Critical Mineral (non-fuel) Resources Index of India

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Critical mineral resources: increasing concern for major economies

USA

US Report Urges Steps to Reduce Reliance on Foreign Critical Minerals

By Reuters
June 4, 2019 10:42 PM

Forbes Billionaires Innovation Leadership Money Consumer

China And The U.S. Heading For A Showdown In An Australian Lithium Mine

India readies its prospectors as hunt begins for lithium and cobalt mines abroad

The mandate for Nalco, HCL and MECL will be to look for and acquire strategic mineral assets abroad, particularly those in which India is deficient.

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Photographer: Nelson Ch

Politics

Trump Enlists Pentagon on Rare-Earth Magnets Amid Chinese Threat

By Jennifer A Dlouhy
July 23, 2019, 4:17 AM GMT+5:30

Source: Reuters, Forbes, The Economic Times, Bloomberg

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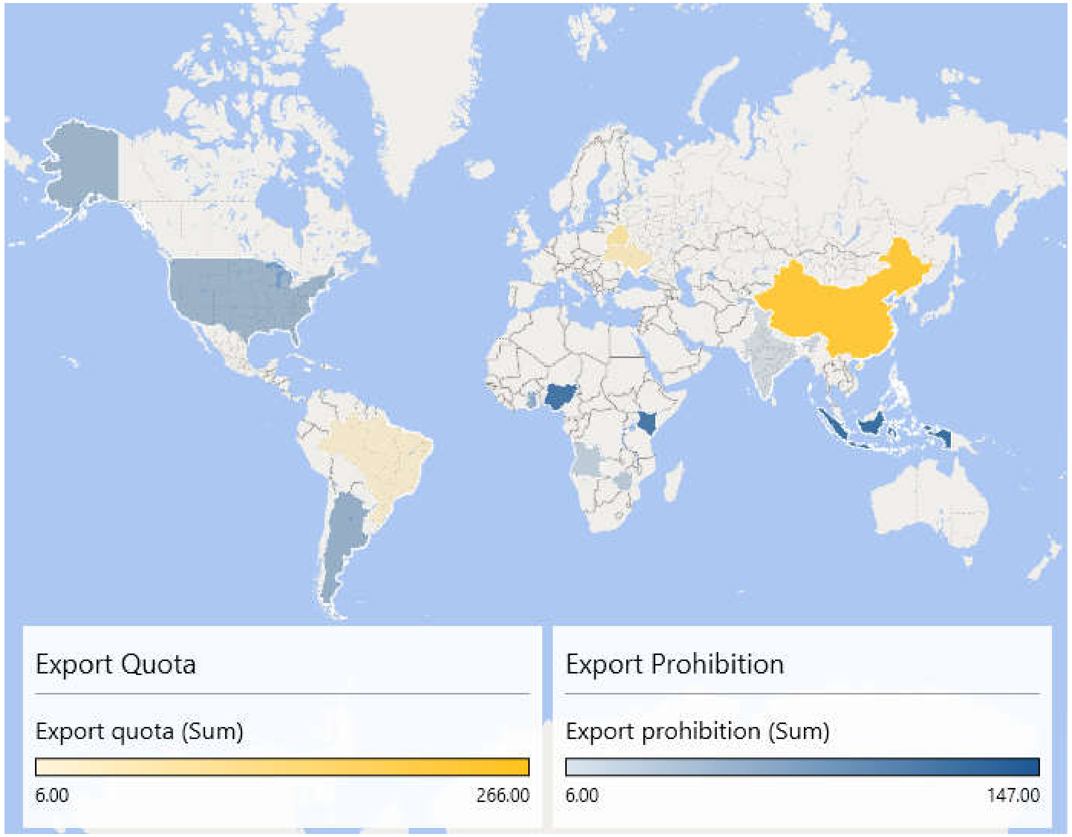
The present global trade on mineral resources



World primary supply of ~49 selected minerals

- Export prohibition – 14 countries
- Export quota – 4 countries
- Export taxes – 23 countries
- Licensing requirement – 36 countries

India

- Mineral wealth is largely **unmapped and untapped**
- **Lack of production** for many modern-day technology materials (no domestic demand)
- We haven't developed **capacity to recover by-product materials** from waste/principle ores

Source: Resourcetradeearth.org, OECD

The importance of critical minerals for India

Manufacturing matters

- Increasing standards of living and a rising population has resulted in an **increased demand for capital goods**
- Modern Industrial activity depends heavily on technology & mineral resources as a raw material. A sustained economy requires both, to add value to its resources
- **Where does India stand now?**
  - Increasing reliance on imports to satisfy domestic demand – increase in imports share of GDP is the highest among the G20 countries for the last 17 years
  - High energy costs, and production inefficiencies are making them non-competitive especially when compared to the major Asian manufacturing hubs
- A weak manufacturing sector results in
  - **i.** **Rising current account deficit** (Electronics import: ~27% of total)
  - **ii.** **low resource efficiency** = Outflow of raw or semi processed materials/minerals & inflow of finished products
  - iii. Low realization of manufacturing value added potential

Source: S. Gurumurthy; **Indian express**

Resource Security/Critical Minerals (1/2)

Globally a matter of concern

United States

- National Research Council (2007), Dept. of Energy (2010, 2011), Department of Defense (2013) – Identified Critical Minerals
- Stockpiling of strategic and critical minerals for defense needs
- House passed National Strategic and Critical Minerals Production Act of 2015 in October

European Union & Others

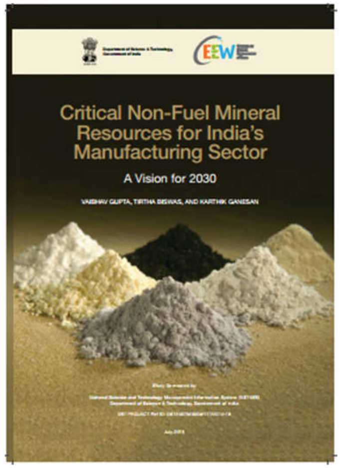
- Assessment of Critical Minerals, now a periodic exercise (2010, 2014, 2018)
- Earlier, United Kingdom & Germany individually conducted studies in 2008 & 2009.
- Japan did separate assessments on – Critical Minerals, Recycling of materials

Source: CEEW Analysis

Resource Security/Critical Minerals (2/2)

- TERI (2010): "Critical non-fuel mineral security: why India urgently needs to have a policy in place"
- Planning Commission (2011): Set up a committee to identify critical minerals
- C-TEMPO & CSTEP (2012): A study on "Rare earths and energy critical elements: A roadmap and strategy for India"
- FIMI (2014): Policy level analysis of exploration status and matter of resource security
- IDSA (2014): Addressed CMR mainly from defense perspective

India: yet to act on International cues !



