Interreg Europe

Co-funded by the European Union

RAW4RES

FREDERIKSHAVN KOMMUNE

REPORT

Documentation and exchange of risk mitigation measures for reducing CRMs and industrial metals territorial depencencies

Activity A1.4

Pathways to increase the territorial resilience to disruptions in the critical raw materials value chains

JULY 2024

Executive Summary

The purpose of this document is to analyse, review, and discuss the territorial evidence collected through the online surveys concerning the territorial evidence on strategically important CRMs in RAW4RES partners' regions and the economic sectors/ activities that are most at-risk/ vulnerable in case of potential supply disruptions, along with effective mitigation strategies to address the vulnerability of territorial CRM supply chains. The analysis and discussion also incorporate the findings from the online scenario building exercise conducted after the collection of territorial evidence as part of the Activity.

To this end, the document comprises the following sections:

- **Chapter 1** provides a brief overview of Activity A1.4, setting the context and purpose for the subsequent analysis.
- **Chapter 2** briefly presents the data collection process emphasing on the individual regions of focus for the data collection process and outlining the questionnaires' structure.
- **Chapter 3** discusses the collected territorial input, starting with an overview of the data collected, including the identity of the online survey and the data processing. It then presents the survey results, first at an aggregated level and then by RAW4RES region. It also examines the stakeholders' input, both at an aggregated level and by industry/sector.
- **Chapter 4** presents the key topics discussed and insights from the online scenario-building exercise and assesses the results of the exercise.
- **Chapter 5** examines and discusses the online survey results in relation to the CRM dependency scoreboard and the mitigation measures identified in the scenario-building exercise.
- **Chapter 6** provides guidelines for integrating risk mitigation strategies into partners' territorial policies according to the needs of each RAW4RES partner.

List of abbreviations

CPUs	Central Processing Units
CRM	Critical Raw Materials
EU	European Union
GPUs	Graphic Processing Units
HREE	Heavy Rare Earth Elements
ICT	Information and Communication Technology
LCA	Life Cycle Assessment
LREE	Light Rare Earth Elements
M3P	Material Match Making Platform
PGMs	Platinum Group Metals
PPPs	public-private partnerships
R&D	Research & Development
R&D&I	Research & Development & Innovation
REE	Rare Earth Elements
RM	raw material
SMEs	Small and Medium Enterprises

List of Figures

Table of contents

1. Introduction

The objective of Activity 1.4, titled “Documentation and Exchange of Risk Mitigation Measures for Reducing CRMs and Industrial Metals Territorial Dependencies,” is to facilitate partners in sharing and learning from each other’s experiences in devising strategies that can help decrease the territorial vulnerabilities of critical raw materials (CRM) and industrial metals’ value chains.

Following a methodological guide, RAW4RES partners gathered territorial data concerning a) the CRMs and metals that are crucial to each territory’s economy, along with input from industrial stakeholders, and b) the regional economic activities or sectors that are most susceptible to potential supply disruptions. Subsequently, FHN conducted a virtual scenario-building exercise, providing partners with a platform to create a CRM dependency scoreboard for each territory and collaboratively pinpoint mitigation measures for territorial activities at risk during potential scarcity and disruption events.

This document builds on the results of the scenario-building exercise, delving into the findings from the gathered territorial evidence and comparing it with the mitigation strategies and the scoreboard developed during the exercise. The report also offers suggestions for enhancing the policy instruments addressed by partners, with a focus on incorporating emergency funding and risk management strategies to handle potential disruptions, as well as modifying the criteria in future calls for business support, with the aim of encouraging supply diversification within project territories.

2. Overview of the Data Collection Process

RAW4RES partners were provided with two questionnaires for data collection. The first, referred to as the partners' questionnaire, was designed to gather information from the project partners. The second, referred to as the stakeholders' questionnaire, was meant to be filled out by the partners' regional stakeholders, particularly those significantly involved in CRM supply chains or CRM mining projects in their region.

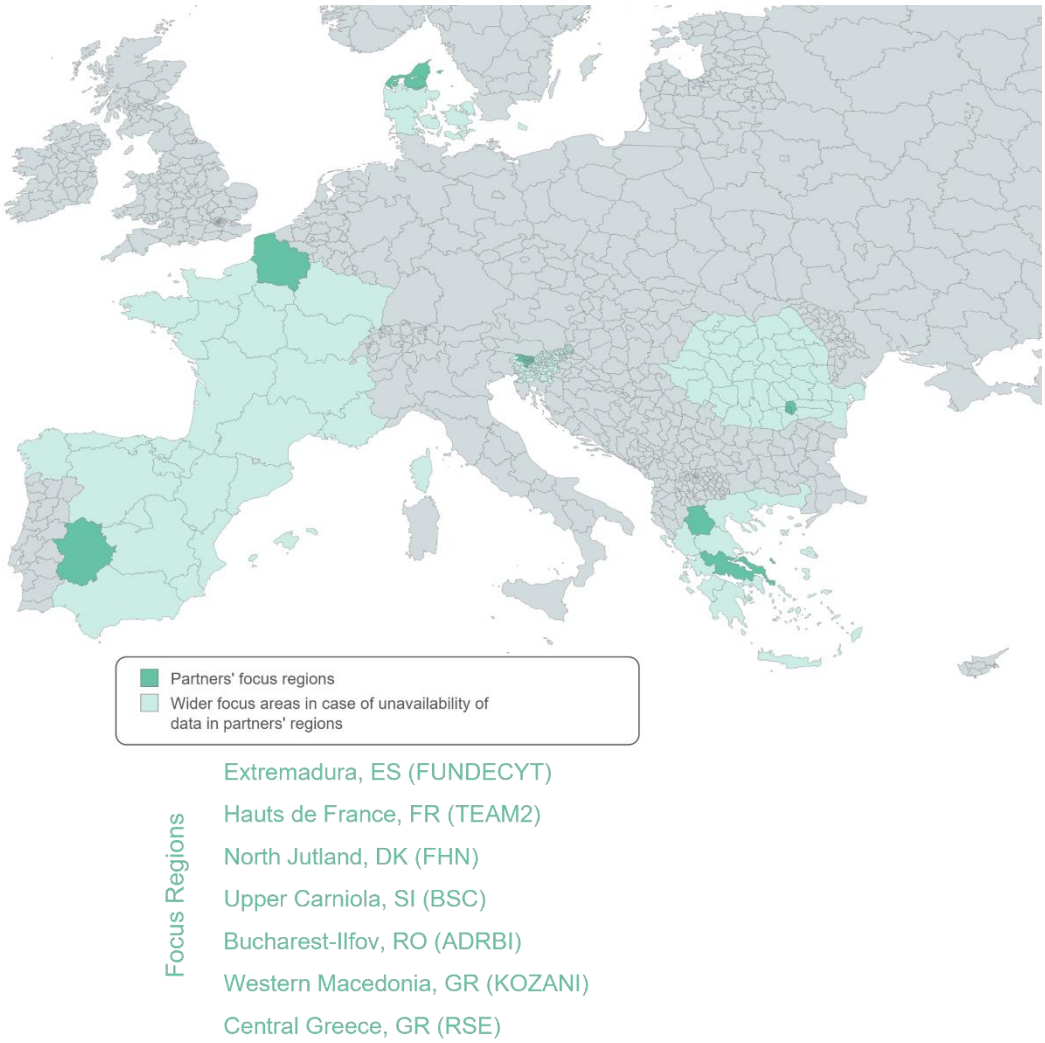

Figure 1: *Map of the RAW4RES partnership indicating the individual regions of focus for the data collection process. (created with mapchart.net)*

Both questionnaires shared a similar structure, incorporating both closed and open-ended questions. These questions were designed to guide respondents in identifying and evaluating: a) the importance of strategic raw materials (RM) and metals; b) the regional economic sectors

and activities most susceptible to potential supply disruptions; c) the significant CRM supply risks and challenges their regions and industries face; d) the most effective strategies to mitigate potential CRM supply disruptions

Each questionnaire consisted of five sections, with Section C differing for partners and stakeholders:

- **Section A:** Contact information
- **Section B:** Identifying critical raw materials and metals that are of strategic importance
- **Section C *(partners' questionnaire)*:** Identifying sectors / economic activities that are most vulnerable to potential supply disruptions
- **Section C *(questionnaire for industry stakeholders)*:** Industry identification and assessment of vulnerability to potential supply disruptions
- **Section D:** Identifying CRM supply challenges and risks
- **Section E:** Identifying risk mitigation strategies

For a detailed presentation of the assessment criteria and descriptors used in each section of the questionnaire, readers are advised to refer to ANNEX I.

In order to ensure efficient data collection within the timeline of Activity A1.4, minimum objectives were established. These objectives were designed both for the acquisition of territorial evidence by the project partners and for obtaining input from industry stakeholders. The purpose of these objectives was to supervise the data collection process and ensure that sufficient information was gathered. In terms of stakeholder participation, a goal was set for each partner to collect feedback from up to 5 respondents, to ensure that sufficient evidence was provided.

3. Presentation and Evaluation of the Territorial Input

This section provides an overview and an evaluation of the territorial evidence collected by partners as well as stakeholders, including a discussion on data quality and consistency.

