SusMatCrit

Teaching Resources on the Sustainable Management of Critical Raw Materials

Trainer's Manual for Geopolitical Aspects

March 2020

eit RawMaterials ACADEMY

This activity has received funding from the European Institute of Innovation and Technology (EIT), a body of the European Union, under the Horizon 2020, the EU Framework Programme for Research and Innovation

Table of Contents

1 Context and Introduction to Training 3

1.1 Training Materials List 4

1.2 Suggested timetable 5

1.3 Key Messages 5

1.4 Learning Objectives 6

1.5 Additional Reading 6

2 Slides and Notes 8

3 Geopolitical exercise notes 17

4 Acknowledgements and Authors 18

5 Citation 19

6 Disclaimer 19

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1 Context and Introduction to Training

This booklet is supplementing the teaching materials and the set of further supporting booklets that have been developed to support teachers in conducting training courses related to the sustainable management of critical raw materials.

SusCritMat aims to educate people from Master's student level up, both in industry and academia about important aspects of sustainable critical raw materials. In a novel concept, it introduces courses on these complex and interdisciplinary topics in a modular structure, adaptable to a variety of different formats and accessible to both students and managers in industry. These courses will develop new skills, which will help participants to better understand the impact and role of critical raw materials in the whole value chain; enabling them to identify and mitigate risks. Understanding the bigger picture and the interconnected nature of global business and society is increasingly necessary to and valued by industry.

SusCritMat is an EU-funded project that brings together the technical and pedagogical expertise of leading educational institutions and business partners. It uses and creates teaching materials which can be combined into different course formats.

The collection of training manuals presents the key messages related with the sustainable management of critical raw materials in three major sections:

- Introduction to criticality
- Analysis of criticality
- Solutions for sustainable management

In particular, the solutions part will be in the focus. The intention is to underline the possibilities that are available to approach and implement a circular economy for critical raw materials and the products bearing these. Doing so the concrete actions, i.e. the things that can be done, are highlighted, instead of only mentioning all sorts of associated problems or barriers in the context of CRMs.

The overall goal of the SusCritMat project is to qualify lecturers to teach the topics themselves. Therefore, the teaching resources do not only provide an introduction and improved insight into selected thematic issues, but also deliver a set of teaching materials "ready-to-use".

- Learning targets that will be reached after having taught the courses
- Presentations on the specific topics including also notes on how to present the slides and key messages.
- Group work exercises including the task or question to work on, if applicable further reading on the methodology and the solutions in case of tasks requiring calculations.
- Assessment questions and the correct answers for each specific topic.
- Additional reading for each topic.

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1.1 Training Materials List

The *SusCritMat project* developed the following teaching materials:

Basics
Critical Resources for Emerging Technologies
Criticality
Supply Chain Resilience
Supply Risk Factors
Circularity
Circular Economy
Characterizing the Urban Mine
Circular Business Models
Waste Management and Recycling Potential
Closing Loops on Product Level
Governance
Geopolitical Aspects
Metals & CRM Scenarios
Restricted Substances Legislation
Impact on Society and the Environment
Sustainability Assessment
Responsible Mining
Responsible Sourcing / Certification
Environmental Aspects
Sustainable Materials Usage
CRM and Sustainable Development
Tools
MFA - Material Flow Management
Good Use of Data
LCA – Life Cycle Assessment
Process Models based on LCA

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1.2 Suggested timetable

The agenda contains a recommended timing for the lecture and exercises. However, depending on the pre-existing knowledge or group size the time can be extended.

- Lecture: 40 minutes
- Exercise: 95 minutes (including 15 minutes break). The exercise can be performed in groups or be an individual assignment.
- Recap: 20 minutes

1.3 Key Messages

This training module introduces frameworks around which geopolitical aspects are explored which have led to the current framing of critical materials in the 21st century. The module includes:

- A presentation giving an overview of key events in the 20th century
- A geopolitical consideration for technological and economical stakes
- A class based exercise to develop viewpoints and lessons learned for learners
- Key guiding topics for teachers in the class based exercise
- A short recap presentation to conclude the class based exercise

This module presents a narrative of the journey to the notion of critical materials in the 21st century. The journey covers the period from the first world war, through to the first use of the term 'critical materials' just before world war two, through the post war period into the 21st century. There is a focus on Europe and USA in this module. However, criticality is not only based on raw materials but also on the technologies that determine their transformation and their use. Technologies are an object of tension as they take part to economical development and to technological sovereignties. Therefore, criticality must be understood along the whole value chain.