⇒ CEEW (2016) advanced this concept with an objective approach

⇒ Extensive consultation happened with government and industry

⇒ Identified 12 minerals relatively critical for India (out of 49)

⇒ Lays the foundation for rigorous and periodic assessments

Report available at: http://www.dst.gov.in/sites/default/files/CEEW_0.pdf

Source: CEEW Analysis

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The Criticality Framework (1/3)

The two dimensional framework

- A pragmatic approach to evaluate criticality of minerals in the entire value chain of a growing manufacturing industry
- Enable a better understanding of bottlenecks in the development of manufacturing (through a mineral lens)

Framework								
Dimensions		**(1) Economic Importance**		**(2) Supply risk**				
Factors		Industrial structure	Consumption pattern	Natural Resource Endowment	Geopolitical Risk	Substitutability in end-use application	Recycling Capacity
Indicators		Sectoral value add as a percentage of national GDP	Percentage share of total industrial consumption going in the sector	Import Dependency	World Governance scores	Substitutability	Recyclability
Data Sources	Base Year (2011)	IIP data - MOSPI	Annual Survey of Industries- MOSPI	IBM Data & Ministry of Commerce	World Bank	Literature reviews	Literature reviews
	Future (2030)	Macro-economic analysis (adapted)	CEEW analysis	CEEW analysis	Unchanged	Unchanged	Unchanged

Source: CEEW Analysis

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The Criticality Framework (2/3)

X- Axis - Economic Importance

The evaluation of the scores for Economic Importance takes into account two factors

1. The Industrial Structure (value addition from each manufacturing sub sector)
2. Consumption pattern of a mineral across the different sub-sectors within the manufacturing sector

Economic Importance = (∑ (% share of consumption in each sector) * (GVA of that sector))/total GDP

Example:

mineral	End use sector	% share	GVA impacted (in USD million)
Antimony	Electronics and Optical products	82%	10903
	Textiles and Apparels	11%	
	Chemicals and chemical products	4%	
	Transport Equipment	1%	
	Rubber , Plastic	1%	
Vanadium	Metals	96%	30997
	Chemicals and chemical products	3%	
	Electronics and Optical products	1%	
	Manufacturing NEC, Recycling	1%	

Source: CEEW Analysis

The Criticality Framework (3/3)

Y- Axis - Supply Risk

Natural Resource Endowment (import dependency)	Geo-Political Risk
Substitutability in end use application	Recycling potential

Supply risk = (Import dependency (%) * WGI-HHI) + substitution risk + recycling risk

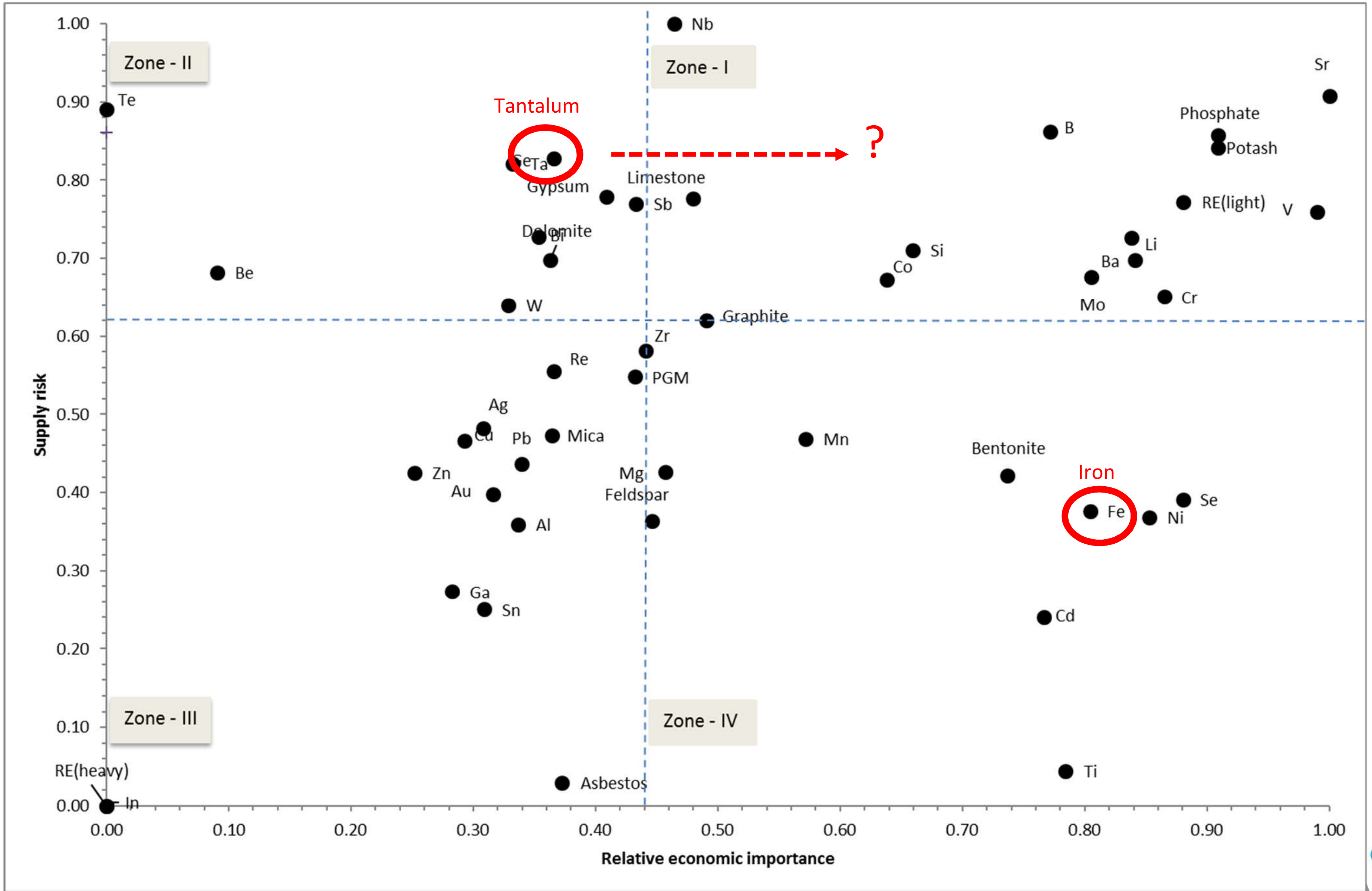
Example:

Mineral	Supply risk score	Supply risk scaled	Geopolitical risk	Substitution risk	Recycling risk	I.D. (%)
Antimony	16.0	7.56	7.7	0.70	7.56	100%
Vanadium	14.4	6.71	3.7	0.69	10.00	100%

- **83%** of the global supplies for Antimony is from China (relatively less stable country)
- Vanadium supplies are more diverse: China (50%); South Africa (30%); Russia (18%) and from politically stable countries relative to Antimony