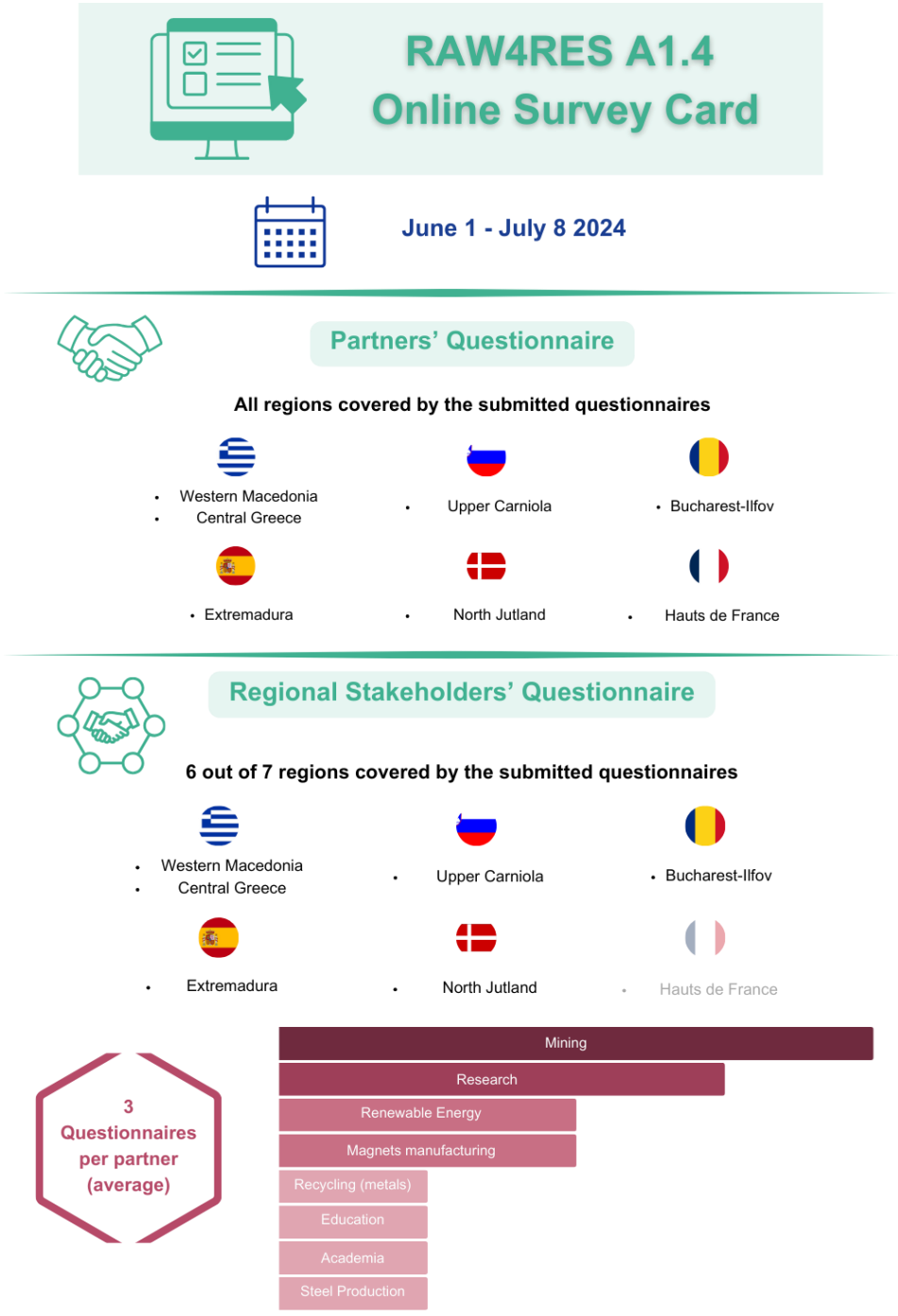

Figure 2: *Online Survey Card*

3.1 Overview of the data collected

At the request of the RAW4RES partners, the submission deadline for both the partners' and stakeholders' questionnaires, originally set for June 21, 2024, was extended to the morning of July 8, 2024. Then the online building exercise, which required a preliminary analysis of the partners' questionnaires, took place on July 9, 2024.

All partners successfully completed the primary questionnaire. However, concerning the secondary questionnaire, There was not any input from French stakeholders. On average, each of the remaining six partners submitted three questionnaires from regional stakeholders (**Figure 2**). Of the 15 stakeholders' questionnaires received in total, over a quarter (4 questionnaires) were from the mining sector, and another 20% (3 questionnaires) were from the research institutions.

It is important to note that certain sectors (mining, research) are overrepresented in the stakeholders' data. Given the limited number of questionnaires received, the results of the analysis are inherently biased towards these sectors. Therefore, *readers are advised to interpret the findings of the data analysis from the stakeholders' questionnaires with caution*.

3.1.1 Data preprocessing

During the initial data processing of the partners' input, some inconsistencies with the guidelines were noticed, leading to the exclusion of certain inputs from the analysis:

- In **Section B**, which focuses on identifying critical raw materials and metals of strategic importance, the Slovenian partner (BSC Kranj) listed ***"low CO_2 steel"*** as an additional CRM of strategic importance for their region (Upper Carniola). However, while steel is indeed of strategic importance, it is not a metal or mineral in itself, and thus it was **not considered in the data analysis** (*see Methodology, Section 2.1 - Definition and Importance of Critical and Strategic Raw Materials*).

- In **Section B**, the Danish partner (FHN) listed ***"neodymium"*** as an additional strategic raw material. However, neodymium is part of the broader set of metallic elements known as Light Rare Earth Elements (LREE), which was already included in the list of predefined raw materials that partners were asked to evaluate. Considering that the partner had already listed LREE as being moderately important (rating 1) for the regional economy, neodymium's evaluation was **incorporated in the evaluation of LREE**.

- In **Section D**, which is dedicated to pinpointing the risks and challenges that could affect CRM supply chains, the French partner (TEAM2) identified as an additional risk / challenge the ***"Massification of end-of-life product or CRM deposit for subsequent recycling"***. This concern has been **categorised under the broader risk of "Limited recycling schemes"**, which encompasses both the disposal of end-of-life products and the absence of recycling initiatives.

- In **Section D**, the Slovenian partner (BSC Kranj) listed ***"Permitting procedures"*** as an additional risk / challenge to the CRM supply chains. However, within the context of the Activity such a concern is an **aspect of the broader risk "Limited domestic resources"** (*see Methodology, Section 2.4 - Supply risks and challenges of Critical Raw Materials value chains in the EU*).

3.2 Presentation of survey results

3.2.1 Partners' Questionnaires – Aggregated Results

From the list of 34 raw materials provided to partners, 24 (or 71%) were assessed as important raw materials[1] by more than half of the partners for their regional or national economies. There was an agreement among all partners on the significance of the set of **Rare Earth Elements (REE)**, including LREE and Heavy Rare Earth Elements (HREE), as well as **battery grade Nickel** (>99.8% purity). **Manganese** was identified by most partners (5 out of 7 or 71%) as critically significant for their economies. In addition to the provided raw materials, **chrome** was identified as critically important by two partners (Region of Central Greece and ADRBI), and **zinc** was also considered critically significant by ADRBI.

On an aggregate basis, all partners evaluated the **renewables sector as the most vulnerable** to CRM supply chain disruptions, with 6 out of 7 partners rating its vulnerability level as critical. The **electric mobility sector** was assessed as the second most vulnerable, with 5 out of 7 partners considering it at high risk due to potential CRM supply chain disruptions.

[1] *It refers to raw materials assessed as being from 1- Moderately important to 3 – Critically important for regional / national economies.*

Concerning technologies, wind turbines were assessed as the most vulnerable to potential CRM supply chain disruptions, with 4 out of 7 partners rating them as extremely vulnerable. Li-ion batteries were identified as the second most vulnerable technology. It's worth noting that the responses varied significantly among partners, likely due to differences in territorial economic activities and their dependence on imports.

There was an agreement among all partners regarding the **impact of EU's import dependency for raw materials on the vulnerability of CRM supply chains**. It was assessed by 5 out of 7 partners, or 71%, as a key factor that could potentially render CRM supply chain vulnerable to disruption. Furthermore, over half of the partners (57% or 4 out of 7) assessed both the geographic concentration of CRM production and the geopolitical tensions and risks as potentially impactful on regional and EU-wide CRM supply chains.

The assessment of risk mitigation strategies varied significantly among partners. It's important to highlight that all partners agreed that **investing in research and innovation** could to some extend mitigate potential disruptions in the supply of CRM. In fact, 3 out of 7 partners rated this as a highly effective strategy. However, when considering the collective average, the **development of domestic production and processing capacities** within the EU was deemed to be significantly effective to address the various risks that make EU CRM supply chains susceptible to disruptions.

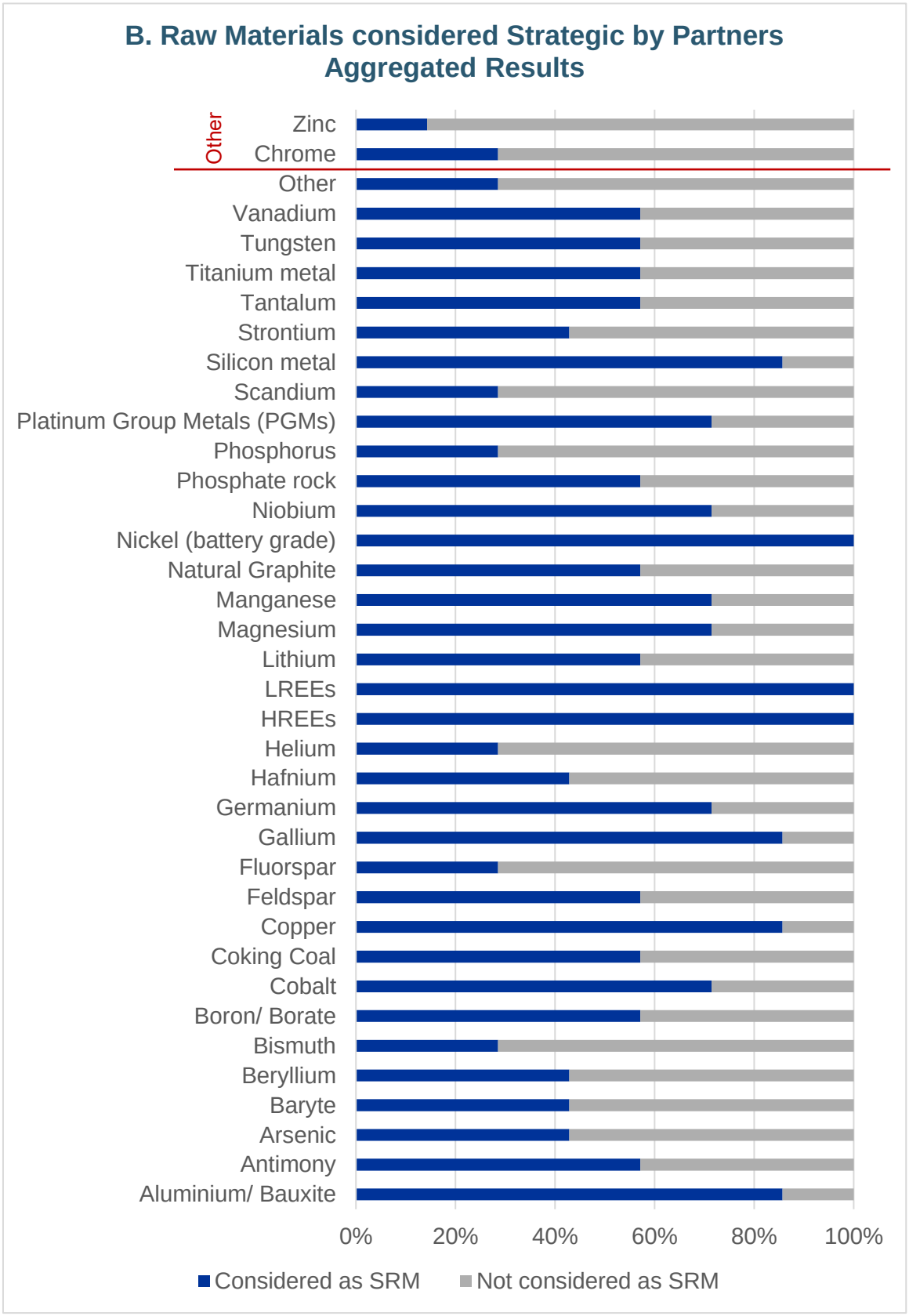

Figure 3: *Partners' Aggregated Raw Materials Scoreboard*

3.2.2 Partners' Questionnaire – Individual Results

Region of Central Greece (GR)

(partner: RSE)

Regional dependency on RM: The regional economy of Central Greece has a considerable dependence on raw materials used in technologies and applications that support the region's green transition. These materials, primarily metals and minerals, are integral to electronic systems, electrical components, and mechanical parts of solar and wind systems. They are also used in batteries for electric vehicles and information and communication technology (ICT) systems.