For teachers and learners who are more familiar with working with historical-geopolitical teaching / learning, there is an opportunity to extend the class based exercise to explore current geopolitical actions with respect to critical materials. This could be further developed to explore future scenarios.

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1.4 Learning Objectives

After following this course, the learner should be able to:

- Explain the mechanisms behind the major geopolitical trends in materials supply and demand;
- Explain the main drivers of geopolitics in relation to materials stocks and flows.
- Describe the geopolitical time-line across the 20th century.
- Describe the interlinkage with issues of sustainability – circular
- Describe a more systemic and a more global vision of criticality
- Critically assess the barriers and drivers of critical materials, in a geopolitical context, going forwards. Define the actions which can effect critical materials issues in the future.

1.5 Additional Reading

1 Abraham. D. S., The Elements of Power: Gadgets, Guns, and the Struggle for a Sustainable Future in the Rare Metal Age, Yale University Press, 2015.

2 Danino-Perraud R. The Recycling of Lithium-Ion Batteries:A Strategic Pillar for the European Battery Alliance, Études de l'Ifri, Ifri, 2020.

3 Eckes. A. E., The United States and the Global Struggle for Minerals, University of Texas Press, 1979.

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13 Johnson J., Harper E.M., Lifset R., Graedel T.E., Dining at the Periodic Table: Metals Concentrations as They Relate to Recycling, Journal of Environmental Science and Technology, Vol 41, 1759-1765, 2007.

14 Le Gleuher M. (2020). Le commerce mondial des déchets de cuivre et d'aluminium a été transformé par les mesures environnementales chinoises et les tensions commerciales sino-américaines. Online, http://www.mineralinfo.fr/ecomine/commerce-mondial-dechets-cuivre-daluminium-ete-transforme-mesures-environnementales

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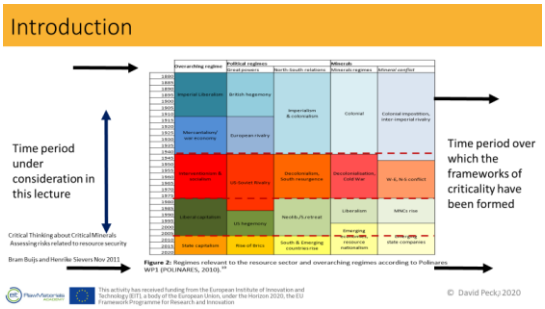
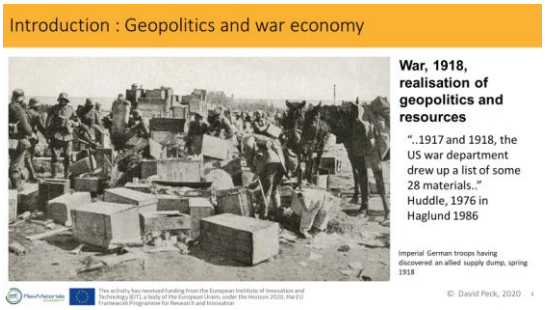
17 National Academy of Sciences, Managing Materials for a Twenty-first Century Military, Contributing authors; Committee on Assessing the Need for a Defense Stockpile, National Materials Advisory Board & Division on Engineering and Physical Sciences, The National Academies Press, Washington, D.C., 2008.
18 Paley, William S, Resources for Freedom, Volume 1, Foundations for Growth and Security, The President's Material Policy Commission Report, 1952.
19 Pavel C.C., Tzimas E. *Raw Materials in the defense industry,* Joint Research Center (JRC), Publications Office of the European Union, Luxembourg, 2016
20 Peck, D.P., Bakker, C.A., Kandachar, P.V., de Rijk, T., Product policy and material scarcity challenges : The essential role of government in the past and lessons for today, Research in Design Series, Vol. 9., IOS Press, 2017.
21 Porter M.E. (1990). The competitive advantage of Nations. The free press edition, New-York
22 Radetzki M, Waren L. *A Handbook of Primary Commodities in the Global Economy,* Cambridge University Press, 2017
23 Simpson R D, Toman M A & Ayres R U, Scarcity and Growth in the New millennium: Summary, Discussion paper 04-01, Resources for the Future, Washington D.C., 2004.
24 Tilton J E, On Borrowed Time? Assessing the Threat of Mineral Depletion, RFF Press, Washington, D.C., 2003.
25 Tilton J E, Depletion and the long-run Availability of Mineral Commodities, Report published by IIED for WBCSD, Washington D.C., 2001.