Source: CEEW Analysis

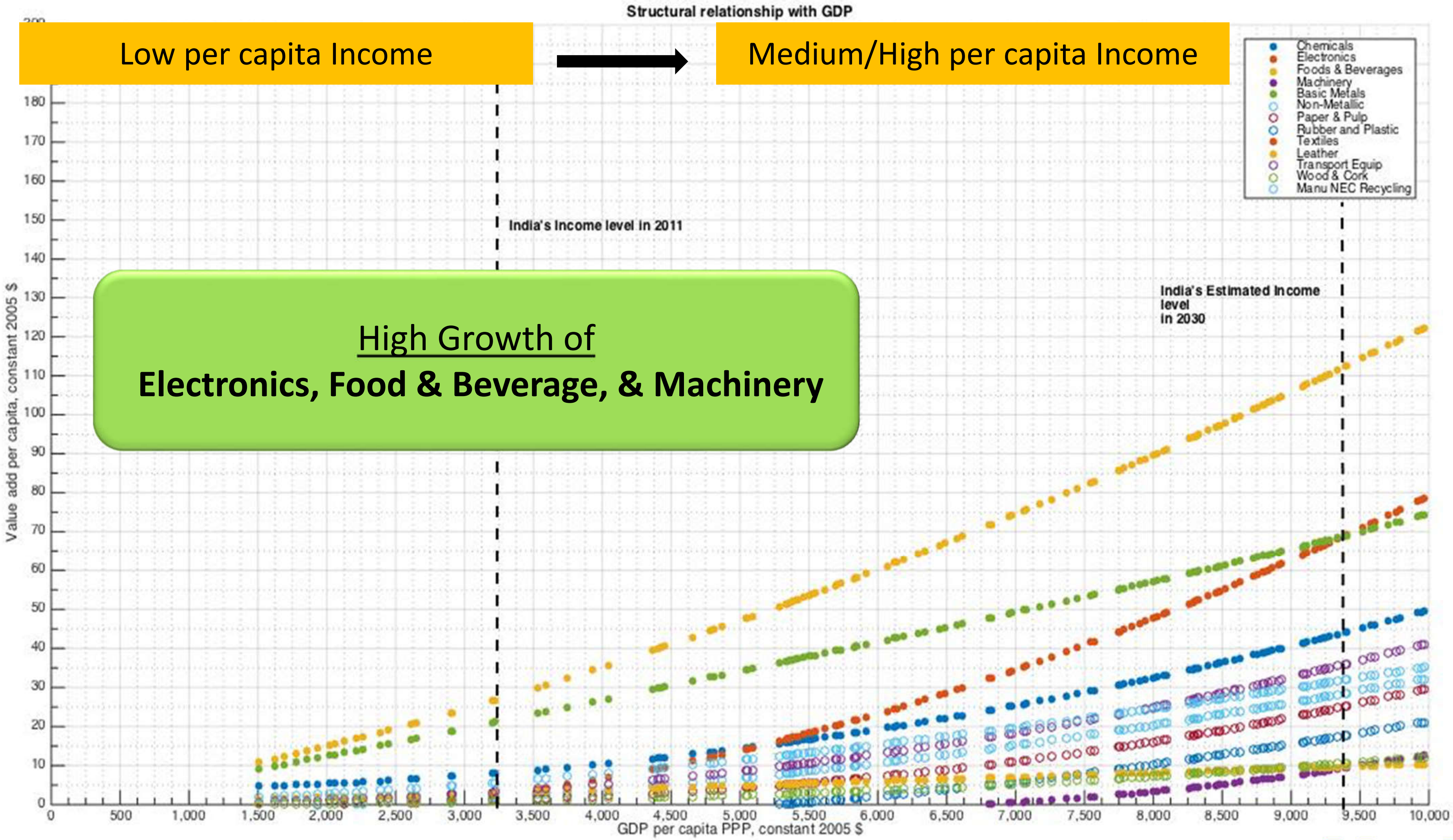
Critical minerals - snapshot for the base year (2011)



Source: CEEW Report (2016): Critical Mineral Resource Framework for India: A vision for 2030

Trajectory for the future: CEEW scenario (1/2)

- **Rise in income levels**: Share towards medium and high technology industries will increase



Source: CEEW Analysis adapted from United Nation Industrial Development Organisation (UNIDO) statistics

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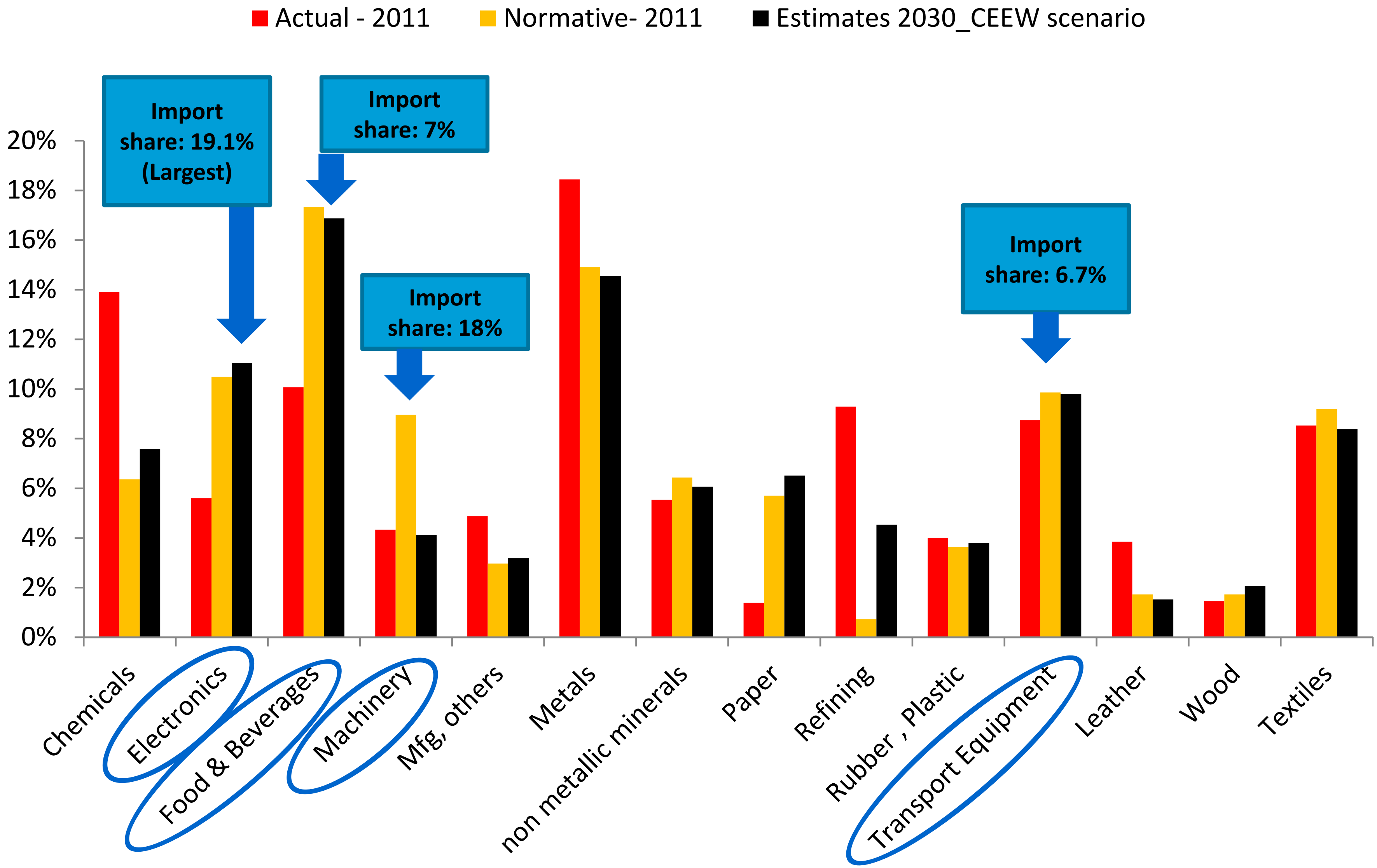
Trajectory for the future: CEEW scenario (2/2)