RM supply risks: The region's renewable energy and electric mobility industries are vulnerable to supply chain disruptions, as they depend heavily on imports. The mining of most of the required CRMs is concentrated in Africa, Asia-Pacific, and Latin America. Crystalline silicon used in photovoltaic cells is imported from the Asia-Pacific region, while REEs and several permanent magnets like cobalt, which are needed for wind turbine components, are primarily sourced from China. Similarly, battery materials such as lithium, nickel, and copper are almost exclusively imported from China and Japan. The Greek partner (RSE) highlighted that the risks associated with the EU's import dependency have increased following China's export restrictions on gallium and germanium[2], both being RREs essential for manufacturing semiconductors, photovoltaics, and optical fibres.

Risk mitigation strategies: According to the partner, to mitigate the RM supply risks, investments in research and development (R&D) are crucial for the exploitation of the region's deposits in nickel, cobalt, and manganese, such as developing dedicated hydrometallurgical processes for recovering cobalt. Notably, METLEN (MYTILINEOS Energy & Metals), following the acquisition of IMERYS BAUXITES in 2023[3], plans to implement a pilot project to assess the most efficient method of gallium extraction from bauxite ores, with the goal of producing 40-45 metric tonnes, per annum, quantities sufficient to meet current European.

[2] China's restrictions in exports of gallium and germanium were announced by China's Ministry of Commerce on July 3, 2023, citing reasons of national security. Under the new controls, special licenses are needed to export gallium and germanium from China. (https://www.bbc.com/news/business-66118831)
[3] https://www.metlengroup.com/news/press-releases/mytilineos-becomes-the-largest-bauxite-producer-in-the-european-union/

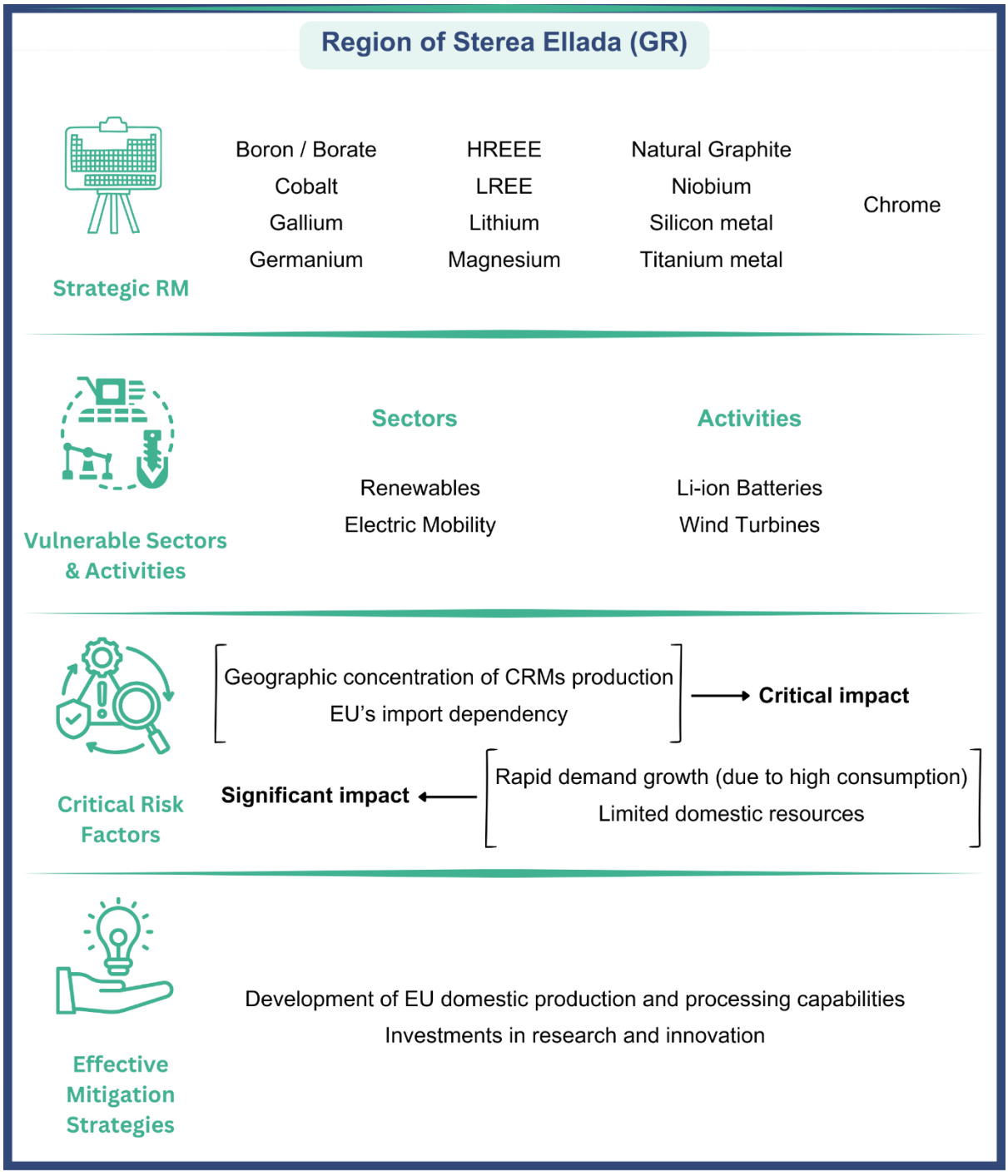

Figure 4: *Scoreboard of the Region of Central Greece (GR)*

Region of North Jutland (DK)

(partner: FHN)

Regional dependency on RM: In the North Jutland Region, CRMs are crucial to the renewable energy sector, but they also play a significant role in the electric mobility and ICT sectors. Materials such as aluminium, boron, manganese, niobium, and the platinum group metals are vitally important for manufacturing wind turbines, fuel cells, Li-ion batteries, heat pumps, and computer components, including processors and graphic processor units (GPUs).

RM supply risks: The region's efforts towards a green transition are jeopardised by the vulnerability of the CRM supply chain due to the EU's import dependency, the rapid growth in demand for CRMs, and geopolitical tensions.

Risk mitigation strategies: According to the Danish partner (FHN) remining and recycling could significantly enhance the self-sufficiency of regional CRM supply chains, thus reducing dependency on non-EU countries for CRM imports, particularly considering that Denmark does not have any CRM deposits. Although there are currently no national strategic initiatives to secure the supply of CRMs, several local and regional projects aim to develop the recycling industry, such as Recycling City[4].

[4] https://www.recyclingcity.dk/en/about-us/why-recycling-city

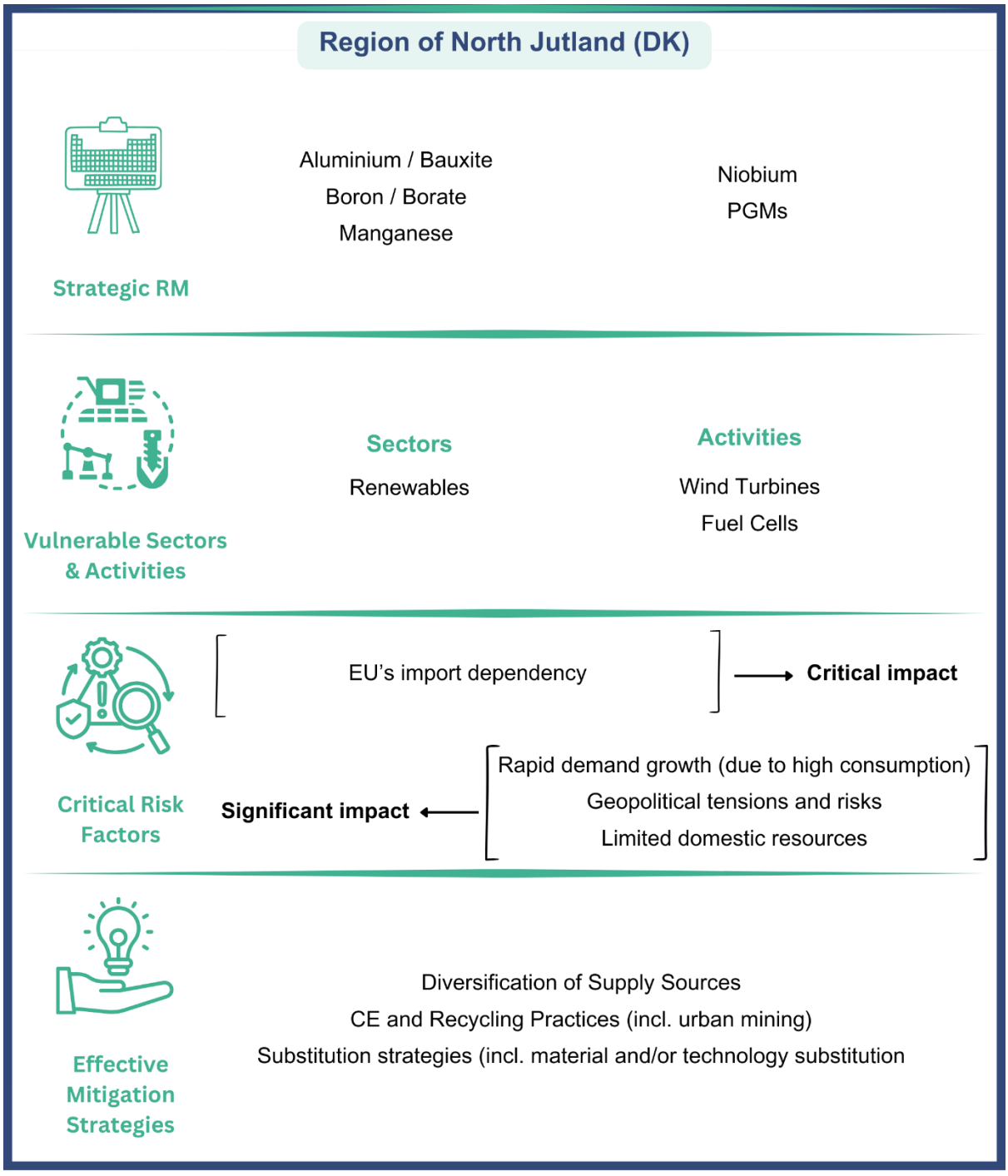

Figure 5: *Scoreboard of the Region of North Jutland (DK)*

Region of Upper Carniola (SI)

(partner: BSC Kranj)

Regional dependency on RM: In line with Slovenia's materials transition efforts, the country is striving to shift towards low-carbon production practices and enhance circular economy strategies. Slovenia's metal processing and machinery industry specialises in developing processed metals and alloys for a range of demanding applications, including inductors, batteries, and transformers. Furthermore, in the Upper Carniola region, numerous SMEs supply components for sectors such as e-mobility, renewables, ICT, aerospace, and defence. Consequently, the region's economy heavily relies on raw materials, particularly aluminium, cobalt, feldspar, fluorspar, REE, magnesium, manganese, niobium, phosphate rock, tungsten, and vanadium.

