.

Table 9 Options for companies and/or governments to anticipate geopolitical and other risks for the phosphate supply.

Options		Companies	Governments
A Increasing control over supply			
1	Capture/defend	Defend supply against piracy	Defend supply against piracy
2	Mine/extract raw materials in own territory	Phosphate exploration in the EU. Urban mining	The Netherlands: extract phosphate from phosphate-saturated soils
3	Mine/extract raw materials in foreign territory (land grabbing)	Invest in (purchase shares) in phosphate mining companies elsewhere	-
4	Specify production in contracts	Sign long-term contracts with phosphate-producing companies	Sign long-term contracts with countries that possess phosphate reserves
5	Bartering	Bartering between phosphate producer and food producer	Guarantee phosphate supply in exchange for soya, infrastructure, knowledge or other products/services
B Strengthening market position			
6	Formalize business-to-business supply	Sign long-term contracts with phosphate-mining operations, e.g. in Morocco	Pursue mutual interests and partnerships with countries such as Morocco, Russia and Algeria
7	Enter into horizontal partnerships	Promote joint procurement of phosphate, also by feed companies	Cooperation in the EU context during negotiations with countries such as China
8	Organize chain integration	Fertilizer or animal feed producers also participate in phosphate mining	-
9	Regional dispersion	Purchasing in more than three countries	Partnerships with countries such as Morocco, Russia and Algeria
10	Price measures	Insurance against price fluctuations. Futures contracts (hedging)	Anti-dumping policy. Bandwidth for phosphate prices in trade agreements
C Reducing demand[132]			
11	Reduce demand volume	Stop overdosing phosphate in fertilization and livestock feed	Balance fertilization required by law
12	Improve efficiency, thus reduce losses	Breed and select crops for efficient phosphate uptake	Provide management tools/precision fertilization
13	Substitution	Substitutes for phosphate in non-agricultural applications	Set specific targets for substitution
14	Recycling	Recovery from wastewater, sewage sludge and waste incineration residues. Recovery from surface water using algae/aquatic plants	Set specific targets for recycling

[132] A useful overview of measures that can be taken to improve the utilization of nitrogen and phosphate world-wide can be found in Sutton et al. 2013. *The challenge to produce more food and energy with less pollution.* www.unep.org

(Table 9, continued)

Options		Companies	Governments
D Structuring global markets for raw materials			
15	Make trade flows transparent	Private registration of phosphate flows and reserves (comparable with the International Zinc Association)	Develop alternative for USGS data: International or European Raw Materials Agency
16	Conclude global/multilateral raw material agreements	-	Establish Round Table on Responsible Phosphate
17	Build up international stockpiles	-	Maintain strategic (regional) stockpiles
18	Regulate trade in raw materials	-	Specify regulations (OESO) on transfer pricing. Tax on potentially harmful phosphate transactions

14.4 Hard or soft landing?

The recoverable reserves of the mineral raw materials for agriculture addressed in this memorandum will eventually become scarce world-wide in an absolute sense. This moment may still be far in the future, but scarcity could happen much sooner as a result of market manipulation by states for geopolitical reasons, and by cartels of privately owned and/or state-owned companies for economic reasons. If raw material security is threatened, then food security can subsequently be endangered, also in the EU. In that case, the EU would risk a hard landing, with severe social and economic damage. But the route to a soft landing is still open. For this purpose, sufficient strategies, technological options and policy options are available. A key condition is that the EU and its Member States begin to act in a proactive, energetic and innovative way.

Appendix 1 Publications about raw materials for agriculture

Publications of the Platform LIS

Food security of the EU
Weijden, W.J. van der, H. Udo de Haes & C.W. Rougoor (2012) *Addressing three major gaps regarding food security in the CAP reform proposals.* Platform Agriculture, Innovation & Society. http://www.platformlis.nl/rapporten/Position-paper-CAP-reform.pdf

Platform Agriculture, Innovation & Society (2011) *The vulnerability of the European agriculture and food system for calamities and geopolitics - A stress test.* Report and advisory document to the Dutch Minister of Economic Affairs, Agriculture and Innovation. http://www.platformlis.nl/rapporten/StresstestEUagrfoodsystem.pdf