Source: CEEW Analysis

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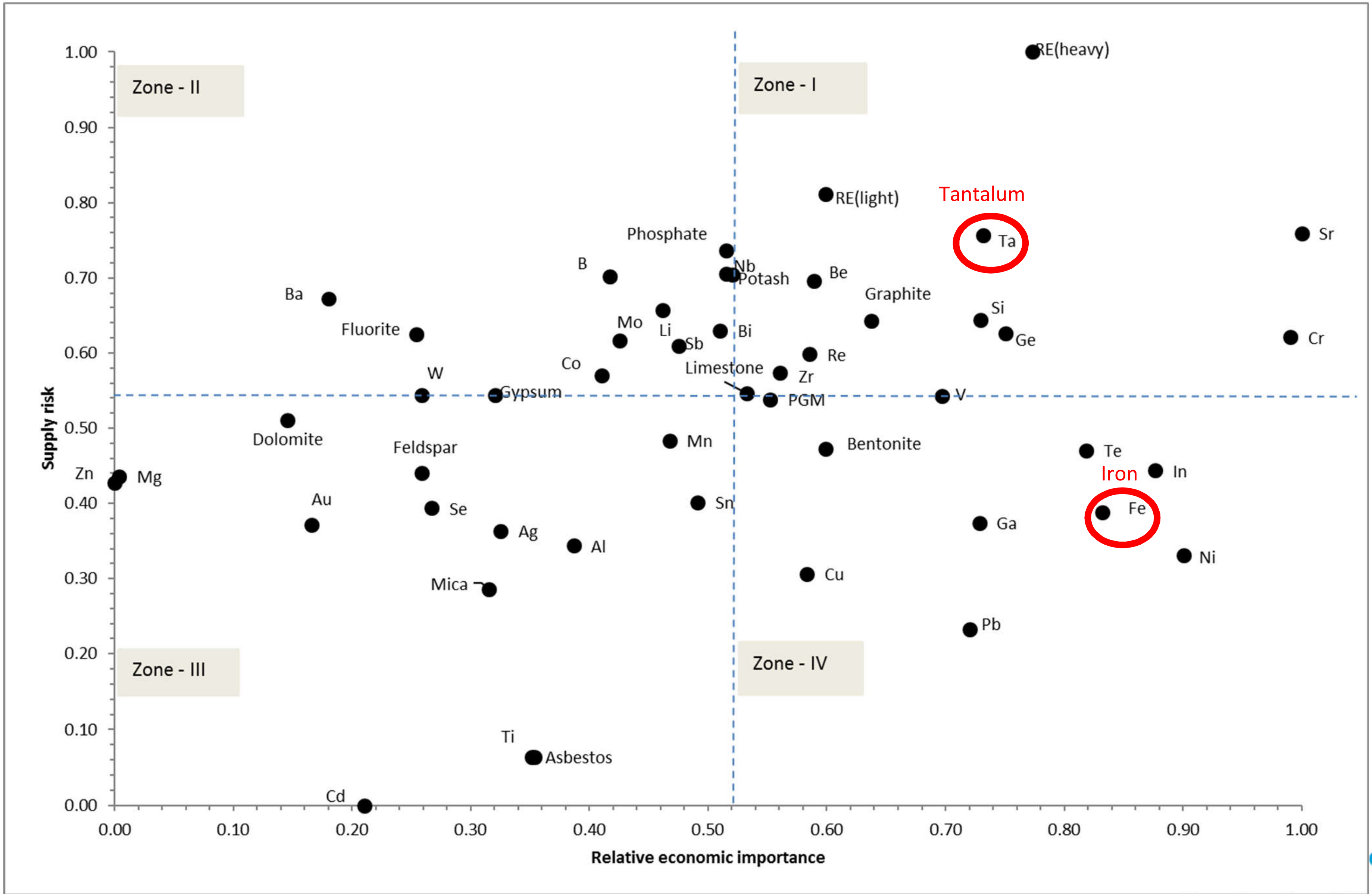
Critical minerals: CEEW scenario for 2030



Source: CEEW analysis

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Critical Minerals in 2030 (1/2)

Rhenium	▪ **Super alloys, machinery** ▪ India: 100% import dependent, no declared resource/reserve ▪ Chile (57%) is a major supplier country ▪ It is a secondary mineral, can be recovered during processing of copper as well.
Beryllium	▪ Traditionally used in Paper processing ▪ **Structural material for** high-speed aircraft, missiles, spacecraft**,** and communication satellites. ▪ India: 100% import dependent. USA (88%) and China (11%) together controls its global supplies. ▪ Hardly any substitutes
Rare earths	▪ Clean energy technologies: LCD screens, metal alloys, hybrid cars, solar/wind energy, lasers and fibre optics, superconductors, ▪ Reserves: Yes, Mining is restricted due to presence of Thorium in Monazite ▪ India: 100% import dependent. China controls 97% of global supplies, and restricted its supplies in 2009
Germanium	▪ Semiconductor material, used in specialised alloys ▪ Secondary mineral, can be recovered from Zinc, copper and lead processing. **India has failed to recover it from mineral waste** ▪ China controls 85% of global supplies
Graphite	▪ Electronics and machine manufacturing ▪ India: Only 5% resource is declared as feasible reserve. Could become a lost opportunity, if substitutes comes in use
Tantalum	▪ Used in capacitors and high-power resistors (electronics) ▪ No reserves in India. Brazil controls 95% of global supplies ▪ Recycling potential is low, and substitutes are difficult to find

Source: CEEW analysis

Critical Minerals in 2030 (2/2)

Zirconium	▪ Chemical and Nuclear industry for corrosion resistant substances ▪ India has reserves which could last for another 50 years. But, lack of substitutes makes it critical for India. ▪ China, South Africa and Mozambique are countries to look after its supplies.
Chromium	▪ Manufacturing of stainless steel. India's reserves are running out sharply. ▪ It's mining is an environmental hazard, difficult to substitute in a cost-effective manner
Limestone	▪ Used as a slag material in metal industry, cement manufacturing ▪ India is self-sufficient, but, new addition of reserves is required, else we would become import dependent to the extent of 20%
Niobium	▪ Alloying agent in steel industry ▪ India is 100% import dependent, with no resources. 95% supplies controlled by Brazil
Silicon	▪ Wide usage across metals (40%), electronics (38%) and transport equipment (17%). ▪ Globally available in ample quantities, but its processing is highly energy intensive. ▪ In India, much of the silicon grade resource is yet to be converted into mineable reserve
Strontium	▪ Used in metal processing, manufacturing of ferrite magnets ▪ India has not declared any resource ▪ China (79%) and Spain (11%) controls its global supplies

Source: CEEW analysis

The updated framework (ongoing)

Current Methodological Improvements (1/2)

Inclusion of trade policy impact on supply risk

Supply risk = (Import dependency (%) * WGI-HHI*trade risk) + substitution risk + recycling risk

Trade risk (TR) can arise from imposition of import taxes, licensing agreements, domestic content obligation, export quotas, and export prohibition

- Indonesia imposed export prohibition on chromium, cobalt, nickel, zirconium in 2014
- China imposed a 30% ad-valorem export tax on lead-zinc, niobium-tantalite exports in 2014

Export Tax

- TR = 1 + 0.1 if (0<ET<= 25%); TR = 1 + 0.2 if (25% < ET < = 75%); TR = 1+ 0.3 if ET > 75%

