European Commission

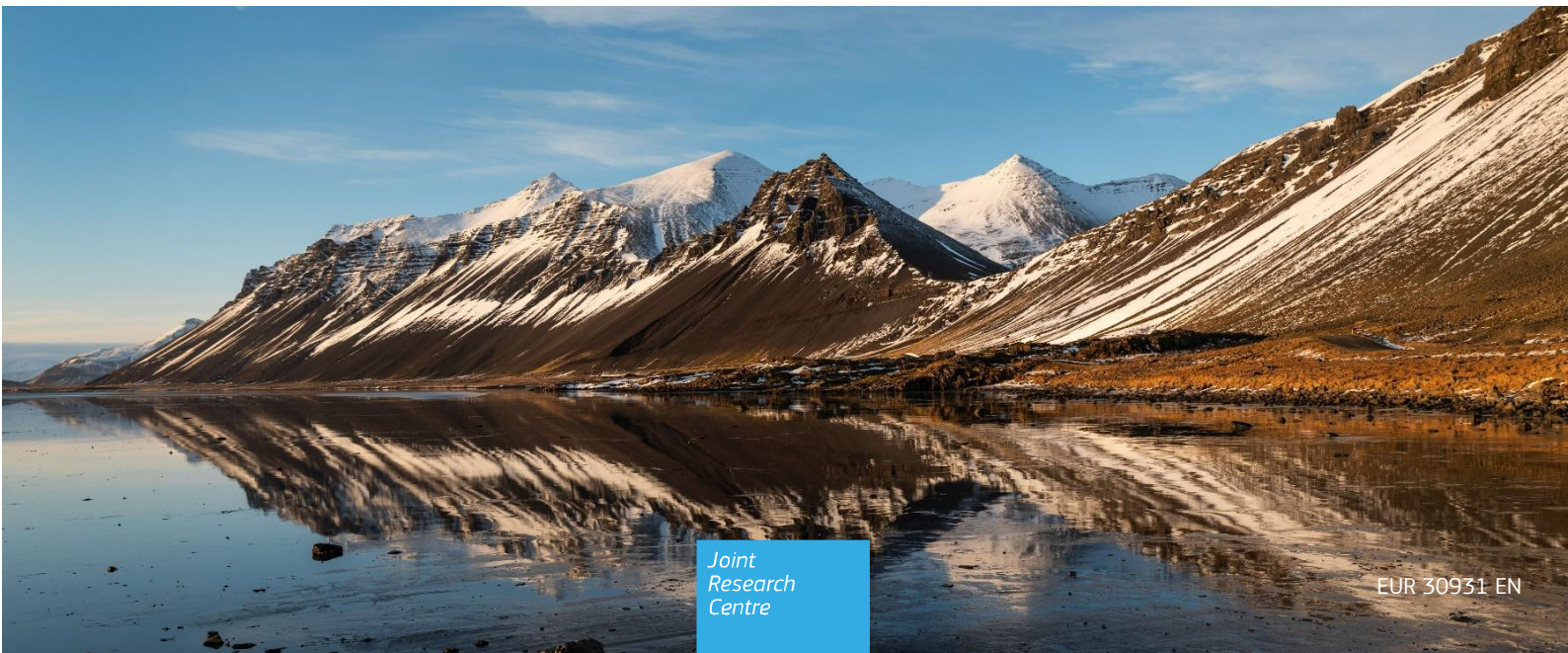
JRC TECHNICAL REPORT

RMIS Roadmap 2021

A mid-term progress report, roadmap and analysis of knowledge management options for the Raw Materials Information System (RMIS)

Hamor T., d'Elia E., Manfredi S.

2021



Joint Research Centre

EUR 30931 EN

This publication is a Technical report by the Joint Research Centre (JRC), the European Commission's science and knowledge service. It aims to provide evidence-based scientific support to the European policymaking process. The scientific output expressed does not imply a policy position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of this publication. For information on the methodology and quality underlying the data used in this publication for which the source is neither Eurostat nor other Commission services, users should contact the referenced source. The designations employed and the presentation of material on the maps do not imply the expression of any opinion whatsoever on the part of the European Union concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Contact information
Name: Simone Manfredi
Address: via E. Fermi 2749, 21027 Ispra, Italy
Email: simone.manfredi@ec.europa.eu
Tel.: 0039.0332.786046

EU Science Hub
https://ec.europa.eu/jrc

JRC126612

EUR 30931 EN

PDF	ISBN 978-92-76-45477-9	ISSN 1831-9424	doi:10.2760/46345
Print	ISBN 978-92-76-45478-6	ISSN 1018-5593	doi:10.2760/220939

Luxembourg: Publications Office of the European Union, 2021

© European Union, 2021

The reuse policy of the European Commission is implemented by the Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Except otherwise noted, the reuse of this document is authorised under the Creative Commons Attribution 4.0 International (CC BY 4.0) licence (https://creativecommons.org/licenses/by/4.0/). This means that reuse is allowed provided appropriate credit is given and any changes are indicated. For any use or reproduction of photos or other material that is not owned by the EU, permission must be sought directly from the copyright holders.

All content © European Union, 2021

How to cite this report Hamor, T., d'Elia, E., Manfredi, S., RMIS Roadmap 2021 - A mid-term progress report, roadmap and analysis of knowledge management options for the Raw Materials Information System (RMIS), EUR 30931 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-45477-9, doi:10.2760/46345, JRC126612.