RM supply risks: The global increase in demand for CRMs coupled with EU's import dependency and the limited domestic resources can lead to significant disruptions in the CRM supply chain.

Risk mitigation strategies: According to the Slovenian partner (BSC Kranj) investments in Research, Development, and Innovation (R&D&I) are required at the national level to mitigate CRM supply challenges. At the EU level, advanced cooperation and the promotion of circular practices could support self-sufficiency. In an effort to secure regional CRM supply BSC Kranj cooperates with the Strategic Research and Innovation Partnership MATerials as end PROducts (SRIP MATPRO[5]) for the efficient management of raw materials. The SRIP MATPRO aims to strengthen strategic alliances and establish horizontal networks within Slovenia. It adopts a value chain approach to accumulate a critical mass of competencies and capacities, complementing various technologies for the development of new materials, products, and services. In addition, BSC Kranj is an active participant in a platform coordinated by the Ministry of Natural Resources and Spatial Planning. This platform facilitates an open exchange of policy measure recommendations that can most effectively support research and business growth in mining and recycling. It promotes the adoption of green technologies, circular economy models, and community engagement practices that could be integrated into policy instruments. The platform also hosts a series of public consultation events on the implementation of the EU's Critical Raw Materials Act in Slovenia.

[5] https://www.gzs.si/matpro/vsebina/ENG/ABOUT-SRIP-MATPRO

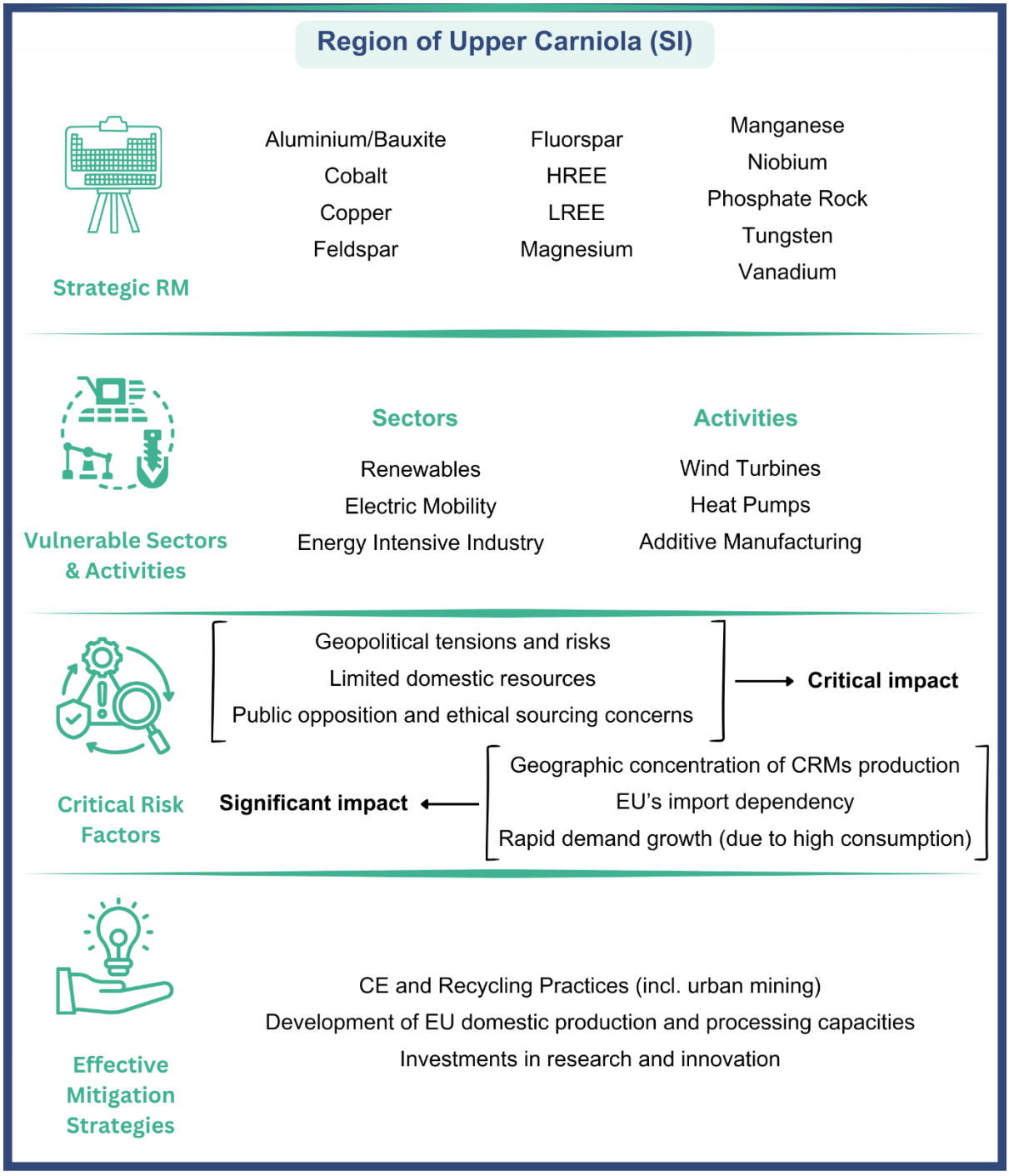

Figure 6: *Scoreboard of the Region of Upper Carniola (SI)*

Region of Bucharest-Ilfov (RO)

(partner: ADRBI)

Regional dependency on RM: In line with the country's vision for the twin transition, the Region of Bucharest-Ilfov prioritises the expansion of wind energy, enhancing building efficiency, and advancing the region's digitalisation. Key components of solar panels used for improving building energy efficiency include gallium, germanium, silicon, aluminium, and copper. Wind turbine components utilise zinc, chrome, nickel, manganese, neodymium, and dysprosium. Upgrading the communication network and establishing data centers require copper, gallium, germanium, platinum metals, and REE.

RM supply risks: A number of raw materials essential to support the regional economy, primarily silicon, tantalum, platinum, and most of the rare earths, are not locally sourced but imported from countries outside the EU. Consequently, the region and the country face significant risks from disruptions in the CRM supply chain due to the EU's import dependency.

Risk mitigation strategies: To address the RM supply chain risks, the country's National Recovery Plan emphasises the importance of circular economy and recycling practices to boost domestic production and mitigate supply chain uncertainties. Stockpiling of strategic or critical RM is also suggested by the Romanian partner (ADRBI) as a viable approach to address storage needs and price volatility in the global CRM markets.

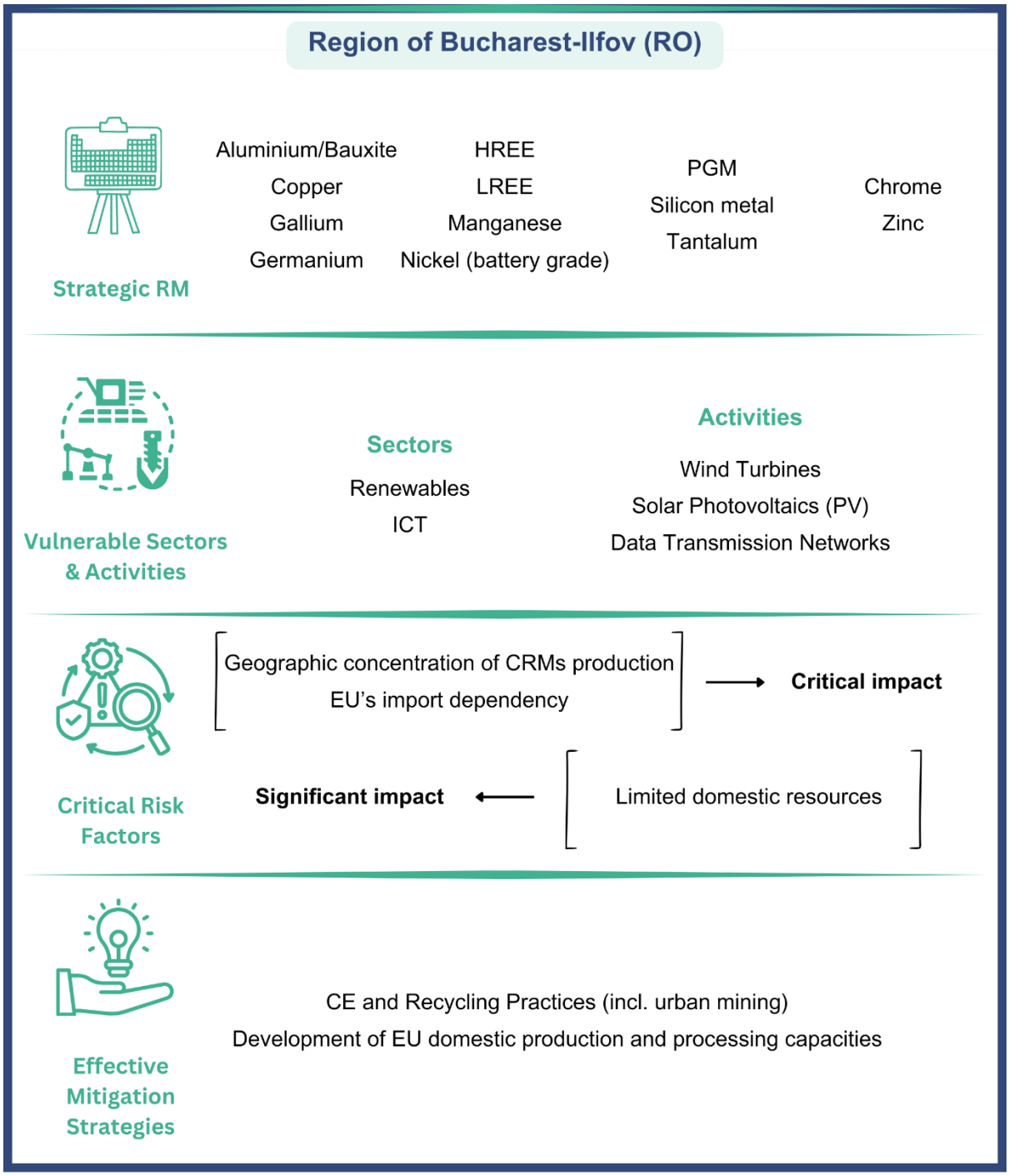

Figure 7: *Scoreboard of the Region of Bucharest-Ilfov (RO)*

Region of Hauts de France (FR)

(partner: TEAM2)

Regional dependency on RM: The Hauts de France region hosts numerous industrial sites specialising in metallurgy (including the steel industry), energy production, and mechanical engineering. Moreover, in recent years, the region has become a significant hub for the battery manufacturing industry[6]. Given the lack of mining in the region, these industries rely solely on imports for a steady supply of CRMs essential for battery and fuel cell manufacturing, such as cobalt, lithium, manganese, graphite, and nickel.

RM supply risks: The supply chains for critical raw materials are highly susceptible to external disruptions, such as geopolitical tensions and material scarcity in the CRM markets. Any disruption in CRM supply could directly result in a halt in manufacturing, further disrupting the supply for other industries like automotive and energy.