Export Quota

- TR = 1 + (County production – quota imposed)/total global production

Export Ban

- TR = 1 + country production/total world production

Licensing requirement/domestic content obligation

- TR = 1+0.1

If a country has more than one measure in place, the measure with highest risk is considered

Source: CEEW Analysis

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Current Methodological Improvements (1/2)

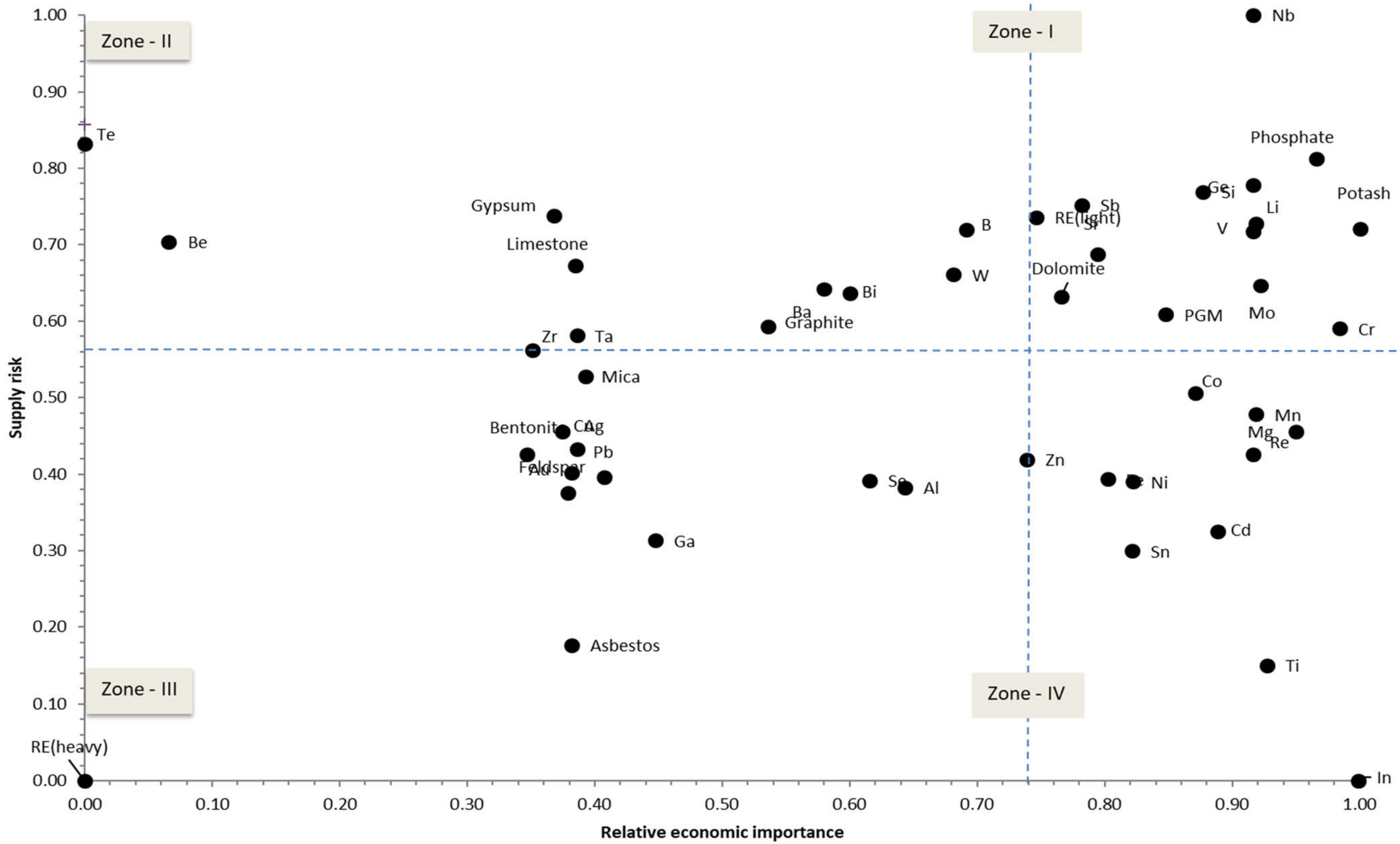
Revised calculation of substitution risk

- 221 products mapped across 16 end-use sectors
- 243 substitutes identified for the products mapped
- Substitutes are compared across stage of development, cost, performance, domestic availability, and their criticality scores (as identified in our previous study)

Mineral	Sector	Products	Substitutes
Indium	Electronics equipment	In flat panel displays (FPD) including LCD TVs, monitors, mobile phones and digital cameras.	1. Aluminium doped zinc oxide 2. Fluorine doped zinc oxide 3. Graphene 4. OLEDs/QLEDs
	Automotive glass	In smart windows	Fluorine doped tin oxide
	Alkaline batteries	For preventing corrosion of the zinc anode and in formation of hydrogen gas	Lithium Ion
	High efficiency Photovoltaics	Used in: thin film PV, in thin film solar cells (CIGS)	copper-zinc-tin sulphide