Contents

1 Introduction 7

2 Policy context & drivers 8

3 The RMIS: state of art 10

4 RMIS development outlook 13

4.1 Work programme 2021-2022 13

4.2 RMIS development plan 2021+ 15

4.2.1 Foresight studies 15

4.2.2 The African country profiles 16

4.2.3 Raw Materials' profiles 20

4.2.4 EU Country Profiles 23

4.2.5 Trade-related profiles for selected non-EU countries 24

4.2.6 Trade module 24

4.2.7 Knowledge Gateway 24

4.3 The Competitive Projects outputs in the RMIS 27

4.4 Dialogue with key Directorate Generals (DGs) 29

4.4.1 Context & purpose 29

4.4.2 DG GROW 29

4.4.3 DG INTPA 29

4.4.4 DG ENV 29

5 A review of EC and JRC knowledge management 31

5.1 EC knowledge management 31

5.2.1 CIRCABC 31

5.2.2 EC Working Groups 32

5.2 Knowledge management at the JRC 33

5.2.1 Horizon scanning 35

5.2.2 JRC Megatrends Hub 36

5.2.3 JRC Competence Centres 38

5.2.4 JRC Knowledge Centres 39

5.2.5 Community of Practice 40

5.3 Knowledge management at RMIS 43

5.3.1 The RMIS knowledge community 43

5.3.2 The RMIS communication 45

6 Conclusions 49

7 References 50

8 List of figures 52

9 List of tables & boxes 53

ANNEX 1: List of publications 54

Authors

Tamas Hamor, Eleonora d'Elia, Simone Manfredi, JRC Unit D3
with contributions from the D3 Raw Materials Team.

Abstract

Knowledge is essential for the sustainable and secure supply of raw materials, both primary and secondary, due to their role in the European Union's (EU) economy and society. Proper knowledge management promotes a globally competitive raw material sector in a broad sense along the whole value chain. This applies not only to exploration, extraction, processing, manufacturing and recycling, but also investments, innovation, trade, spatial development, skills and education. Knowledge is also key for policy support, informed debate and decision-making.

The Raw Materials Information System (RMIS) is the European Commission's (EC) reference web-based knowledge platform on non-food, non-energy raw materials from primary to secondary sources. The RMIS is a permanent website of the Joint Research Centre (JRC) Science Hub, originally a commitment in the 2015 Circular Economy Action Plan(CEAP). The RMIS is a core component of the EU Raw Materials Knowledge Base (EU RMKB), the vital interface between European stakeholders and the EU policy community. In particular, it facilitates harmonised availability of key data and analyses, highlights priority needs, as well as contributes to coordinated dissemination.

The RMIS has significantly developed since its launch in 2015. During this six years the RMIS reached its mature stage, supporting the the implementation of numerous EU Community policy fields which required its services, as also explicitly manifested in their sectoral policy documents. The RMIS has become a well-known, reliable information and knowledge source with a well-established stakeholders network of ca. 200+ experts, a wider interest group of circa 1400 recipients of the RMIS Newsletters, and the several thousand visitors who look for raw materials related information at the RMIS each month.

The RMIS is expected to fulfil an increasingly broad spectrum of knowledge needs related to raw materials. Towards this end, the RMIS knowledge provider network includes most relevant EU funded projects on raw materials, such as specific calls under the Horizon 2020 scheme and European Institute of Innovation & Technology (EIT) Raw Materials projects.

Considering the above facts and the disciplined JRC knowledge management recommendations, the RMIS has arrived at a major milestone of its lifecycle. It thus becomes crucial to decide on which way(s) it shall progress forward when considering an enhanced future knowledge management facility and practice.

This report provides an overview of the key foreseen RMIS development priorities for, roughly, the period 2021-2024. It also includes an assessment of the knowledge management instruments at the EC and JRC levels with a view of identifying feasible options to improve the RMIS knowledge management functions.

Executive Summary

The Raw Materials Information System (RMIS) - a permanent website of the JRC Science Hub - is a commitment in the 2015 Circular Economy Action Plan([1]) (CEAP). Since 2015, the RMIS acts as the EC's reference knowledge platform on non-energy, non-food raw materials from primary to secondary sources, along the entire raw materials value chains and considering the full material life cycle. The RMIS, markedly upgraded in 2017([2]), fulfils a wide range of knowledge needs integrating information by a broad spectrum of EU and international knowledge providers.

The RMIS provides the core basis for raw materials knowledge and analyses required to support EU policy, such as the European Green Deal([3]), the new Circular Economy Action Plan([4]) and the new 'Industrial Strategy for Europe'([5]). The RMIS supports EC policy needs through data management and a web interface, in particular addressing knowledge needs identified by the European Commission related to the secure and sustainable raw materials systems and value chains.

During 2015-2020, the RMIS reached the end of its initial development phase in accordance with the plans set in the 'Roadmap 2017'(Manfredi et al. (2017)) and the 'Roadmap 2019' (Manfredi et al. (2019a)), respectively. The RMIS became a reliable information and knowledge source with a core stakeholders' network of 200+ experts, a wider interest group of 1400+ recipients of the bi-annual RMIS Newsletters, and the several thousands of unique visitors each month([6]).

Its sustainable operation is ensured by the JRC institutional work programme, complemented by internal arrangements with competent policy DGs. The JRC, the in-house scientific and technical evidence-based knowledge provider of the European Commission, is committed to ensure hosting this prestigious information system.

Considering – among others – the progressing Green Deal([7]), the new EU policy requiring knowledge on raw materials, the forthcoming Horizon Europe knowledge funding scheme and the contribution to the overarching JRC knowledge management role, the RMIS can continue to act as the EC's reference knowledge platform on raw material value chains only by systematically refining its development priorities, so to best facilitate the knowledge needs identified by the EC.

Consulted policy DGs (GROW, ENV, INTPA, TRADE) acknowledged the work of the JRC in developing the RMIS to its current level. They, also, supported the idea of developing a more sophisticated service on scientific and technical information delivered by EU projects and international literature through automated search capacities for thematic selection. In accordance with requests from DG INTPA and DG TRADE, attention shall also be given to key EU (raw materials) trade partners, including e.g. a number of specific African countries. As a response to these emerging needs, a new thematic section focused on Africa is being included in the RMIS (complementing and linking to the overarching JRC Africa Knowledge Platform). Finally, the RMIS is considering also the suggestion of DG INTPA that due weight shall be provided to e.g. South American and the Caribbean countries.