Risk mitigation strategies: Enhancing the resilience of regional and EU CRM supply chains requires the advancement and support of urban mining as highlighted by the French partner (TEAM2). Recycling alone is insufficient to provide the quantities of CRM required to support the digital transition. By promoting urban mining and processing end-of-life products into usable CRM-based materials, the region can become independent and resilient to externalities.

6 https://www.france24.com/en/live-news/20230512-battery-makers-turn-northern-french-region-into-electric-valley

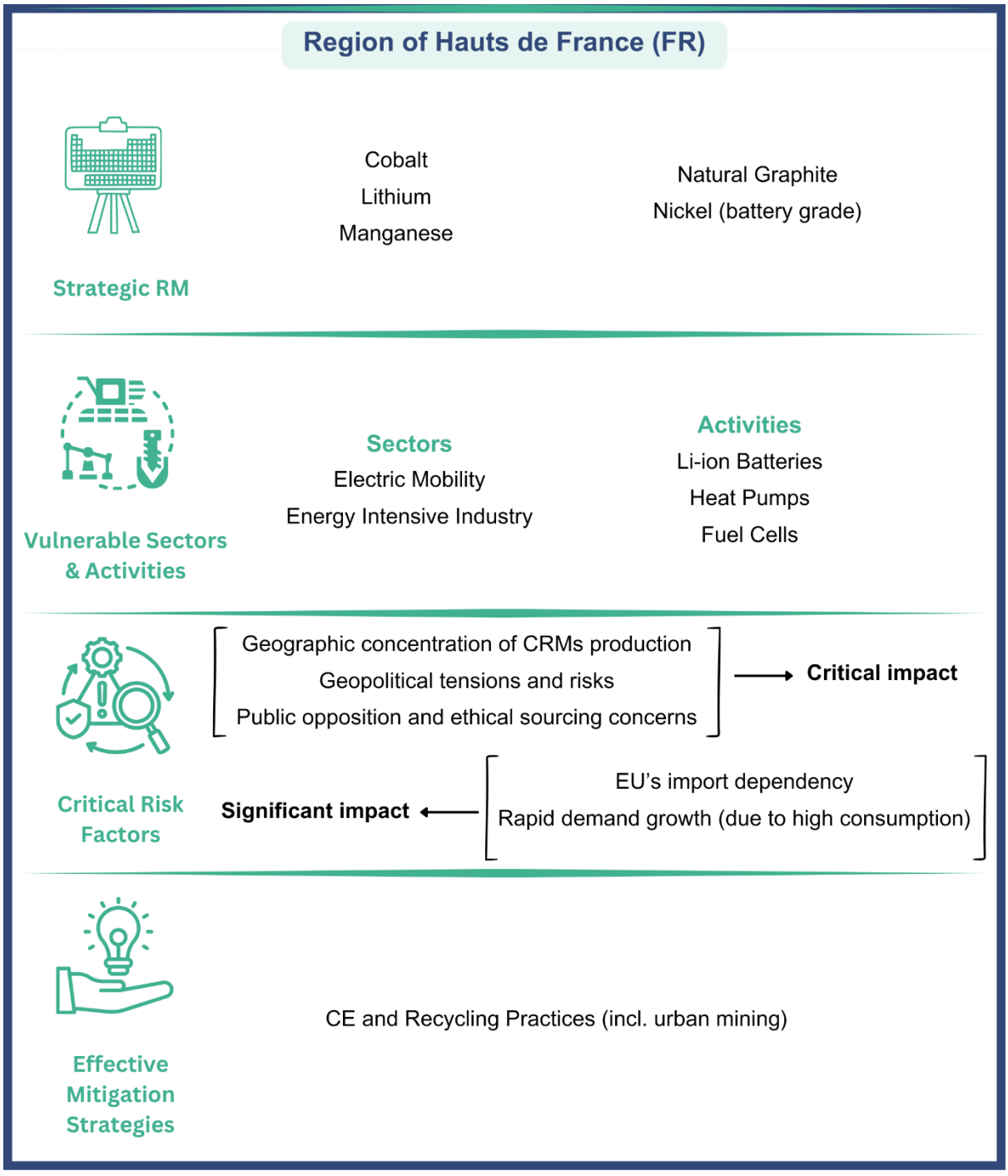

Figure 8: *Scoreboard of the Region of Hauts de France (FR)*

Region of Extremadura (ES)

(partner: FUNDECYT)

Regional dependency on RM: The Region of Extremadura relies on a variety of raw materials to support its energy-intensive industries, including the ICT, renewable energy, and electric car manufacturing industry. The region is renowned for copper mining and has significant potential for base metals and high-tech and energy transition metals such as cobalt, indium, and REE.

RM supply risks: As highlighted by the Spanish partner (FUNDECYT) public opposition from local communities to existing or new mining operations amplifies the region's industrial ecosystem's dependency on imports of CRMs. This dependency makes the regional CRM supply chains highly vulnerable to disruptions due to factors outside the EU, such as geopolitical tensions and potential external supply constraints.

Risk mitigation strategies: Investments in R&D aimed at improving the circularity of mining activities could mitigate public opposition, which primarily stems from concerns about the mining sector's environmental and social impact. In turn, this could enhance the regional domestic production of critical and strategic raw materials.

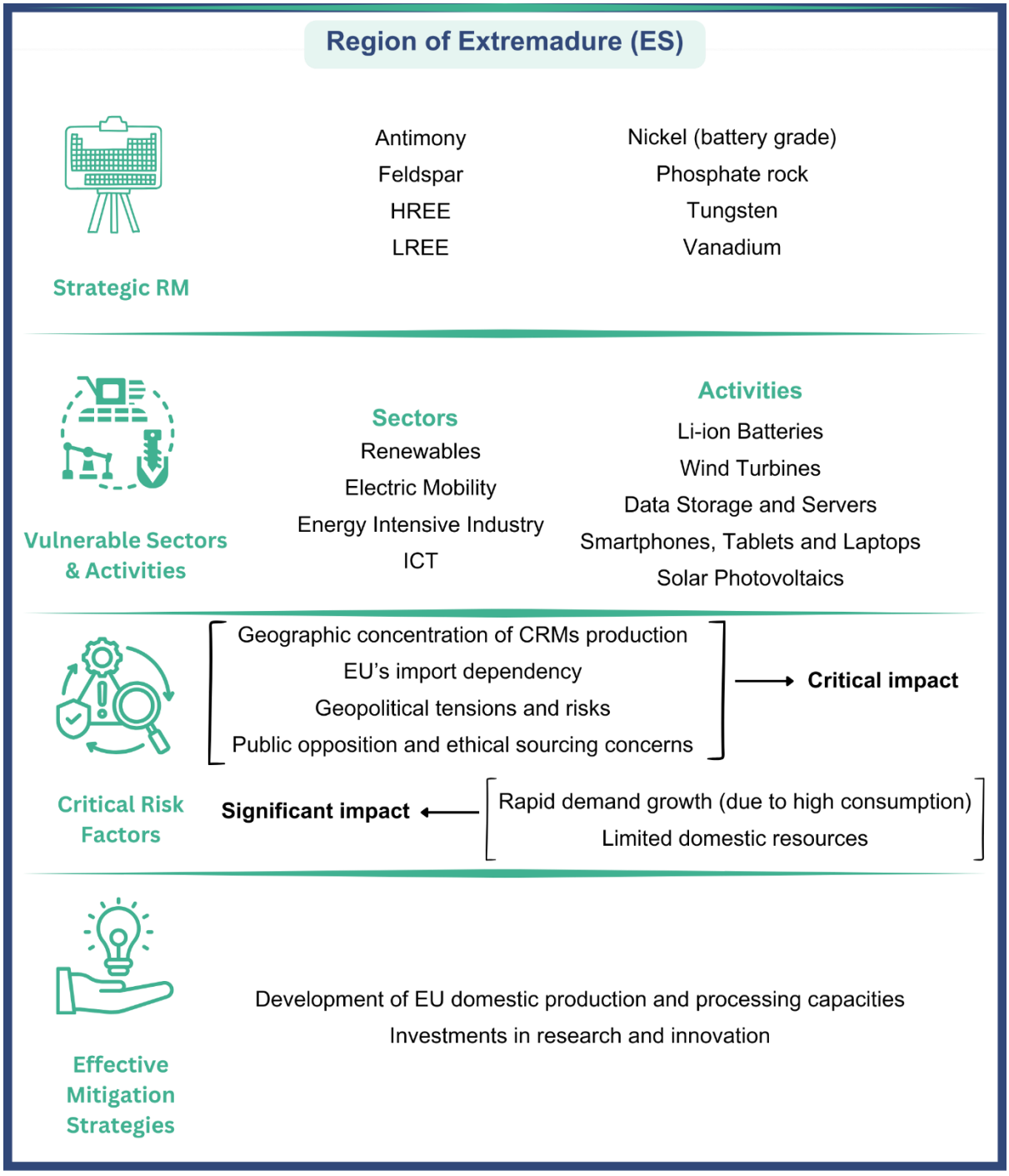

Figure 9: *Scoreboard of the Region of Extremadura (ES)*

Region of Western Macedonia (GR)

(partner: KOZANI)

Regional dependency on RM: Similarly to the region of Central Greece, the region of Western Macedonia, also requires a variety of CRMs to support its industrial sectors, particularly the renewable energy, electronics, and electric mobility industries which are pivotal to the region's transition from lignite to a low-carbon economy. Various CRMs are essential for manufacturing components of wind turbines, solar panels, batteries, and advanced electronics.

RM supply risks: The region's industrial sectors rely on a stable supply of CRMs, and the EU's import dependency poses a significant risk to their supply chains. According to the relevant partner (KOZANI) the region's economic vulnerability has been exposed by the COVID-19 pandemic and geopolitical tension in Ukraine. This vulnerability may intensify in the near future as the demand for CRMs is expected to grow rapidly to support the EU's net-zero transition.

Risk mitigation strategies: Given the lack of CRM deposits in the EU, circular economy strategies are necessary to substitute imports from China and other countries. Moreover, strategic reserves can serve as a buffer against short-term disruptions, while funding R&D can reduce reliance on CRMs.

The Region of Western Macedonia is actively involved in securing CRM supply through strategic initiatives. These include investing in sustainable mining and processing, promoting recycling and circular economy practices, and enhancing research and innovation through collaborations with academic institutions and EU-funded projects. Additionally, the region is forming strategic partnerships and diversifying its economy away from lignite-based energy, focusing on CRM-related industries to stimulate growth and resilience.