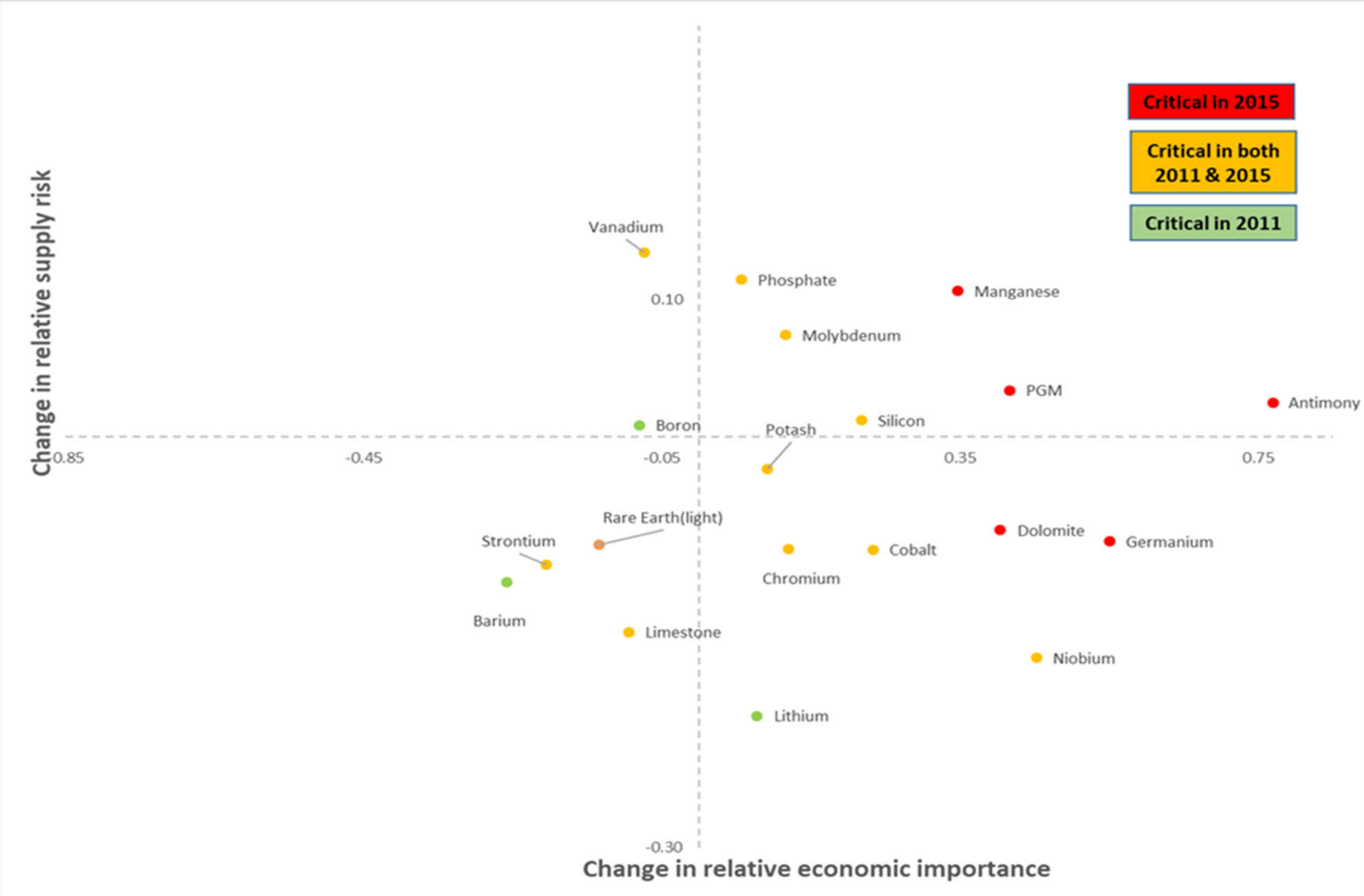
Source: CEEW Analysis

Critical Minerals in 2015



Source: CEEW Analysis

Comparison between 2011 and 2015



Source: CEEW Analysis

Minerals became critical between 2011 and 2015

Mineral	Key factors influencing criticality
Antimony	• Between 2011 and 2015, antimony found more diverse usage across the manufacturing sectors, which is reflected by the decrease in share of consumption in the semi-conductor industry from 80% to 14% • India is 100% import dependent for antimony supplies. China is the single largest supplier of antimony catering to more than 80% of global production
Dolomite/Limestone	• India has a vast resource base for limestone and the explored reserves (9% of discovered resources) could sustain for another 60 years of current production level • Supply risk is largely on the account of non-recovery from usage as a construction material (largely in cement manufacturing)
Germanium	• The mineral became critical in 2015, primarily due to increase in economic importance. It is been increasingly used to produce specialty alloys • Worldwide it is largely recovered as a by-product of zinc ore processing. India is 100% import dependent, despite being world's fourth largest producer of its parent mineral zinc!
Manganese	• Consumption of manganese is forecasted to increase further as India's National Steel Policy aims to increase the per capital steel consumption close to the global average (208 kg per person) by 2030 • In 2016, India imported more than half of the total manganese consumption roughly amounting to 2 million tonnes of ore
PGMs	• Economic importance for platinum group of metals nearly doubled in the period. PGMs are increasingly being used as catalysts in the chemicals industry • India is 100% import dependent for supplies of PGMs. Global supplies of PGMs are concentrated only in few countries: South Africa, USA, and Russia together produces more than 90% of global supplies

Source: CEEW Analysis

Minerals remained critical between 2011 and 2015 (1/2)

Mineral	Key factors influencing criticality
Chromium	• India is world's third largest producer of chromium, further expeditious exploration efforts are required, as the exiting reserve base in India would sustain for only 14 years at current production rate • There is considerable (yet challenging) scope of finding a suitable substitute (of less toxic nature) as well as improving its recycling/recovery rate from end-of-life products made up of stainless steel
Cobalt	• Major uses of cobalt are in chemicals (paints and dyes) and in corrosion resistant alloys. It is difficult to substitute from its application in special alloys, magnets, chemicals (paint and dyes), cutting tools etc. • India is 100% import dependency. Around 70% of global production coming from a single country (Dem. Republic of Congo) thus having a very high geo-political risk associated with the mineral supplies.
Molybdenum	• Major consumption is in the metals sector to produce highly specific alloys. Similar to Cobalt, it is used in specialty alloys, and is difficult to substitute without compromising the quality • India is 100% import dependency; 70% of global production coming from a single country (Dem. Republic of Congo)
Niobium	• Worldwide it is considered as a strategic and critical mineral due to its high relevance in creating super-alloys for aerospace and military applications (missiles, jets) • India has not declared any resource for this mineral and is 100% import dependent for its use
Rare Earths	• Increasingly used in clean technology products, super alloys, flat screens, magnets, nuclear reactors, optical fibres etc. • India is among the few countries bestowed with rare earth elements reserves. However, due to lack of viable technology and association of Indian ore monazite with radioactive material (thorium), their production is highly restricted and undisclosed.

Source: CEEW Analysis

Minerals remained critical between 2011 and 2015 (2/2)

Mineral	Key factors influencing criticality
Silicon	• It is abundantly available mineral globally. However, its processing into suitable grades is contingent on availability of suitable technologies.
Strontium	• It has peculiar role in providing brilliant red colour to modern fireworks. Glow-in-dark paints and plastics are also due to unique properties of this mineral. There are very few substitutes available for its characteristic properties • India is 100% import dependent for its supplies. China is a dominant producer for this mineral
Vanadium	• Primarily used in manufacturing of ferroalloys. It is difficult to substitute from its application in special alloys with similar cost performance. India's demand in steel consumption will further increase the consumption of the mineral. The mineral is mainly found in with titaniferous magnetite, already proved reserves with a high R/C of 360 years. Yet no primary production in India • Minor recovery from alumina industries takes place owing to low vanadium content in east coast Bauxite grade
Potash and Phosphate	• Single largest use in the manufacturing of chemical fertilisers. This accounts for a substantial contribution in economic value addition. Currently, the mineral has no substitutes as a nutrient provider. • More than 80% of domestic demand is currently met through imports.

Source: CEEW Analysis

Minerals becoming non-critical between 2011 and 2015

Mineral	Key factors influencing criticality
Boron	• The mineral moved out of critical zone due to its decrease in economic importance. Compared to 2011, consumption in chemicals sector (a high value-added sector) decreased and consumption in mechanical equipment sector (to impart temperature resistant properties) increased.
Barium	• Similar to boron, the consumption of barium decreased in chemicals sector and increased in the rubber and plastics sector. Currently, almost half of the total domestic consumption is in the form of barium sulphate to be used as filler in plastics industry and paper brightener.
Lithium	• While globally the minerals find majority of its usage in making re-chargeable batteries for electronic appliances and electro-mobility solutions, in India its use is currently limited as catalysts in petroleum refining industries and industrial chemicals in the form of chlorides, bromides and carbonates • Although India is 100% import dependent for the mineral, the supply risk for the mineral decreased primarily due to reduction in geo-political risk of its supplies indicating a more liberal trade of the mineral. Considering the recent global mining investment trends, the production of Lithium is shifting from the "Lithium Triangle" to the "Lithium Valley" in Western Australia . Currently, Australia alone caters to more than half of global production

Source: CEEW Analysis

Critical Minerals Web-Portal (ongoing)