Burger, K., J. Warner & E. Derix (2010) *Governance of the world food system and crisis prevention*. Wageningen UR. http://www.platformlis.nl/rapporten/Foodshock-web.pdf

Jansen, D.M., C.P.J. Burger, P.M.F. Quist-Wessel & B. Rutgers (2010) *Responses of the EU feed and livestock systems to shocks in trade and production.* Plant Research International, Wageningen UR. http://www.platformlis.nl/rapporten/Food%20security-web.pdf

Meuwissen, M.P.M., K. Burger & A.G.J.M. Oude Lansink (2010) *Resilience of food companies to calamities – perceptions in the Netherlands.* Business Economics & Development Economics, Wageningen UR.
http://www.platformlis.nl/rapporten/Resilience-web.pdf

Burger, K. (2009) *Food calamities and governance – an inventory of approaches.* Development Economics, Wageningen UR.
http://www.platformlis.nl/rapporten/Calamities-web.pdf

Phosphate
Udo de Haes, H.A., J.L.A. Jansen, W.J. van der Weijden & A.L. Smit (2009) *Phosphate – from surplus to shortage.* Steering Committee for Technology Assessment.
http://www.stuurgroepta.nl/rapporten/phosphatedef.pdf

Smit, A.L., P.S. Bindraban, J.J. Schröder, J.CG, Conijn & H.G. van der Meer (2009) *Phosphorus in agriculture: global resources, trends and developments.* Report to the Steering Committee Technology Assessment of the Ministry of Agriculture, Nature and Food Quality, The Netherlands. PRI.
http://www.stuurgroepta.nl/rapporten/phosphorusinagriculture.pdf

Micronutrients
Udo de Haes, H., R.L. Voortman, T. Bastein, D.W. Bussink, C.W. Rougoor & W.J. van der Weijden (2012) *Scarcity of micronutrients in soil, feed, food, and mineral reserves. Urgency and policy options.* Platform Agriculture, Innovation & Society.
http://www.platformlis.nl/rapporten/scarcity_of_micronutrients.pdf
Geopolitics

Hees, E. (2013) *Voedsel, grondstoffen en geopolitiek - Rapportage aan het Platform Landbouw, Innovatie & Samenleving.* [Food, raw materials and geopolitics – Report for the Dutch Platform Agriculture, Innovation and Society]. With summary in English. CLM Research and Advice.
http://www.platformlis.nl/rapporten/Voedsel_grondstoffen_geopolitiek-Rapportage_PlatformLIS-2014-web.pdf

Other reports on raw materials

Berg, M. van den et al. (2011) *EU Resource Efficiency Perspectives in a Global Context.* The Hague, PBL Netherlands Environmental Assessment Agency.
ec.europa.eu/.../pdf/res_efficiency_perspectives.pdf

Chardon, W.J. & O. Oenema (2013) *Verkenning mogelijke schaarste aan micronutriënten in het voedselsysteem.* [Exploring possible micronutrient scarcity in the food system] Alterra-rapport 2413. http://edepot.wur.nl/257460

HCSS, TNO & CE Delft (2011) *Op weg naar een Grondstoffenstrategie. Quick scan ten behoeve van de Grondstoffennotitie*. [Towards a Strategy on Raw Materials. Quick scan for the Raw Materials Memorandum] The Hague Centre for Strategic Studies. Report no 08|06|11.
http://www.ce.nl/?go=home.downloadPub&id=1188&file=Op_weg_naar_een_grondstoffenstrategie.pdf

HCSS & LEI (2013) *The emerging geopolitics of food. – A strategic response to supply risks of critical imports for the Dutch agro-food sector.* The Hague Centre for Strategic Studies. Report no 19|02|13. http://www.hcss.nl/news/report-the-emerging-geopolitics-of-food/647/

Interdepartementale Projectgroep Schaarste en Transitie (2009) *Schaarste en transitie - Kennisvragen voor toekomstig beleid.* [Scarcity and Transition - Research questions for future Policy]
http://www.rijksoverheid.nl/documenten-en-publicaties/brochures/2009/11/01/schaarste-en-transitie-kennisvragen-voor-toekomstig-beleid.html