With regard to climate and environment policies, the OECD's low carbon transition plans shall be taken into account and presented. In the context of responsible sourcing, the presentation of the EITI (Extractive Industry Transparency Initiative([8])) is recommended. The RMIS provides a number of indicators in the foresight dashboard to monitor the transition to a green economy. The consumption footprint should also to be included in line with the Environmental Footprint analyses (EPLCA([9]), PEF([10])). In the frame of the 2020 Circular Economy Action Plan, the feasibility of the market observatory for secondary materials will be assessed.

Also, in harmony with the above requests of the competent DGs, the key deliverables of the current 2021/2022 JRC institutional work programme include, inter alia, continuous update and further release of material-specific and EU country-specific profiles, analysis of environmental aspects along certain strategic raw materials value chains (e.g., in collaboration with the European Environment Agency (EEA)), build capacities on forecast analyses. Proposed plans also include the further strengthening of foresight analyses, the further development and

([1]) COM(2015) 614
([2]) RMIS Roadmap & Progress Reports in 2017 and 2019
([3]) COM(2019) 640
([4]) COM(2020) 98
([5]) COM(2020) 102
([6]) This roadmap presents the RMIS and its development priorities as of November 1st, 2021.
([7]) COM(2019) 640
([8]) https://eiti.org/
([9]) https://eplca.jrc.ec.europa.eu/
([10]) https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

integration of material-specific and country specific profiles (also for African countries), the introduction of the Thematic Gateway, and opening of new subchapters such as Sustainability Certification, among others.

Building on a preliminary Concept Note prepared in March 2021 as basis for discussions with competent policy DGs (GROW, ENV, INTPA, TRADE), this report provides an overview of the short and mid-term (2-4 years) RMIS development priorities and key foreseen milestones, as well as a decision support assessment of available options to strengthen RMIS knowledge management functions.

An additional objective is to continuously enhance RMIS knowledge managements functions in a way that all knowledge products included in the RMIS can affectively support EC's priorities and needs on raw materials. The preliminary finding is that the Knowledge Centre (incl. an Observatory) and the Community of Practice could be the most suitable facilities to enhance its networking capacity and inclusiveness.

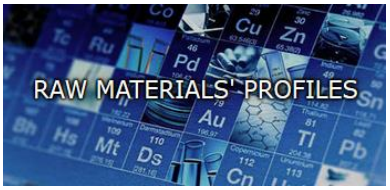
Table 1. Summary of RMIS content and development milestones, as of November 1st, 2021

RMIS main tiles	Current content	2021+ development plan
	1. Overview 2. Knowledge needs 3. News & events 4. Stakeholders 5. Funding options	- Continuous update, as events and policy drivers require.
	1. European policy 2. EU legislation 3. International conventions & initiatives 4. Member States (MS) legislation	- Opening "Safeguarding mineral deposits" sub-section is considered on the spatial planning and land use planning legislation and good practices based on MINLAND project([11]); - Update of EU and MS legislation.
	1. Terminology (glossary) 2. Library 3. JRC Science Hub	- "Terminology", "Library" and "JRC Science Hub" will become part of "Raw Materials Knowledge Gateway"; - Continous updates.
	1. What are CRMs 2. What the EC does 3. The CRM list 4. CRM dashboard 5. Material factsheets 6. Mineral inventory	- Inclusion of the 2023 list and future lists of critical raw materials, with 80+ RM-specific criticality factsheets, also in co-operation with the SCRREEN II project([12]).
	1. Raw Materials Scoreboard: 2016, 2018, 2021 and Scoreboard Laboratory 2. EIP monitoring & evaluation 3. Circular Economy monitoring 4. Resource Efficiency Scoreboard	- Host and visualize future Raw Materials Scoreboard editions; - Update of the Scoreboard Laboratory, and the EIP (European Innovation Partnership on Raw Materials) monitoring & evaluations.

([11]) https://www.minland.eu/project/
([12]) https://scrreen.eu/

RMIS main tiles	Current content	2021+ development plan
	1. SRMs in the CE action plan 2. Monitoring SRMs: data, indicators, tools 3. SRMs in priority areas of the CE AP (Circular Economy Action Plan) 4. SRMs in specific industry sectors	- "SRMs (secondary raw materials) in specific industry sectors": an updated list of H2020 projects related to secondary raw materials will be included; - A possible merging of the priority areas with the specific industry sectors; - A sectoral approach can be presented as a dedicated tile entitled "Raw Materials for Strategic Value Chains". For (sub)topics, the most visible sector shall initially be the battery/mobility sector data.
	1. Environmental dimension 2. Social dimension 3. Sustainable development goals 4. Responsible sourcing	- New sub-chapter on "Sustainability Certification", based on the CERA project ([13]); - Possible development of new sub-chapters (nature protected areas, industrial and natural risks, good practices, influence on criticality); - Develop a sustainable sourcing map viewer application that visualizes environmental and social indicators also with data on production and trade; - Improve the linkages to information at material level, building on the prototype on alumina.
	Country level data and information	- In the raw materials trade flows section: elaboration of separate visualizations for country's trade in primary raw materials and intermediate goods; - Development of country's overview of import tariffs on raw materials (new sub-section); - Trade agreement section: continue compiling data and information for country's overview of participation in trade agreements (for the rest countries).
	1. Foresight analyses 2. Material flows 3. Supply chain viewer 4. Raw materials in the battery value chain	- Material Flow Analysis (MFA) section will be updated, improved and expanded by the new Material System Analises (MSAs), and by new country scale MSAs based on ESTAT data; - Possible development of new section on "Dual use materials"; - Integration of new foresight studies by JRC/GROW.