Objectives of the tool

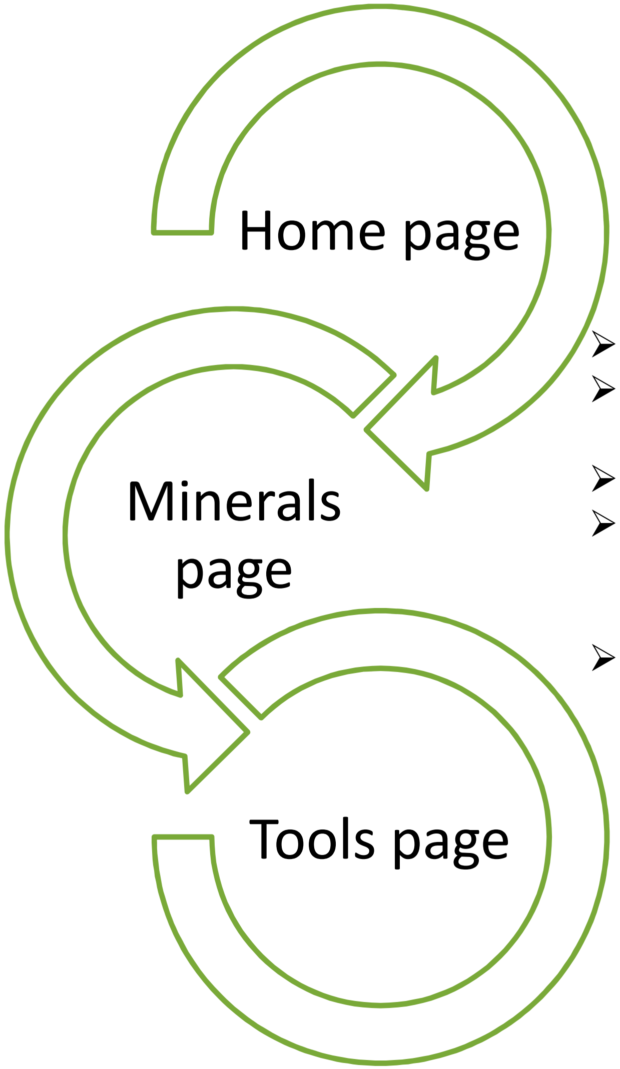
- Structural dynamics of the manufacturing sector in India
- **Critical Mineral Resources (CMR)** relevant for India – periodic exercise
- Potential areas of Intervention – Exploration, Trade, Research and development

- Policy Planning and Decision making – Comprehend current policy decisions into practical scenarios to assist government, industry, and business investors
- Technology, Scale, Regulation – promoting R&D ecosystem in a targeted manner
- Understanding actual Value proposition associated with critical minerals

- Data availability and quality – Finding gaps, promoting collaborations, providing an interactive interface to amass information via crowdsourcing
- Resource efficiency
- Resource Security
- Economy and development of sector

Source: CEEW Analysis

User interaction with the web-portal – key pages



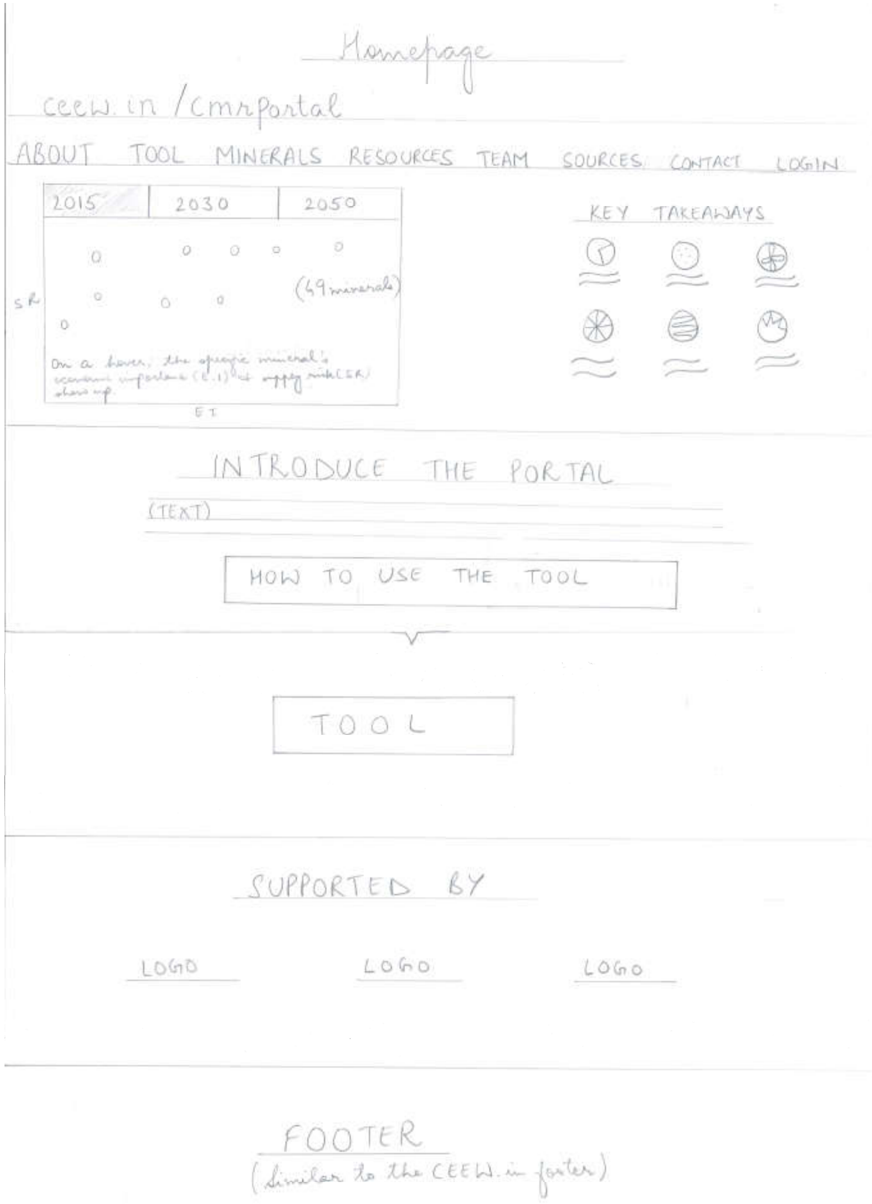
- ➢ Identify critical minerals in the base(2015) and future(2040/50) year
- ➢ Choose between future growth scenarios
- ➢ Key observations for a particular year
- ➢ Selecting a particular mineral takes to the minerals page

- ➢ Individual mineral specific pages
- ➢ Detailed information on consumption pattern across end-use sectors/applications
- ➢ Annual demand, domestic production levels
- ➢ Global supply positions, relative geo-political, trade risks of supplier countries – identify potential trade agreement opportunities
- ➢ Current extent of recycling and potential substitutes across end-use applications

- ➢ Create customised scenarios by selection of more than 30 parameters
  - ➢ Macro economic growth rates
  - ➢ Policy choices: import substitution, targeted manufacturing
  - ➢ Future trade relations, trade policies
- ➢ Identify critical minerals