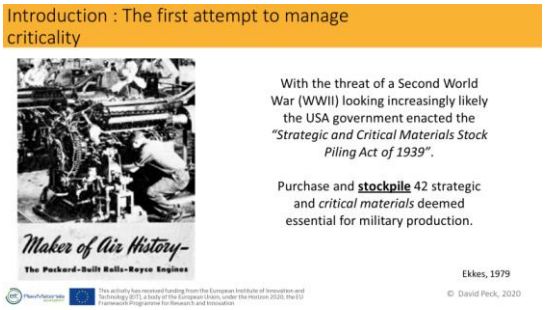
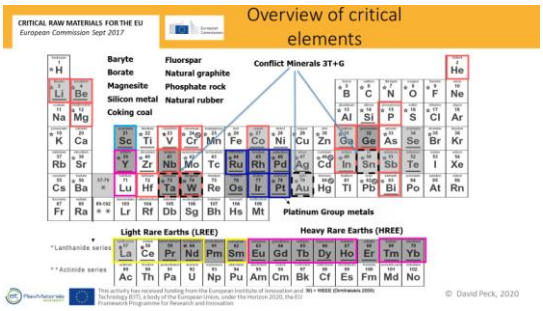
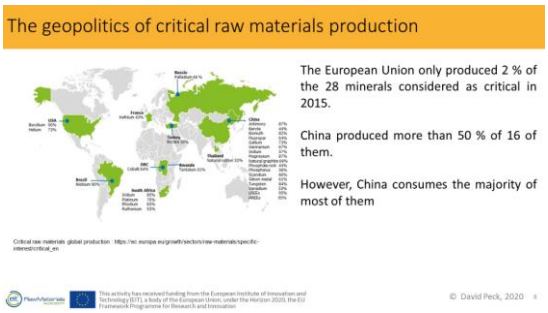
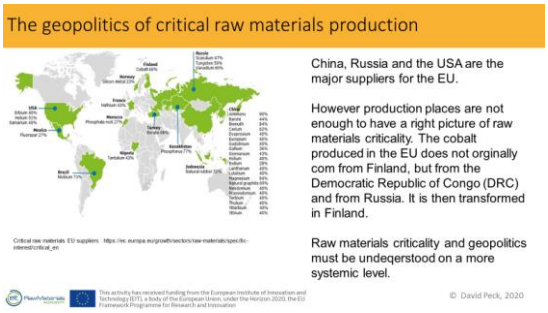
2 Slides and Notes

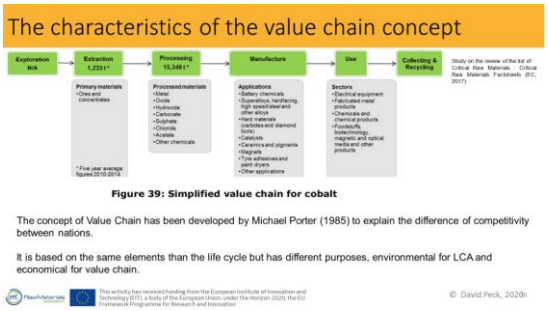
Slides are supplied in ppt format with annotations.