([13]) https://www.cera4in1.org/

RMIS main tiles	Current content	2021+ development plan
	1. Raw materials profiles for 80 materials 2. Mineral inventory	- The newly introduced dashboard of indicators will be further expanded and refined; - Additional materials to be included; - Development of additional modules covering resources & reserves, trade, demand, production, sustainability and circularity.
	Country profiles for 27 EU countries	- Update of the underlying data and information periodically; - Country reports to be published and added to the online profiles in RMIS.
	Information available for 21 stakeholders and knowledge providers at national and EU levels	- Complete restructuring of the Gateway towards a more "thematic" focus: inclusion of "Library", "Terminology", "European projects", JRC Science Hub" ; - Set up a gateway for a potential RMIS knowledge management network (Community of Practice / Knowledge Center / Observatory) and a scientific metadata service on the long term; - The emptied tile will be replaced by a specific chapter on Africa.

1 Introduction

This RMIS Roadmap is the overarching steering document in support of the definition of a joint common vision, scope, and development options for the years to come. These are being defined through interactions with selected policy DGs, EU agencies (in particular the European Health and Digital Executive Agency (HaDEA) and European Environment Agency (EEA)), and EIT RawMaterials. This Roadmap defines milestones which reflect short-term and long-term objectives, priorities, as well as the strategies and actions to be followed.

The basis of this report is the Joint Research Centre (JRC) 2021/2022 Institutional Work Programme, the project titled Raw Materials Information System (RMIS) No.30323 under the Project Portfolio 'Strategic Value Chains – secure & sustainable raw materials' (SVC - RAWMAT) No.20143. The project is expected to deliver a number of outputs (as presented in chapter 4.1), one of which is this current report.

The RMIS acts as the EC's reference knowledge platform on non-energy, non-agricultural raw materials from primary to secondary sources, along the entire raw materials value chains. The RMIS provides the core basis for raw materials knowledge and analyses required to support EU policy, in particular the European Green Deal([14]), the 2020 Circular Economy Action Plan([15]) and the 'Industrial Strategy for Europe'([16]).

Since 2015, the RMIS contributed to numerous topics that are in the core mandate and competence of various policy DGs such as GROW([17]), INTPA([18]), ENV([19]), TRADE([20]). Examples include, among others, the Strategic Implementation Plan (SIP) of the European Innovation Partnership (EIP) on Raw Materials (RM EIP SIP) objectives, such as access to harmonized information on responsible sourcing and trade issues (first pillar of the Raw Materials Initiative, RMI([21])), on Member States framework conditions about minerals and on environmental impact assessment (RMI second pillar), and knowledge on secondary raw materials (SRMs) (RMI third pillar). The RMIS has facilitated knowledge needs related to the triennial list of Critical Raw Materials (CRMs) for Europe and the development of the biennial EU Raw Materials Scoreboard – among others.

The RMIS supports EC policy needs through data management and a web interface. It contributes to addressing knowledge needs identified by the EC related to environmental and social sustainability (particularly climate change, responsible sourcing, and circularity) and security-of-supply (supply risks/criticality, resilience). Key related considerations, hence, include e.g. member state and EU policy/governance, material stocks and flows (reserves, urban stocks, trade, production, and circularity), supply chain risks/bottlenecks, and resilience.

The RMIS addresses a broad range of thematic areas that are relevant in the analyses of raw materials and their supply/value chains. Special focus is, and will be, given to those value chains identified by the EC as fundamental to achieving the low carbon / digital transition and strategic autonomy of Europe, for example.

These include batteries, vehicles, renewable energies, information and communication technologies (ICT) and electronics, space and defense, as well as energy- and carbon- intensive industry([22]).

([14]) COM(2019) 640
([15]) COM(2020) 98
([16]) COM(2020) 102
([17]) Internal Market, Industry, Entrepreneurship and SMEs
([18]) International Partnerships
([19]) Environment
([20]) Trade
([21]) COM(2008) 699
([22]) Regulation (EU) 2018/1999/EU

2 Policy context & drivers

The contribution of raw material value chains to achieving a prosperous, modern, competitive, circular and climate-neutral economy is widely acknowledged by EU policies. For instance, the 2008 EU Raw Materials Initiative([23]) stresses that raw materials are essential for the sustainable and sound functioning of Europe's industries. The 2013 Strategic Implementation Plan (SIP) of the European Innovation Partnership (EIP) on Raw Materials highlights the need for a European Union Raw Materials Knowledge Base (EURMKB).

In this context, the Raw Materials Information System (RMIS) is a commitment in the 2015 Circular Economy Action Plan([24]). The RMIS therefore provides the core basis for raw materials knowledge and analyses to support EU policies, in particular the European Green Deal, the new Circular Economy Action Plan, the new Industrial Strategy for Europe, the EU Strategic Foresight 2021, and the EU Resilience Dashboard([25]) (Fig. 1).

Figure 1. RMIS and its current policy drivers

Source: JRC

Access to resources is also a strategic security question for Europe's ambition to deliver the Green Deal. Ensuring the safe and sustainable supply of raw materials, in particular of critical raw materials necessary for clean technologies, digital, space and defence applications, by diversifying supply from both primary and secondary sources, is therefore one of the pre-requisites to make this transition happen: "*sustainability and transparency requirements for batteries taking account of, for instance, the carbon footprint of battery manufacturing, ethical sourcing of raw materials and security of supply, and facilitating reuse, repurposing and recycling*". To become more competitive as it becomes greener and more circular, industry will need a secure supply of clean and affordable energy and raw materials.

In particular, the RMIS facilitates knowledge needs related to e.g. EU circular economy, economic resilience, the new trade policy, trade of dual-use items, civil, defence and space industries([26]), the triennial list of Critical Raw Materials (CRMs) for Europe, the development of the biennial EU Raw Materials Scoreboard, the strengthening of the raw materials knowledge base for Africa, complementing the development of the overarching JRC Africa Knowledge Platform([27]). Rapidly emerging new policy fields, such as, for example the Hydrogen Strategy, and the Plastics Directive([28]) represent additional demand for RMIS services.