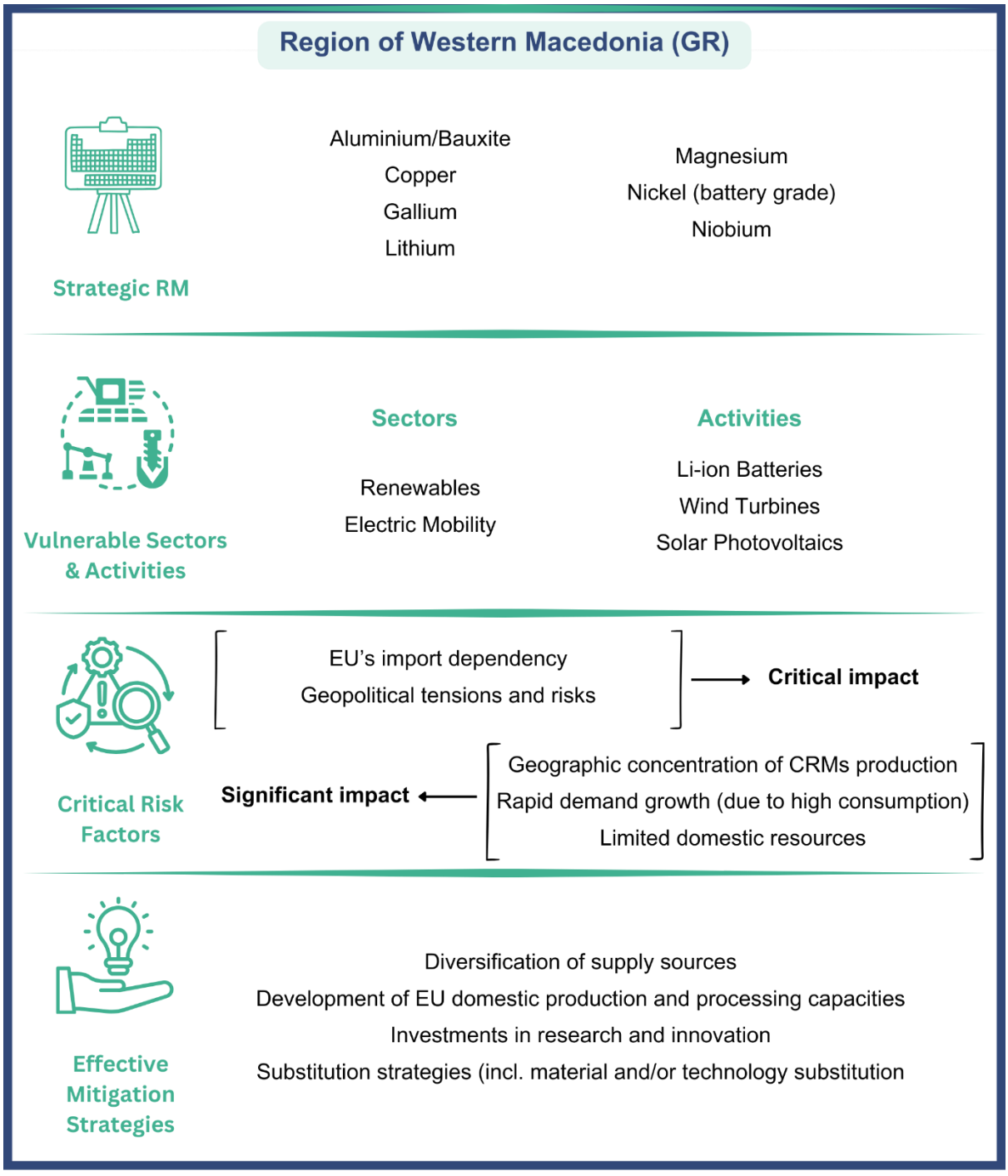

Figure 10: *Scoreboard of the Region of Western Macedonia (GR)*

3.2.3 Stakeholders' Questionnaire

The importance of CRMs varies among stakeholders, reflecting the specific needs and characteristics of their economic activities. However, **aluminium/bauxite, boron/borate, manganese, and silicon metal** emerged as materials of significant importance to most sectors represented in the online survey. For these CRMs, which are deemed critically important for the concerned sectors, participants indicated that currently, there are **no viable alternatives or substitutes** in their operations.

According to the survey, the industry **most vulnerable** to CRM supply chain disruptions is the **metal recycling industry**, followed by the mining and renewable energy industry, and to a lesser extent, the research sector.

There was a consensus among participants regarding the major risks to their operations. The **EU's dependency on imports**, prone to geopolitical tensions and risks, was identified as the main concern impacting vulnerable CRM supply chains. The limited domestic resources and the geographic concentration of CRM production were also seen as significant challenges for the consistent supply of CRMs essential to the sectors' operations.

Participants largely agreed on effective strategies to mitigate CRM supply chain risks. Diversification of supply sources and the promotion of circular and recycling practices, including urban mining, were assessed as the most effective strategies. Specifically, participants emphasised that having **multiple sources of raw material, along with strategic reserves from EU or national sources**, is the most effective strategy as it provides alternatives in times of crisis. Research, innovation, and substitution strategies can also offer long-term solutions. In this context, participants noted the use of **modelling tools for compositional design and Life Cycle Assessment (LCA)** can bring significant improvements in the sustainability and resilience of CRM supply chains, supported by the optimisation of experimental processes.

A summary of the input received on a sector / industry base is given below. With the exception of "Education" and "Academia", the information reflects the respondents' opinion regarding the CRM risks of their respective industry/sector. For the two sectors of "Education" and "Academia", the information refers to the evaluation of CRM risks with regard to the regional economies.

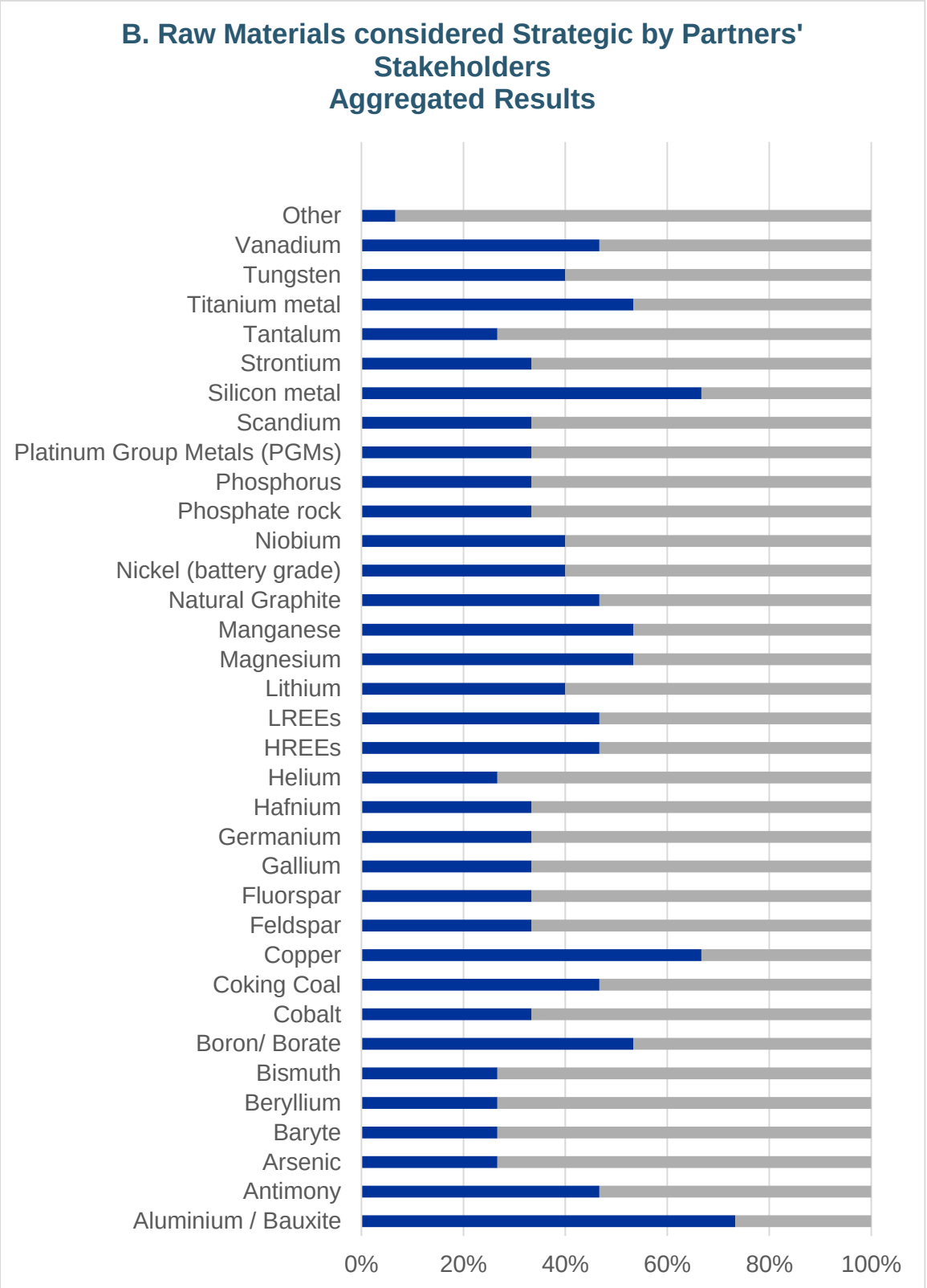

Figure 11: *Stakeholders' Aggregated Raw Materials Scoreboard*

Figure 12: *Raw Materials importance scoreboard based on stakeholders' input.*

Mining

- Strategic RMs: aluminium, cocking coal, silicon metal

- Vulnerability in the event of potential CRM supply disruptions: high risk
- Most important risks: limited domestic resources, import dependency
- Most effective mitigation strategy: diversification of supply sources

Renewables

- Strategic RMs: aluminium, arsenic, boron/borate, HREE, silicon metal
- Vulnerability in the event of potential CRM supply disruptions: high risk
- Most important risks: EU's import dependency, geopolitical risks and tensions
- Most effective mitigation strategy: diversification of supply sources

Metals Recycling

- Strategic RMs: aluminium, silicon metal
- Vulnerability in the event of potential CRM supply disruptions: critical risk
- Most important risks: geopolitical tensions and risks, public opposition and ethical sourcing concerns
- Most effective mitigation strategy: diversification of supply sources, CE and recycling practices, development of EU domestic production and processing capacities, investments in research and innovation, stockpiling the materials at risk or products containing them

Research

- Strategic RMs: Boron/borate, feldspar, manganese, phosphate rock
- Vulnerability in the event of potential CRM supply disruptions: high risk
- Most important risks: geopolitical tensions
- Most effective mitigation strategy: CE and recycling practices, investments in research and innovation

Education

- Strategic RMs: aluminium, beryllium, lithium, nickel, PGM
- Vulnerability in the event of potential CRM supply disruptions: -
- Most important risks: EU's import dependency, geopolitical tensions and risks, limited domestic resources

- Most effective mitigation strategy: diversification of supply sources, CE and recycling practices, development of EU domestic production and processing capacities

Academia

- Strategic RMs: -
- Vulnerability in the event of potential CRM supply disruptions: moderate risk
- Most important risks: rapid demand growth. geopolitical tensions and risks, geographic concentration of CRMs
- Most effective mitigation strategy: CE and recycling practices

Magnets Manufacturing

- Strategic RMs: boron/borate, HREEs
- Vulnerability in the event of potential CRM supply disruptions: moderate risk
- Most important risks: limited domestic resources
- Most effective mitigation strategy: diversification of supply sources

Steel Production

- Strategic RMs: silicon metal
- Vulnerability in the event of potential CRM supply disruptions: moderate risk
- Most important risks: EU's import dependency, geopolitical tensions and risks, limited domestic resources
- Most effective mitigation strategy: diversification of supply sources

4. Presentation and Evaluation of the Scenario-Building Exercise Outcomes

The online scenario building exercise took place on 9 July 2024, with the participation of 10 representatives from six project partners, as the French partner did not attend the virtual exercise. The aim of the online collaborative exercise was for partners to discuss the common challenges faced at regional level regarding CRM value chain dependencies and disruptions, and to further elaborate on effective mitigation measures that could address at-risk territorial activities under potential CRM scarcity and disruption events.