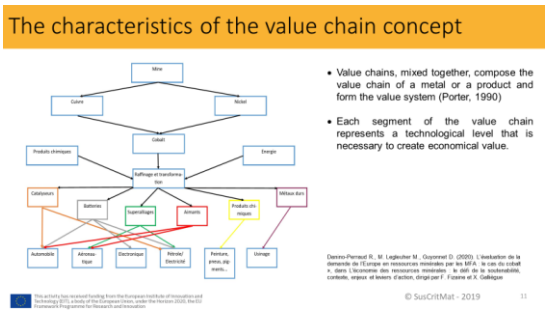


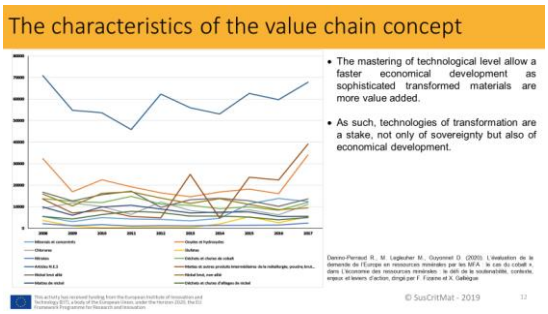
- Even in the antiquity, mineral resources have been a strategic issue for Athens (Laurion mines for silver) or Rome (Tin from the Cornwall).
- The economic take-off of Europe in the 16th century has been the result (among others) of the contribution of the gold from South-America during the Spanish conquest.
- The colonial conquest of the 19th century aimed at controlling the commercial roads and the resources of the colonized countries (Gold and diamonds in South-Africa, rubber in Indochina, Tin in Birman, Nickel in New-Caledonia…).
- Both World War I and World War II unveiled the differences

	between “have” and “have not” countries and the strategy to organize or acquire the supplies. ● After the war, the reconstruction, the cold war and the decolonization disrupted the structures of the mining industry, between a growing consumption, nationalization (copper in Zambia and Zaire) and raw materials used as weapon (chromium and Manganese by the USSR). ● The end of the cold war and the victory of liberal capitalism transformed again the structures of the industry, with the concurrence brought by the foremost communist countries. ● Finally, the beginning of the 21th century showed the revival of state capitalism, with the organization and the planning of investments and supplies in raw materials (China) (Humphreys, 1995; 2013).
	Noticing some shortages during the war and the diminution of some materials’ US reserves, the list considered 28 materials and among them: nickel, chromium, manganese, copper or zinc (Ecke, 1980).
	Mineral resources played a major role in the conduct of the two world wars: ● The naval blockade of Germany diminished its resources and prevent it to develop new technological project like the tank (World War I).

	• Mineral resources has been decisive for the German decision to sign a treaty then to invade the Soviet Union and for Japan to invade south-east Asia. The possession of resources on their territories has been a decisive element for the final victory of the allies (Ecke, 1980).
	Among the 42 strategic and critical materials: aluminium, antimony, chromium, manganese, magnesium, molybdenum, tin, tungsten, vanadium
	
	
	



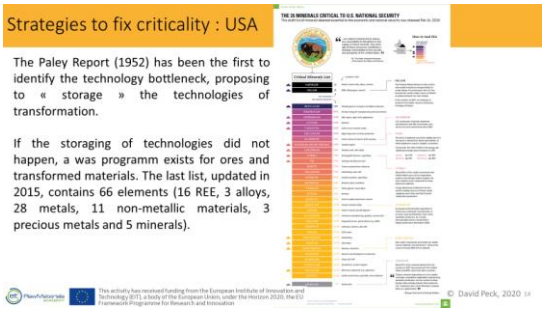




The cobalt market is divided in five types of products from the less to the more sophisticated:

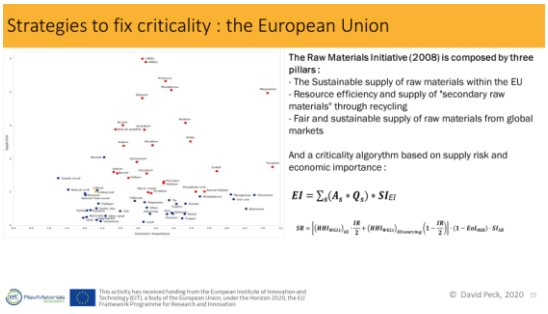
- Ores and concentrates
- Intermediates products (mattes and other intermediary products of cobalt
- metallurgy; nickel alloys; Mixed nickel-cobalt hydroxides…)
- Chemical products (Oxides, hydroxides, sulfates, nitrates, chlorides…)
- Metallic products (Article of cobalt)
- Waste and scraps

- On the picture, ores and concentrates have the lowest value, intermediate
- products and chemicals, the middle value and cobalt metal, the highest .