Krimpen, M.M. van, A.M. van Vuuren & P. Bikker (2013) *Behoefte en verbruik van micronutriënten in de diervoeding*. [Need for and use of micronutrients in animal nutrition].WUR Livestock Research rapport 673. http://edepot.wur.nl/251789

Ridder, M. de, S. de Jong, J. Polcar & S. Lingeman (2012) *Risks and opportunities in the global phosphate rock market - Robust strategies in times of uncertainty.* The Hague Centre for Strategic Studies. Report 17|12|12. http://www.hcss.nl/reports/risks-and-opportunities-in-the-global-phosphate-rock-market-robust-strategies-in-times-of-uncertainty/116/

University of the West of England, Bristol, *Science for Environment Policy In-depth Report: Sustainable Phosphorus Use.*
http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR7.pdf

Appendix 2 Participants in sessions on geopolitics

Participants in 4 September 2009 workshop on Geopolitics and global governance

Kees Burger	Wageningen UR, Development Economics Group
Nico Heerink	Wageningen UR, Development Economics Group
Eefje Derix	Wageningen UR, Disaster Studies Group
Jeroen Warner	Wageningen UR, Disaster Studies Group
Prof. Michiel Keyzer	Centre for World Food Studies (SOW-VU)
Gerd Junne	Professor of International Relations, UvA
Prof. Rob de Wijk	HCSS
Prof. Coby van der Linde	Netherlands Institute of International Relations Clingendael
Bertram Zagema	Oxfam Novib
Marije Breedveld	Ministry of the Interior and Kingdom Relations
Peter Besseling	Ministry of Agriculture, Nature Management and Fisheries
Peter Keet	Ministry of Agriculture, Nature Management and Fisheries
Hannah Koutstaal	Ministry of Agriculture, Nature Management and Fisheries
Sicco Stortelder	Ministry of Agriculture, Nature Management and Fisheries
Evert-Jan Aalpoel	Platform LIS
Carin Rougoor	Secretary, Platform LIS
Prof. Helias Udo de Haes	Platform LIS
Wouter van der Weijden	Chair, Platform LIS

Participants in 7 October 2010 Roundtable discussion on Geopolitics and food security

Michel Rademaker	HCSS
Hugo Stam	CEO, Cefetra
Prof. Rudy Rabbinge	University Professor, Wageningen UR
Joost de Jong	Ministry of Economic Affairs, Agriculture and Innovation
Hans Sprangers	Ministry of Economic Affairs, Agriculture and Innovation
Evert-Jan Aalpoel	Platform LIS
Anne Loeber	Platform LIS
Ger Roebeling	Platform LIS
Carin Rougoor	Secretary, Platform LIS
Wouter van der Weijden	Chair, Platform LIS

Appendix 3 Platform Agriculture, Innovation and Society: mandate and members

The work of the Platform Agriculture, Innovation and Society contributes to the knowledge policy of the Ministry of Economic Affairs through:

1. Exploring the consequences of possible technological developments and considering alternatives and/or;
2. Exploring possible technological contributions to the solution of societal problems relevant to the policy fields of the Ministry and/or;
3. Exploring and making explicit the standards and values that are involved with specific developments, as well as the differences in standards and values between various groups in society.

The following people, all in an individual capacity, are members of the Steering Committee:

- *Drs.* W.J. (Wouter) van der Weijden, Chair (director Centre for Agriculture and Environment Foundation)*
- Dr A.M.C. (Anne) Loeber (researcher and Assistant Professor University of Amsterdam)*
- Prof. dr H.A. (Helias) Udo de Haes (Emeritus Professor of Environmental Studies, CML, Leiden University)*
- Prof. dr G. (Guido) Ruivenkamp (Professor of Critical Technology Construction, Wageningen University and Research Centre)
- Mr J.C.P. (Jan Cees) Vogelaar (dairy farmer, initiator of HarvestaGG)*
- *Drs.* J.S. (Bas) Rüter (head of sustainability Rabobank).

* Member of the 'Geopolitics' project group, which prepared the advisory memorandum and the report.

Contact information

Platform Agriculture, Innovation and Society
Executive secretary: Dr Carin Rougoor
c/o CLM Research and Advice
P.O. Box 62
4100 AB Culemborg
T: 0345 470769
E: crougoor@clm.nl
I: www.platformlis.nl