At the start of the exercise, each partner representative briefly outlined the most important CRM(s) for the region's economy. As depicted in **Error! Reference source not found.**, the responses varied significantly, reflecting the diverse economic activities of the different RAW4RES regions, as discussed in the previous chapter.

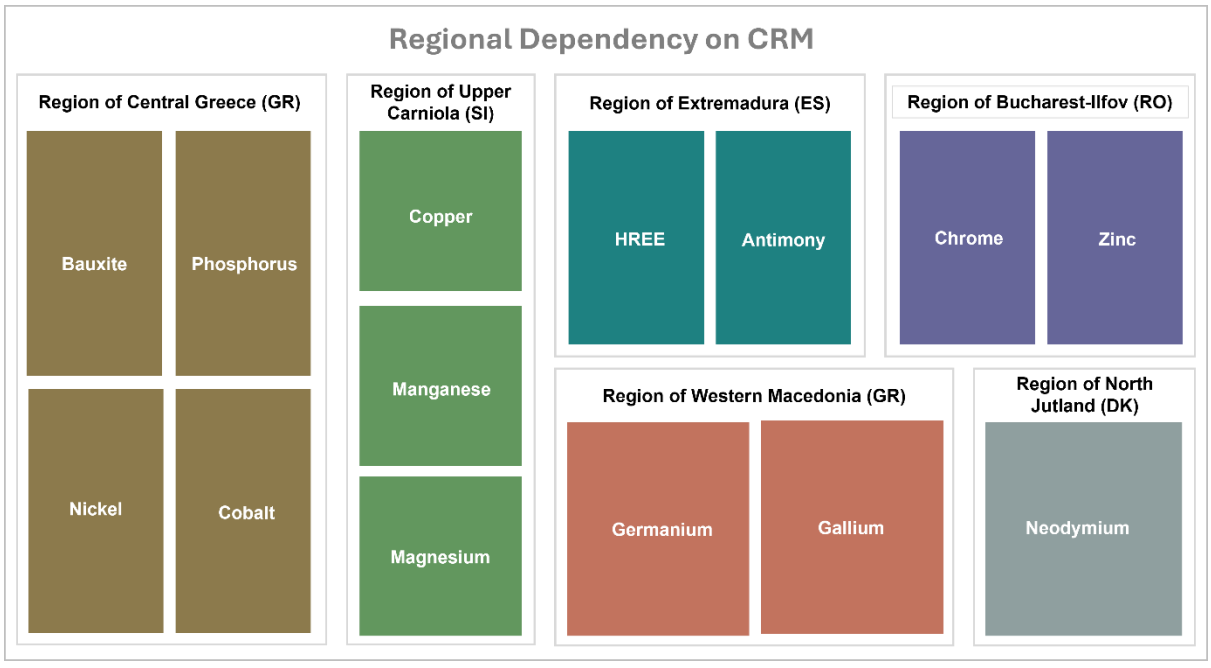

Figure 13: *Partner's input during the online exercise regarding the territorial dependency on CRM.*

Participants were divided into two groups of five. Each partner was asked to privately complete the same questionnaire from the online survey, excluding the open-ended questions and the last section E concerning mitigation strategies. After collecting the questionnaires, a common CRM scoreboard was established in the main session room. This scoreboard highlighted the

importance of CRMs for regional economies and identified the main sectors and activities at risk from CRM supply chain disruptions.

As shown in **Figure 14**, the **energy intensive industries** (particularly the steel industry) along with the **renewables and the electric mobility sectors** are assessed as the most dependent on raw materials. The manufacturing of various components of wind turbines, solar photovoltaics, Li-ion batteries, and fuel cells is significantly at risk from disruptions in the supply chains of essential CRMs, including aluminium, cobalt, gallium, manganese, chromium, zinc, and magnesium. These CRMs are primarily concentrated in regions outside the EU and are imported from third countries, making their supply chains highly susceptible to external conditions such as third-country export restrictions and geopolitical tensions.

Partners agreed that the most effective mitigation strategies to address the challenges of territorial supply chains were the adoption and advancement of **circular practices**, as well as **investments in R&D to develop substitution solutions**. Both these strategies are considered to improve the local supply of CRMs. Particularly identifying the CRMs already in waste streams and extracting them, a practice referred to as **urban mining**, was seen as a solution with great potential by all partners.

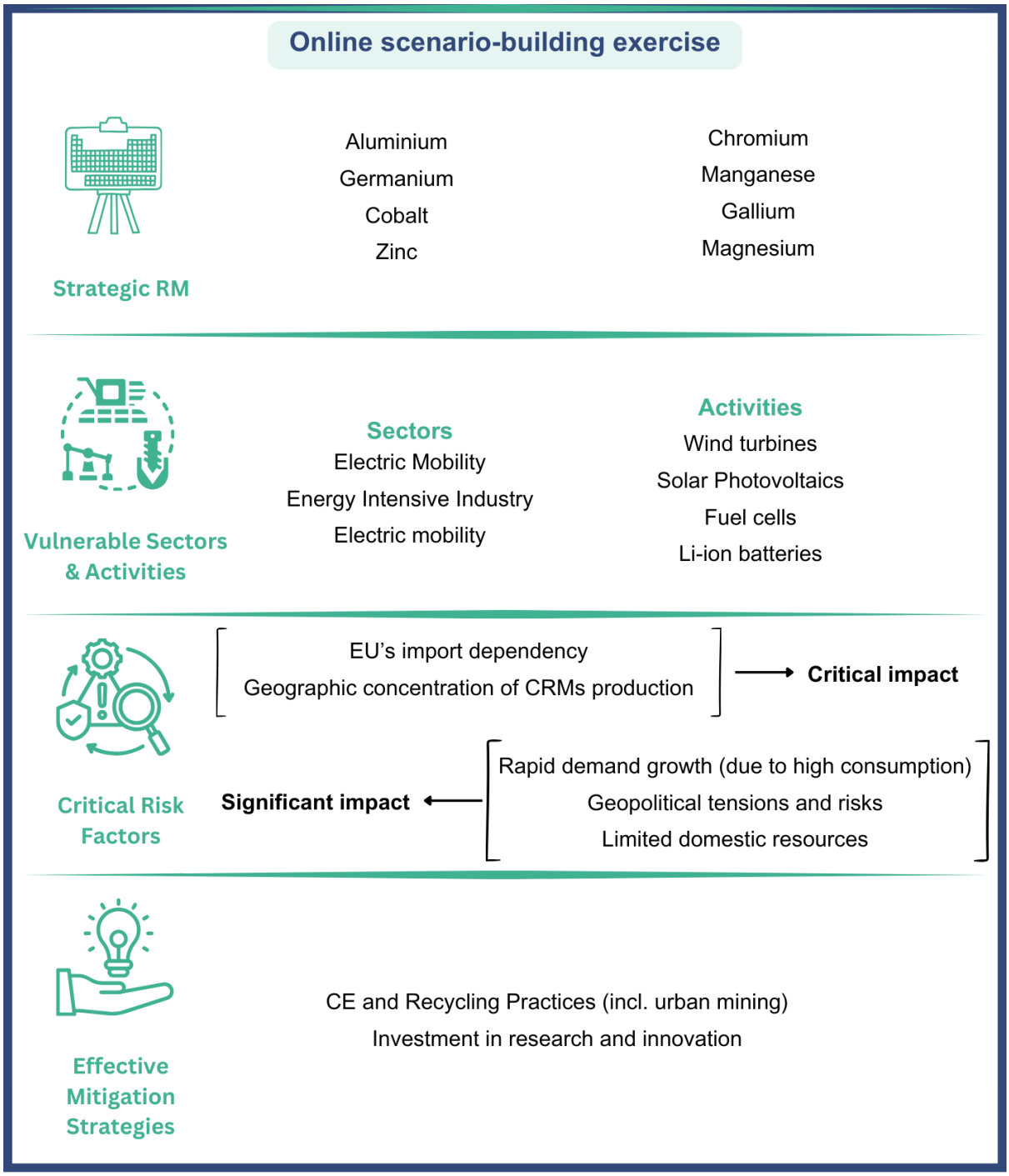

Figure 14: *Scoreboard of the online exercise (aggregated results)*

5. Discussion of the Results

The virtual exercise verified the results of the online survey regarding the **importance of securing reliable and unhindered access to raw materials in advancing the regions' twin (green and digital) transition and securing regional economies**. RAW4RES regions depend on the expansion of **low-carbon technologies**, mainly renewable energy production and electric mobility, to support the **decarbonisation of the energy sector and the energy intensive industries** such as steel and aluminium production. In addition, the **construction of data centers** and the upgrade of **data transmission networks**, both of which play a pivotal role in advancing digitalisation, are heavily dependent in supply of a number of raw materials.

Both partners and stakeholders, evaluated the following **raw materials of strategic importance** for the advancement of the twin transition: **bauxite, aluminium, nickel, HREE, boron/borate, manganese, copper, gallium, and silicon metal**. These raw materials are crucial for manufacturing solar panels, wind turbine mechanical parts, and electronic components used in renewable energy installations. Furthermore, they are essential for producing batteries and fuel cells, constructing data centers, and manufacturing device components like central processing units (CPUs) and GPUs.

It is worth noting that lithium and cobalt, both essential for the manufacturing of batteries and data servers, have not been evaluated as raw materials of strategic importance by partners, despite their expected significant demand increase in the mid-term horizon. By 2050 the demand for cobalt is expected to increase up to 350%[7] compared to 2020 levels, while lithium demand is anticipated to be nearly 60 times higher than today[8].

There was also a consensus regarding the challenges that regional raw material supply chains face due to the **limited domestic resources** of strategic CRMs and the consequent **dependency on imports** to maintain a steady supply of these materials to the various industries. Particularly, the concentration of CRM production in regions of Asia, Africa, and South America[9] is a major concern for both public authorities and industry representatives. The import of CRM from these regions is susceptible to disruptions which may arise from local geopolitical tensions or state-imposed market restrictions on exports from CRM-rich countries.