Examples :

- Ores : oxides of aluminium and beryllium
- Metals : Aluminium, béryllium, cadmium, chromium, cobalt, cuivre, gallium, indium, lithium, nickel, niobium, vanadium, zinc, zirconium.
- Alloys : aluminium-lithium, beryllium-copper, cadmium-zinc.
- Precious metals : Iridium, palladium, platinum.
- Non metallic : arsenic, germanium, graphite, silicium carbides...



Among the variables:

→ Supply risk:

- Imports reliance
- Recycling input rate
- Substitution index

→ Economic importance:

- Economic importance of a material in an industrial sector
- Substitution index

Strategies to fix criticality : Japan

Japan strategy is managed by the Japan Oil Gas and Metal National Corporation (JOGMEC) and is based on four pillar : Diplomatic action, recycling, substitution and storage.

An active diplomatic action help japanese companies to invest in raw materials through credit facilities or technology transferts.

The recycling and substitution strategy based on an strong R&D politics is one of the more advanced of the world

JOGMEC

Japan Oil, Gas and Metals National Corporation

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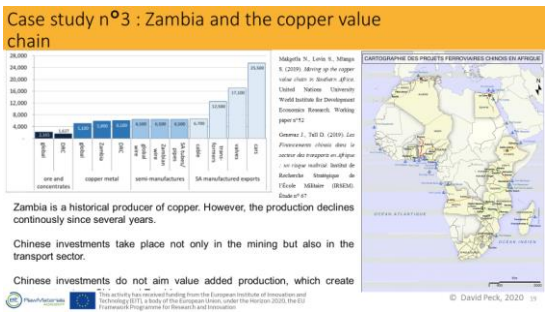
Examples of participation to projects linked to critical raw materials:

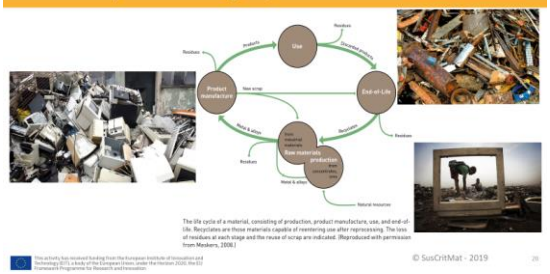
- Financing Lynas (Australia), the only company outside China to produce
- rare earths ores.
- Building of the cobalt refining facilities of Corel Bay and Taganito in the
- Philippines.
- Exploitation of lithium and building of a refining facility in Argentina
- (Orocobre) by Toyota.

Legislation for recycling:

- Basic Act for Establishing a Sound Material-Cycle Society (Basic
- Framework Act)
- Fundamental Plan for Establishing a Sound Material-Cycle Society
- Waste Management and Public Cleansing Act on the Promotion of
- Effective Utilization of Resources
- Act on the Promotion of Sorted Collection and Recycling of
- Containers and Packaging (Containers and Packaging Recycling Act)
- Acton Recycling of Specified Kinds of Home Appliances (Home Appliance

	• Recycling Act) • Acton Recycling of End-of-Life Vehicles • Small Home Appliances Recycling Act
	
	• The quantities of materials sometimes required are so low (a few grams) that production or supply is not an issue. • The issue is the transformation and the production of a very sophisticated product integrable in military materials. • Furthermore, one of the main issue is the number of intermediaries between the main companies and the raw materials.
	• Zambia is a historical producer of copper. However, the production declines continously since several years. • Chinese investments take place not only in the mining but also in the transport sector. • Chinese investments do not aim value added production, which create tensions between China and Zambia.

Case study n°4 : The geopolitic of wastes

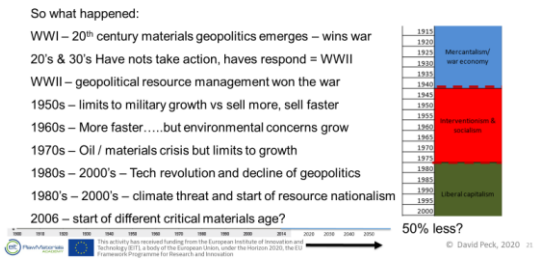


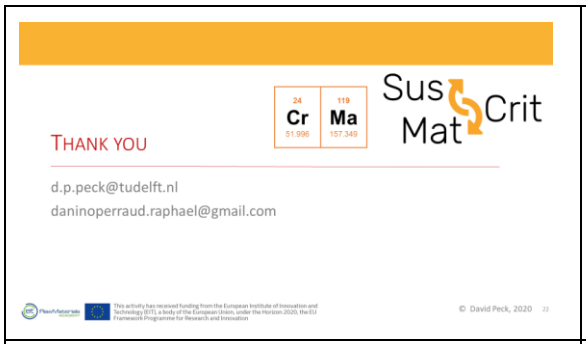
Wastes, as they are composed of valuable metals, are becoming a geopolitical and an industrial stakes. They might be a part of the solution of the issues related to the raw materials supplies, but also allow the creation of jobs and economic values through the development of the industry.