The RMIS supports EC policy needs by information and knowledge management through a web interface, in particular on trade, environmental and social sustainability (climate neutral and conflict-free responsible

([23]) COM(2008) 699
([24]) COM(2015) 614
([25]) COM(2018)29; SWD(2018)17; COM(2019)640; COM(2020)98; COM(2020)102; COM(2021)350; COM(2021)750; https://ec.europa.eu/info/sites/default/files/resilience_dashboards_en.pdf
([26]) COM(2021)32; COM(2021)66; COM(2021)42; COM(2021)70
([27]) COM(2020)474; COM(2012)82; JOIN(2020)4; https://africa-eu-partnership.org/sites/default/files/userfiles/africamainreportonline_0.pdf
([28]) COM(2020)301; Directive 2019/904/EU

sourcing([29])), and security of supply. Key contextual considerations include Member States' and EU governance, material stocks and flows (natural reserves and urban stocks, production, trade, circularity), supply chain hot spots, and economic system resilience([30]).

The RMIS addresses a broad range of thematic areas relevant in the analysis of raw materials supply/value chains, with special focus on those industrial ecosystems identified by the EC as fundamental to achieving the carbon neutral digital transition and Open Strategic Autonomy of Europe. These include batteries and vehicles, ICT and electronics, space and defence, as well as energy intensive industry.

Batteries have a crucial role in decarbonizing transport, renewable power generation, provision of electricity to off-grid communities, etc. Consequently, they are key technologies for sustainable development. Demand for them is growing rapidly worldwide and the market for batteries is expected to continue growing at an estimated 25% per year (Mancini et al., 2021). Therefore, the EU considers that the battery sector is strategic for industrial competitiveness and in achieving the aims of the European Green Deal([31]). Strategic Action Plan on Batteries was adopted in 2018. This is a comprehensive set of measures to develop an innovative, sustainable, and competitive battery 'ecosystem' in Europe([32]). The European Commission recently proposed a new Battery Regulation with mandatory sustainability requirements which include supply chain due diligence for minerals used in batteries([33]).

Responsible sourcing has been high in the EU agenda for many years and the Conflict Mineral Regulation (addressing tin, tungsten, tantalum and gold, 3TG) entered into force on January 1, 2021([34]). Furthermore, the Commission has also announced a horizontal initiative on due diligence for 2021 and it is currently in the process of reviewing the Non-Financial Reporting Directive([35]), which requires large EU companies to disclose information on social and environmental impacts.

In line with the RMIS mission and services, the EU-funded raw materials projects are to feed in with their results into the development of the RMIS([36]) since 2018. In the Horizon 2020 Work Programme 2018-2020, "12. Climate action, environment, resource efficiency and raw materials", numerous calls in the frame of "Greening the economy in line with the Sustainable Development Goals (SDGs)", stressed that actions should contribute to building the EU knowledge base of primary and secondary raw materials for solid decision making, and particularly to the further development of the RMIS.

In the forthcoming Horizon Europe funding scheme, a similar reference to the RMIS may be applied in the relevant calls of Cluster 4 "Digital, Industry and Space"([37]).

As one of the latest developments, the updated Industrial Strategy has been released on 5th May 2021([38]). The main theme of the Strategy is the Open Strategic Autonomy and related EU strategic dependencies and capacities for which a new review process will be set up. Along with other well-defined actions, the Commission announced the creation of several new Industrial Alliances on:

1. Processors and Semiconductors;
2. Data, Edge and Cloud;
3. Space Launchers; and
4. Zero Emission Aviation.

These will be developed in parallel to the existing/new IPCEIs ("important projects of common European interest") on hydrogen, next-generation cloud, low-carbon industry, pharmaceuticals and a second IPCEI on cutting-edge semi-conductors.

The above listed EU policies indicate an increasing role of raw materials and the RMIS in supporting, presenting and making further sense of the entire value chain of raw materials' information.

([29]) Regulation 2017/821/EU; Com. Recommendation 2018/1149/EU
([30]) COM(2020)493; COM(2021)32
([31]) COM(2019) 640
([32]) COM(2018) 293
([33]) Proposal for a Regulation of the European Parliament and of the Council concerning batteries and waste batteries, repealing Directive 2006/66/EC and amending Regulation (EU) 2019/1020 COM(2020) 798 final
([34]) Regulation (EU) 2017/821
([35]) Directive 2014/95/EU
([36]) Commission Decisions C(2018)4708, C(2020)6320
([37]) https://ec.europa.eu/info/sites/default/files/research_and_innovation/funding/documents/ec_rtd_horizon-europe-strategic-plan-2021-24.pdf
([38]) https://ec.europa.eu/commission/presscorner/detail/en/ip_21_1884

3 The RMIS: state of art

Figure 2. RMIS homepage([39])

Source: RMIS website

Since 2015, the RMIS' scope has progressively expanded and nowadays covers most of the raw material supply chain. There are various traditional services/platform in operation which focus on the different aspects along the chain, such as environmental and social sustainability, energy intensive sectors, trade, material flows – but the RMIS is a kind of one-stop-shop entry that carefully brings together all this information in an increasingly integrated manner (Fig. 2).

RMIS' goal, scope and development plans have previously been discussed with potential users and published in two Roadmaps reports (Manfredi S., et al. 2017 and 2019a).

The RMIS structure, content and tabloid design are aimed at being user friendly and sufficiently flexible to promptly meet policy requirements and stakeholders' needs. The twelve front cover chapters and their two-level subchapters provide clear entry-points for key raw material topics. The conventional must-have contents are increasingly complemented by analytical and visualization tools in a harmonic way and ensuring a degree of freedom for a fast response to rapidly emerging fields. The RMIS now includes dynamic analytical applications with up-to-date visualization tools such as the Supply Chain Viewer, the Battery Value Chain, and Trade.