[7] https://eurometaux.eu/media/jmxf2qm0/metals-for-clean-energy.pdf
[8] https://ec.europa.eu/docsroom/documents/48878
[9] https://www.oecd.org/en/publications/economic-policy-reforms-2023_9953de23-en.html

To address these supply chain risks which are expected to intensify due to the rapid global demand for CRMs, partners and stakeholders highlighted the need for investing in **research and innovation**, while also adopting **circular mining, production, and processing practices**, along with effective **recycling**, to enhance the sustainability and resilience of regional CRM supply chains. Methods such as LCA and cradle-to-cradle design coupled with the use of digital solutions, such as structural modelling, can further improve the overall approach.

The **advantages of urban mining** in combination with the adoption of circular business models along the CRM value chain were particularly highlighted during the online exercise. Urban mining can provide a largely independent source of raw materials for both RAW4RES partners with existing raw material extraction industries (GR, ES, RO, FR) and those without (SI, DK). In addition, material sourcing from urban mining is largely independent both in time and geographically, and is therefore not immediately negatively affected by short-term disruptions to primary supply[10]. However, the quality of waste significantly impacts the efficiency and profitability of urban mining. High-quality waste streams with a higher concentration of target materials are more economically viable to process. In addition, the efficiency of separation technologies (related to the purity and quality of recovered materials) plays a crucial role in determining the profitability of urban mining.

Complimentary to regional mitigation strategies, **stockpiling at EU level** can help address short-term supply interruptions of strategic raw materials. Particularly for emergent and strong manufacturing industries which are vital for the green and digital transition, setting up EU stockpiling facilities and releasing those reserves when access to CRM is difficult or prices are high has been suggested by the European Parliament[11] as potentially effective in mitigating supply shocks. Experts have proposed[12] that the EU stockpiling policy should cover 60 days of imports, with the value of the CRM stockpile estimated at €6.5billion (based on the selection of raw materials) including operational costs and direct investments other than product acquisition

[10] https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccn/2020/Fraunhofer_ISI_Urban_Mining.pdf
[11] https://www.europarl.europa.eu/RegData/etudes/BRIE/2023/739394/EPRS_BRI(2023)739394_EN.pdf
[12] https://www.europarl.europa.eu/thinktank/en/document/IPOL_STU(2022)740058

6. Guidelines for the Integration of Risk Mitigation in Territorial Policies

6.1 Regional Operation Programme "Central Greece 2021-2027"

Region of Central Greece (GR)

To enhance the mining and processing businesses' competitiveness in the region the RSE is advised to:

- Encourage the development of regional recycling networks to facilitate the exchange of secondary raw materials. This could involve creating an online platform where businesses can trade these materials. The platform could be built on the design of the National Electronic Waste Register[13], and adapt it to the needs of the regional businesses focusing on the registration and subsequent trading of postconsumer waste, industrial scrap, and by-products from manufacturing operations.

- Support local small and medium enterprises (SMEs) that often lack the resources and expertise to implement circular economy schemes and risk mitigation measures. Working with industry associations, the RSE could design and finance capacity building programmes for regional SMEs in the CRM value chain and facilitate their collaboration with regional major players in the region.

6.2 Frederikshavn Municipality DK2020 Climate Plan2030

Frederikshavn Municipality (DK)

As Denmark lacks own reserves of CRMs and metals, FHN is advised to implement policy measures that promote recycling, akin to the concept of a "Recycling City." The following actions could be considered:

- Establish a dedicated support office to assist businesses in navigating recycling initiatives effectively. The office could provide guidance, resources, and financial advice to promote the adoption of sustainable and circular practices from local CRM businesses.

[13] https://wrm.ypeka.gr

- Develop an online monitoring system to strengthen local trading of scrap materials. This system could also facilitate matchmaking between suppliers and collectors, streamlining the exchange of recyclable materials in the region.

6.3 Regional Development Programme of Gorenjska 2021-2027

BSC, Business Support Centre, Kranj, Ltd (SI)

To facilitate the establishment of a local recycling value chain, with a specific focus on e-waste, BSC could collaborate with the Council of Gorenjska Region and the Development Council in order to prioritise:

- The development of an online repository that compiles best practices related to the collection, separation, and treatment of various types of CRM-containing objects (such as mobile phones, laptops, and food cans). This repository would serve as a valuable resource for businesses and individuals seeking guidance on sustainable handling of these materials.

- The launch of dedicated support schemes that will include calls for proposals to offer regional businesses, mainly SMEs, financial support for taking urban mining activities particularly those employing environmentally friendly technologies in order to enhance the Upper Carniola region's deposits of strategic raw materials.

6.4 Regional Operational Programme for the Bucharest-Ilfov Region 2021-2027

Bucharest – Ilfov Regional Development Agency (ADRBI)

Considering the territorial challenges of the industry in Bucharest-Ilfov, ADRBI is advised to prioritise the following actions:

- Collaboration with financial institutions, primarily banks, to create financial support services, such as low-interest loans, grants, or other financial products, for SMEs in the CRM value chain to upgrade their operations by improving overall efficiency as well as adopting circular and green practices.

- Active involvement of regional SMEs in the policy dialogue and decision-making processes. Establishing advisory committees with SME representatives or organising

consultation sessions could foster meaningful engagement and address their specific needs concerning the adoption of circular and green practices.

6.5 Regional Operation Programme of Hauts-de-France 2021-2027

TEAM2 (FR)

To address the challenges posed by limited extractive operations and heavy reliance on extra-regional markets, TEAM2 should leverage its role in implementing the Regional Operational Programme of Hauts de France. TEAM2 could advise the Hauts de France Regional Council to:

- Implement recognition programs to acknowledge and reward SMEs in the CRM value chain that successfully implement circular practices. Such programs would not only incentivise the transformation of SMEs but would also elevate their profile, helping them gain market visibility and credibility within investors.
- Create dedicated support centres focused on advancing recycling practices, particularly within the regional metallurgy industry. These centres could offer upskilling programs for local workers, enhancing their expertise in innovative circular technologies and methods related to sourcing, treatment, and recycling of CRM.

6.6 RIS3 Extremadura 2027

FUNDECYT Scientific and Technological Park of Extremadura (FUNDECYT-PCTEX) (ES)

FUNDECYT is advised to support the re-orientation of the mining and processing enterprises' toward environmentally responsible practices, with a specific focus on the region's metallurgical value chains. To achieve this FUNDECYT could implement the following actions:

- Promote the establishment of regional recycling networks to facilitate the exchange of secondary raw materials. These networks would enhance collaboration among CRM value chain stakeholders and contribute to the sustainable resource management in the region.
- Foster public-private partnerships (PPPs) that jointly invest in circular CRM management initiatives and mitigation measures related to the supply chain disruption risks. By sharing the costs of research and development, these partnerships could drive and promote responsible practices within the CRM value chain.

6.7 Circular Economy Action Plan of the Municipality of Kozani

Municipality of Kozani (GR)

Considering the strong dedication of the Municipality of Kozani to the transition to a circular economic model, the Municipality of Kozani is advised to:

- Leverage the Material Match Making Platform (M3P), co-developed by KOZANI, to expand and strengthen circular economy collaborations among businesses. The M3P could also include a dedicated section for the promotion of efficient recycling practices which would further expand regional recycling ecosystems for the (re)use of locally sourced raw materials.

- Engage with industry associations, which often have close relationships with regional SMEs, so as to develop upskilling and reskilling programmes for local workers within the CRM industry as well as training initiatives specifically on circular management of CRMs for local SMEs. These initiatives are essential to support the local workforce during the coal phase out in the Region of Western Macedonia.

7. Annexes

Annex I Assessment criteria and descriptors for assessing the different factors

Section B: Identifying Critical Raw Materials and metals that are of strategic importance *Evaluating the significance of the identified CRMs for their region or country's economy, or for their specific industry in the case of industrial stakeholders.*	
1: Moderately important	The identified CRMs have a moderate contribution to and significance for the development of the region or country's economy - or their specific industry in the case of industrial stakeholders.
2: Important	The identified CRMs have a major contribution to and significance for the development of the region or country's economy - or their specific industry in the case of industrial stakeholders.
3: Critical	The identified CRMs have an extremely high contribution to and significance for the development of the region or country's economy - or their specific industry in the case of industrial stakeholders.
Section C (partners' questionnaire): Identifying sectors/ economic activities that are most vulnerable to potential supply disruptions Assessing the risk of vulnerabilities for identified regional sectors/ activities/ technologies in the event of potential CRM supply disruptions.	
1: Moderate risk	The identified regional sectors/ activities/ technologies have moderate vulnerability to potential CRM supply disruptions.
2: High risk	The identified regional sectors/ activities/ technologies are highly vulnerable to potential CRM supply disruptions.
3: Critical risk	The identified regional sectors/ activities/ technologies are extremely vulnerable to potential CRM supply disruptions.
Section C (questionnaire for industry stakeholders): Industry identification and assessment of vulnerability to potential supply disruptions Assessing the risk of vulnerabilities in stakeholders' industry/operations in the event of potential CRM supply disruptions.	

1: Very low risk	The risk of stakeholders' industry/ operations being affected by potential CRM supply disruptions and exhibiting vulnerabilities is very low.
2: Low risk	The risk of stakeholders' industry/ operations being affected by potential CRM supply disruptions and exhibiting vulnerabilities is low.
3: Moderate risk	The risk of stakeholders' industry/ operations being affected by potential CRM supply disruptions and exhibiting vulnerabilities is moderate.
4: High risk	The risk of stakeholders' industry/ operations being affected by potential CRM supply disruptions and exhibiting vulnerabilities is high.
5: Critical risk	The risk of stakeholders' industry/ operations being affected by potential CRM supply disruptions and exhibiting vulnerabilities is critical.
Section D: Identifying CRM supply challenges and risks Assessing the criticality of identified CRM supply risk factors/challenges and their impact on the value chains of regional sectors and/or the overall region's economy – and for the industrial stakeholders on their industry/operations.	
1: No impact	Considering potential CRM supply disruptions, the identified risk factors/ challenges have no impact on the value chains of the regional sectors/ the overall region's economy/ the stakeholders' operations.
2: Minor impact	Considering potential CRM supply disruptions, the identified risk factors/ challenges have minor impact on the value chains of the regional sectors/ the overall region's economy/ the stakeholders' operations.
3: Moderate impact	Considering potential CRM supply disruptions, the identified risk factors/ challenges have moderate impact on the value chains of the regional sectors/ the overall region's economy/ the stakeholders' operations.
4: Significant impact	Considering potential CRM supply disruptions, the identified risk factors/ challenges have significant impact on the value chains of the regional sectors/ the overall region's economy/ the stakeholders' operations.
5: Critical impact	Considering potential CRM supply disruptions, the identified risk factors/ challenges have critical impact on the value chains of the regional sectors/ the overall region's economy/ the stakeholders' operations.

Section E: Identifying risk mitigation strategies Assessing the effectiveness of identified risk mitigation strategies in addressing potential CRM supply disruptions within their region, or for industry stakeholders, within their operations.	
1: Partially effective	The identified strategy can adequately contribute to mitigating potential CRM supply disruptions.
2: Adequately effective	The identified strategy is adequately effective in mitigating potential CRM supply disruptions.
3: Significantly effective	The identified strategy can be significantly effective in addressing potential CRM supply disruptions.