However, they face several issues:

- Illegal exportation: About 50% ow the waste of electric and electronic equipments (WEEE) collected in the European Union are illegally exported (Huisman *et al.,* 2015)
- Scraps industry: the reuse of scrap is of strategic concerns, they are also of environmental concerns. In 2019, China put an import ban on copper and aluminium scraps, not pure enough or too polluted to be recycled. It caused an important disruption of the recycling industry in Europe (Le Gleuher, 2019).
- Investment in recycling facilities for lithium-ion batteries show that it is becoming an industrial stake as much as an environmental stake (Danino-Perraud, 2020.

Geopolitics and resources summary

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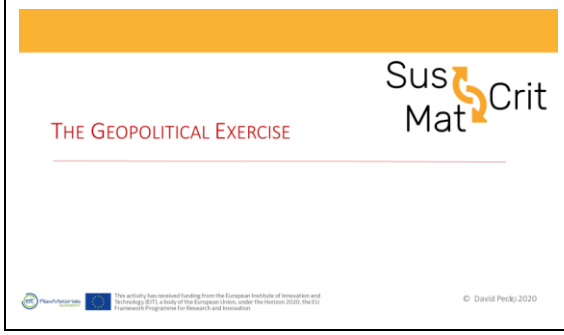
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THE GEOPOLITICAL EXERCISE
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3 Geopolitical exercise notes

In your group / pairs / individually, you are one of the following type of countries and you must develop a strategy for exploiting your own mineral resources and/or assure a sustainable supply for your industry:

- You are a developed country with an unknown number of mineral resources, but potentially important considering your industrial past. However, you face a strong internal opposition led by environmental activists and a lack of political determination to implement an active mining politics. How do you think it could be possible to relaunch the mining industry?

- You are a developed country with a strong industry and a high technological level but with very few resources. Led by strong financial and political support, how would you manage to ensure a sustainable and necessary supply for your industry and your economy?

- You are a developed country with active mining policies and industries feeding your important needs. However the open-market strategy does not encourage the investment in your resources because of lower profits and competition of other cheaper producers. What would be your interest in developing your mining industries? How could you do it? Would you have other possibilities? Could you develop your foreign investment?

- You are a developing country and want to bring out your mineral resources for your own purposes. However, your administrative system of investment is not efficient and would need to be transformed. As your country is vast and your resources unknown you could need to develop infrastructures to allow the transport and the transformation of materials. You are provided with reasonable financial means (limited by come corruption) but will need to respect new standards of production.

- You are a developing country and a historical producer of some mineral. Because of economical circumstances, your production went down and so did your administrative and political system. As you want to take advantage of a good economic context you need foreign money to develop your resources. Your population and your economic counsellors also ask for the development of the downstream industry to create new jobs and value for the whole economy. However, you have to negotiate the taxes level and the compensations with the foreign companies supported by their own government.

- You are a under-developed country and face heavy debt, corruption, illegal working and infrastructures issues. Some group are contesting your leadership, potentially leading to civil war. You are one of the poorest country on the planet but your underground contain the majority of the most important metals in the world. As their exploitation could be the source of great revenues for your country, it could also encourage poverty and corruption. What could you imagine to optimally develop your industry and your country?

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4 Acknowledgements and Authors

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The following authors have contributed to prepare the complete teaching material kit and intend to provide an overview of major topics surrounding the sustainable management of critical raw materials:

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Steven Young, University of Waterloo

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6 Disclaimer

The teaching materials within the SusCritMat project have been prepared with great care and experienced several revisions. Nevertheless, the consortium assumes no liability for the topicality, completeness and correctness of the content provided.

In case you have suggestions or other feedback how to improve the materials, we value your opinion: Please contact us via the project webpage https://suscritmat.eu/contact/.

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