The first (2015) version of RMIS was not fully suitable to address growing needs and requests. Hence, in 2017, a substantial restructuring was carried out. This ended with the launch of so-called RMIS 2.0 during the 2017 Raw Materials Week event (see more details in Manfredi et al., 2017). The resilience of the continuously renewed RMIS is reflected by the need for only minor but prompt changes in response to new policy priorities and requests (Manfredi et al, 2019a). For example, the tile 'Industry & Innovation' was replaced by 'Foresight, Strategic Value Chains & Material Flows'. The quasi-parallel features of the Critical Raw Materials Factsheets

([39]) As of November 1st, 2021.

(which are part of the triennial list of CRMs for the EU), and the Raw Material Profiles, complement well, but should ultimately converge into one product. Hence, action and changes are made retaining both the front-end, quality assured information as well as the broader complementary qualitative/quantitative knowledge. In this case, it includes a closely interaction with the related SCRREEN II Horizon 2020 project([40]), which is further advancing the factsheets.

In parallel to the continuous development of the underlying, integrated RMIS database, the RMIS is being increasingly fed by international data sources. The integration of international data sources into the RMIS database is, however, sometimes challenging and resource intensive. This has been partly overcome by designing different RMIS datasets supporting some specific RMIS' applications (e.g. Trade, Supply Chain Viewer, RM Scoreboard).

Knowledge management is a distinguished "horizontal" objective highlighted both in the Raw Materials Initiative and in the RM EIP's Strategic Implementation Plan. The explicit formal mandate given to the JRC for the further development of the RMIS was given in the 2015 Circular Economy Action Plan. One important core element of knowledge management is building an expert stakeholders' knowledge network in order to establish multilateral ways of information flows, a precursor for setting validated information base and for distributing and serving information to the interested community (see more details in Chapter 5). In addition, a well-based massive community strongly supports the legitimacy of knowledge conveyed to political decision makers on given high priority topics and issues. Several are already established by other EC services, such as the European Innovation Partnership (EIP) on Raw Materials where, together with DG GROW, the JRC provides support related to the RMIS and closely interacts.

The JRC RMIS team of ca. 15 specialists from well complementing diverse professional fields, organized four dedicated RMIS workshops and three 'EU knowledge base events' as part of the annual Raw Materials Week events([41]), in cooperation with EASME (now HaDEA), DG GROW, and H2020 projects. The outcomes were summarized in proceedings and contributed to further developments/direction of the RMIS (Manfredi et al., 2019; Hamor et al., 2019; D'Elia et al., 2021).

Cooperation was also agreed with partner entities (EIT Raw Materials, HaDEA, EEA, EGS, OECD, H2020s) which has contributed to the development of numerous chapters of RMIS. Finally, five editions of the bi-annual RMIS newsletter were circulated to 1400+ stakeholders (see chap: 4.11.1).

As shown in Box 1, a series of annual consultative for a was launched in 2017 as international RMIS workshops, merged in 2020 with the EASME/HaDEA raw materials workshops. Parallel to this event, a specific event on knowledge management was launched in the frame of the EU Raw Materials Week([42]) organized jointly by JRC and DG GROW. These two complementing events form the basis of an expert network of ca. 1400 stakeholders who are interested in the topic and actively contributing to the development of RMIS.

Box 1. RMIS development: overview of policy context & key milestones

2008: EU Raw Materials Initiative (RMI)([43]).
2013: Strategic Implementation Plan (SIP) ([44]) of European Innovation Partnership (EIP) on raw materials highlights need for European Raw Materials Knowledge Base (EURMKB).
March 2015: JRC launches RMIS 1.0.
December 2015: Specific action in Circular Economy Action Plan([45]) focuses on the key role of the RMIS and mandates its further development.
March 2017: 1st International RMIS workshop.
May 2017: RMIS 2.0 Roadmap & Progress report([46]) (Manfredi et al., 2017).

([40]) https://scrreen.eu/
([41]) https://www.eurawmaterialsweek.eu/2021
([42]) https://ec.europa.eu/growth/content/raw-materials-week-2017_en
([43]) https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0699:FIN:en:PDF
([44]) https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/content/strategic-implementation-plan-sip-0
([45]) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52015DC0614
([46]) http://publications.jrc.ec.europa.eu/repository/bitstream/JRC106005/rmis_roadmap__progress_report_-_final_-_final_-_online.pdf

November 2017: Launch of RMIS 2.0 at the first EU Raw Materials Knowledge Base (RMKB) event as part of the Raw Materials Week([47]).

December 2017: H2020 SC5 2018-2020 call, "projects shall contribute to the further development of the EC RMIS".

May 2018: 2nd International RMIS workshop.

June 2018: Workshop with selected H2020-SC5 projects to discuss how their work supports RMIS development, organized by the "Executive Agency for Small and Medium sized Enterprises" (EASME), DG GROW and DG JRC.

November 2018: Raw Materials Knowledge Base event at the Raw Materials Week.

June 2019: 3rd International RMIS workshop, and proceedings reports.

November 2019: Launch of the RMIS newsletter (Manfredi et al., 2019c) to 1400 recipients, second RMIS Roadmap & Progress Report (Manfredi et al., 2019a).

November 2019: Raw Materials Knowledge Base event at the Raw Materials Week.

September 2020: Release of Commission Communication on Critical Raw Materials Resilience([48]) with RMIS development plan towards strategic foresight to develop robust evidence and scenario planning on raw materials supply, demand and use for strategic sectors([49]).

December 2020: JRC-EASME Technical Workshop "Channelling knowledge from European projects into the Raw Materials Information System (RMIS)", and its proceedings report.

November 2021: RMIS Roadmap2021+.

November 2021: Raw Materials Knowledge Base event at the Raw Materials Week, Brussels.

December 2021: JRC-HaDEA Technical Workshop "Channelling knowledge from European projects into the Raw Materials Information System (RMIS)".

([47]) http://eurawmaterialsweek.eu/
([48]) COM(2020)474
([49]) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0474&rid=1

4 RMIS development outlook

4.1 Work programme 2021-2022

The cornerstone of RMIS development strategy and plans is the biennial JRC institutional Work Programme. For 2021 and 2022, the project titled Raw Materials Information System (RMIS) No.30323 (as part of the Project Portfolio 'Strategic Value Chains – secure & sustainable raw materials' (SVC- RAWMAT) No.20143) is to a number of outputs, one of which is the current report.