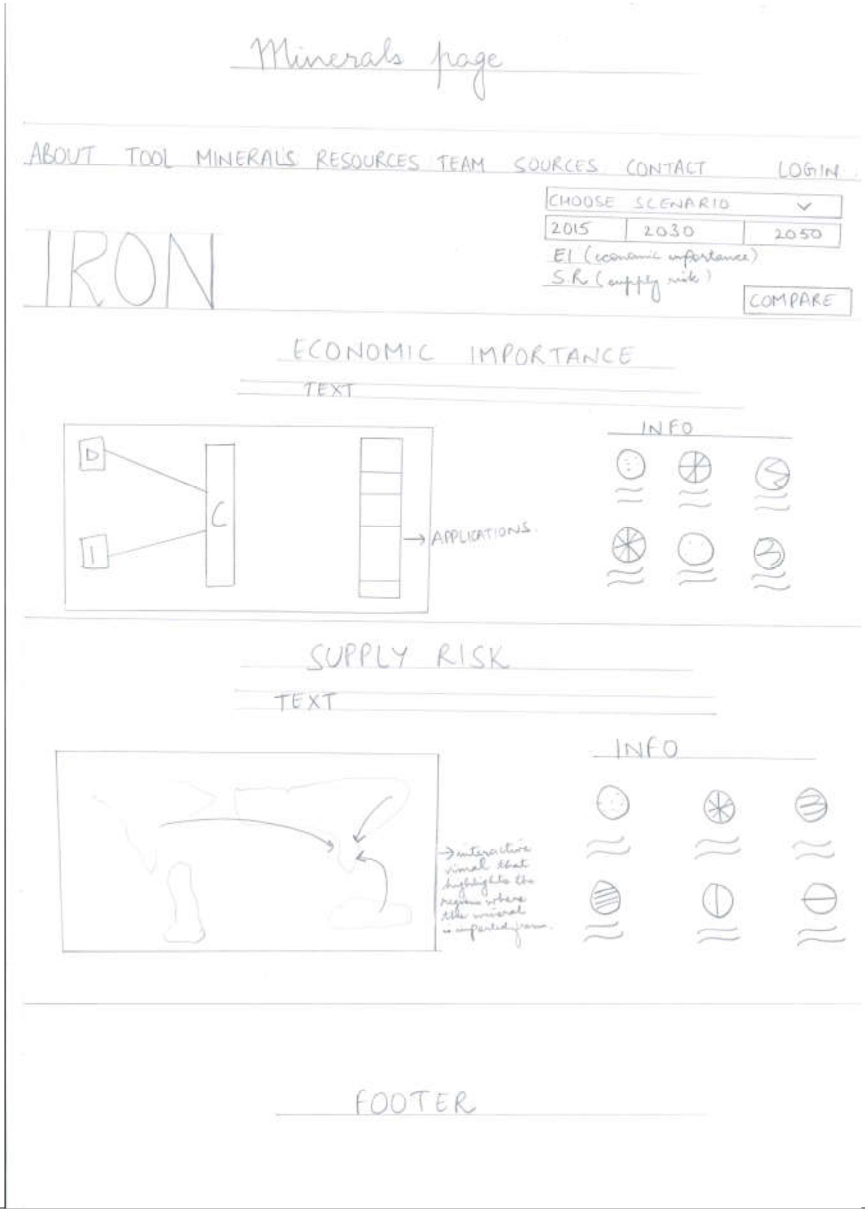
Source: CEEW Analysis

Draft layout – Home page



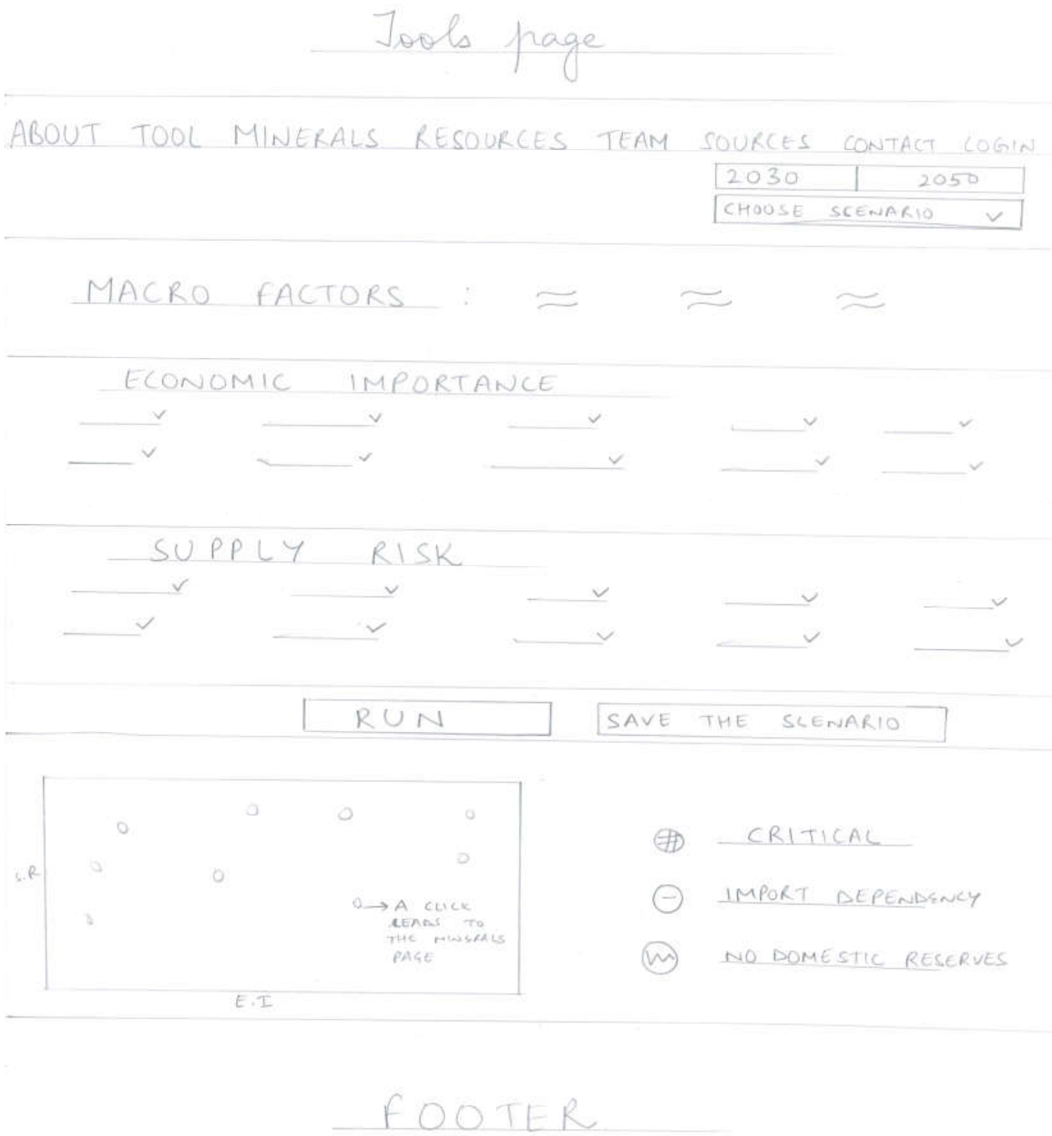
Source: CEEW Analysis

Draft layout – Minerals page



Source: CEEW Analysis

Draft layout – Tools page



Source: CEEW Analysis

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Thank you

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