The objectives of the institutional RMIS work programme include:

- The continuous update and further development of material-specific and EU country-specific profiles that provide information and quantitative indicators supporting knowledge to the EC policy needs on raw materials.
- The development of a brand-new module focused on Africa and including e.g. profiles for a number of African countries (similar to those developed for EU countries).
- The support on data required by, and provided by, future-orientated/forecast analyses of specific/strategic raw materials supply and value chains, accounting for key aspects related to sustainability & security of supply (responsible sourcing, criticality, resilience, etc.); with close interactions with the SureVAL Project([50]).
- To further strengthen the RMIS network through e.g. systematic knowledge exchanges with selected EU projects (such as H2020 projects) and key stakeholders in the raw materials sectors from Member States and European/international organisations.
- To closely interact with policy DGs on their needs, as well as within the JRC for e.g. interactions related to strategic value chains, with ESTAT, with EASME/HaDEA and with the EEA.
- To facilitate availability, coherence and quality assurance of data and information required and generated by different policy support developments both through underlying data management as well as via the RMIS web interface.

There is a rationale and well-thought scoping considerations behind these ambitious objectives. The RMIS will continue to support the EC policy needs through data management and a web interface, in particular addressing needs related to sustainability (specifically climate change and responsible sourcing) and security-of-supply (supply risks/criticality, resilience). The RMIS focuses on raw materials value chains, their full life cycle, including both primary (extracted/harvested) and secondary (recovered/recycled) materials.

Strategic value chains identified by the EC are a key focus in the RMIS. These include batteries and vehicles, ICT and electronics, space and defence, as well as energy intensive industry. The raw materials considered are mainly abiotic (metals and minerals), but also include some biotic materials such as timber and rubber. Food, crop-based and e.g. fossil fuel related materials are excluded (as they are covered explicitly elsewhere by extensive and dedicated activities).

The RMIS geographical scope include:

- the European Union and the neighboring countries;
- a dedicated pilot module on Africa equally addressing key information related to supply/demand to the EU as well as associated social and environmental considerations;
- Selected countries' data and indicators of trade in non-food, non-energy raw material commodities for Australia, Brazil, Canada, Chile, China, Indonesia, New Zealand, South Africa, Ukraine, USA.

The temporal scope is both past and present information, but also e.g. including future-orientated and foresight knowledge.

The RMIS' scope includes a broad range of thematic areas that are relevant in the analyses of raw materials and their supply/value chains. Hence, key related considerations include Member States and EU policy/governance, material stocks and flows (reserves, urban stocks, trade, production, circularity), supply chain risks/bottlenecks, resilience, environment particularly climate change, and social considerations (responsible sourcing, conflict minerals). These key fields, or thematic areas, provide the foundations in the RMIS web interface in e.g. material-specific and country-specific profiles as well as the basis for the main entry-points. They are also the fundamental basis of the underlying knowledge base.

([50]) SureVAL (SUstainable and secure sourcing of Raw materials for future competitive and low carbon European strategic VALue chains) is the Institutional project n.30325 belonging to the overarching JRC Raw Materials portfolio (n. 20143), as part of the 2021/2022 JRC work programme.

What concerns the methodological tools to be applied, the RMIS developments build upon a number of practical approaches, including:

- **Collection, analysis, and compilation of data & knowledge** produced by the JRC, by the EC ([51]) with Member States, by agencies of the EU ([52]), by European Geological Surveys, by international organisations (OECD, UN, World Bank) and by recognised third parties from e.g. industry and academia. This is conducted through regular knowledge-focused interactions related to specific DG policy support activities and needs across the JRC. Moreover, it involved participation in e.g. Raw Materials Week coordinated by DG GROW and dedicated annual RMIS workshops focused on specific needs.
- **Conception, design and management** of specific IT applications, structuring and management of the web interface and the underlying RMIS database.
- **Analysis and filtering of knowledge** from internal and external sources for each of the different thematic areas.

Six deliverables are foreseen within the 2021/2022 RMIS institutional work programme:

1. Further development of ***Raw Materials' Profiles***. Raw materials' profiles provide access to knowledge relative to the supply and value chains of raw materials such as the broad group of materials analysed in the context of the 2020 EC criticality analysis, conflict minerals, base metals, and selected biotic materials. Raw materials' specific information includes sections related to security-of-supply and sustainability. This involves material stocks and flows, supply chain risks/bottlenecks, resilience, environment particularly climate change, and social considerations.
2. Further development of ***EU Country Profiles***. The further development of the 'EU Country Profiles' tile in the RMIS, including improvements/update of the existing. Country profiles provide access to selected country-specific information related to raw materials and their supply and value chains. Country specific information is structured in relation to trade, security-of-supply and sustainability. This includes material stocks and flows (reserves, stocks, trade, production, circularity), investments and regulatory framework, supply chain risks/bottlenecks, raw material use, environment particularly climate change and pollutants' emissions, and social&policy considerations (e.g. governance, occupational safety).
3. Analysis of **selected environmental and social sustainability aspects of raw materials supply for strategic raw materials value chains** (joint JRC-EEA deliverable). This joint JRC-EEA deliverable aims to compile knowledge related to the environmental and social sustainability of (non-energy, non-agricultural) raw materials supply, with a focus on e.g. critical raw materials, conflict minerals and selected strategic value chains. A key consideration will be the development of lists of materials related to high concerns in the contexts of climate change of responsible sourcing/conflicts in these sectors. This knowledge will be duly included in the RMIS, allowing to enrich scope and content of the RMIS' tile focused on sustainability, and may be used to support the development of selected indicators for e.g. next editions of the EU Raw Materials Scoreboard. The proposed cooperation also aims at monitoring the progress of selected EU countries in ensuring a secure and sustainable supply of raw materials.
4. Development of new tile/pilot content for RMIS, with focus on Africa. Available knowledge on raw materials for African countries may be limited and fragmented. Nonetheless, African countries are vital raw materials trade partners for Europe; essential to meeting many EU policy objectives. This deliverable aims to develop pilot profiles for more coherent and reliable knowledge on raw materials in Africa and its countries. This includes e.g. the development of selected ***African Country Profiles*** in relation to sustainable, secure sourcing and circularity of raw materials in Africa.
5. ***2021 RMIS Roadmap & Progress Report, i.e. the present report***. This RMIS Roadmap is the overarching steering document. This 2021 edition of the RMIS Roadmap is developed for the Raw Material Information System to define a joint common vision, scope, and development options for the years to come. Its content is defined through interactions with selected policy DGs, JRC colleagues, ESTAT, EASME/HaDEA, and EIT-RM. The Roadmap defines milestones with colleagues/stakeholders and accounting for its focal role for the European Raw Materials Knowledge Base and European policy support needs. These milestones reflect short term and mid-term objectives, priorities, as well as the strategies and actions to be followed.

([51]) e.g. DG ESTAT, DG TRADE, DG GROW, DG ENV, INTPA
([52]) e.g. the European Environment Agency (EEA) and the European Health and Digital Executive Agency (HaDEA, former EASME)

6. ***RMIS Networking and Cooperation***. The RMIS will expand and strengthen its interactions with networks, initiatives and activities related to data, information and expertise exchange with Member States and selected organisations. This includes organization of events, such as the Annual International RMIS Workshop. In the frame of the EU Raw Materials Week that is held in Brussels in November each year, JRC – upon agreement with DG GROW – will support e.g. the organization of the EU Raw Materials Knowledge Base Day. It also includes the development of the bi-annual RMIS Newsletter, as well as other informative material (leaflets, flyers, etc.).

4.2 RMIS development plan 2021+

A realistic mid-term (2-4 years) development scenario for the RMIS involves the below ambitious, but normally feasible, development objectives.

4.2.1 Foresight studies

Historically, the RMIS team contributes to foresight studies. One example is the recently released first-ever EC **Strategic Foresight Report** ([53]), aiming to identify emerging challenges and opportunities to better steer the European Union's strategic choices. The EC 2020 Strategic Foresight Report builds on insights and examples from e.g. the Report *"Critical Raw Materials for Strategic Technologies and Sectors in the EU - A Foresight Study*".

With its periodically updated complex datasets, intelligence and capacity developed and supported by the team, the RMIS has arrived at the mature state of its life cycle in line with the expectations of its stakeholders, in integrating functions and services capable of supporting future foresight studies in the raw materials demand and supply value chain realms (Fig. 3).

Primary raw materials markets are traditionally international, and a similar tendency can be observed for secondary raw materials trade. Therefore, RMIS has to broaden its geographical coverage at a higher rate, and to monitor some parameters at a greater frequency than before. Inter alia, this dictates the following objectives to be achieved in the mid-term.

The RMIS will be capable to support data required by future-orientated foresight analyses of specific strategic raw materials supply and value chains, accounting for key aspects related to sustainability & security of supply (climate change, responsible sourcing, criticality, resilience, etc.). Inter alia it will be essential, for example, the link to key knowledge outputs from other activities within the JRC 'Raw Material Portfolio', including the SureVAL Institutional project, as well as a number of activities financed through arrangements between the JRC and other EC services.

Figure 3. Major EC foresight reports on resilience and critical raw materials

Source: JRC

([53]) https://ec.europa.eu/info/strategy/strategic-planning/strategic-foresight/2020-strategic-foresight-report_en

4.2.2 The African country profiles

The EU, as a key trade partner of African countries, can be part of facilitating fairer and greener, more responsible sourcing of raw materials. This well justifies the development of a new RMIS section dedicated to Africa (Figs. 4-10). This RMIS development builds upon synergies with other JRC activities such as the overarching JRC Africa Knowledge Platform ([54]) (AKP), the EDGAR database ([55]), as well as reflecting the interests and dialogue established with other policy DGs; primarily DG ENV, DG INTPA and DG GROW.

In this new tile, the user will be able to select an African country and discover e.g. what are its main raw material exports and their importance to EU and find several indicators and maps about the environment, circular economy, resource governance and working conditions.

As mentioned above, RMIS development builds upon synergies with other JRC activities such as the overarching JRC Africa Knowledge Platform, the EDGAR database, as well as reflecting the interests and dialogue established with other policy DGs; primarily DG ENV, DG INTPA and DG GROW. As a result of this dialogue, the following suggestions were made:

- countries' priorities: DG ENV (Rwanda, Senegal, South Africa, Nigeria, Ghana, Kenya, Morocco, Egypt), DG GROW (shortlist: Senegal, DRC, Namibia, Gabon, Mozambique, Zimbabwe; long list: Rwanda, Nigeria, Tanzania, Ghana, South Africa, Botswana, Cameroon, Zambia, Madagascar, Sierra Leone, Uganda, Cote d'Ivoire, Burkina-Faso, Burundi, Malawi, Mali, Angola), DG INTPA (DRC, Rwanda, Tanzania, Guinea, Liberia);
- different focus: critical raw materials, China's investments, sex disaggregation in ILO's (International Labour Organization) mining official workforce figure;
- additional indexes: e.g. Index of Climate Change Vulnerability score (ND-GAIN index), information from EITI (Extractive Industry Transparency Initiative ([56])).

JRC has a long-standing tradition in the context of the Africa-EU Partnership ([57]) where raw materials have a distinguished role. The RMIS already has detailed relevant chapters under the Environmental & Social Sustainability such as Social Dimension, Sustainable Development Goals, Responsible Sourcing, most of which are directly applicable for Africa. Equally other modules, such as on trade, highlight from where EU countries receive raw materials, etc.

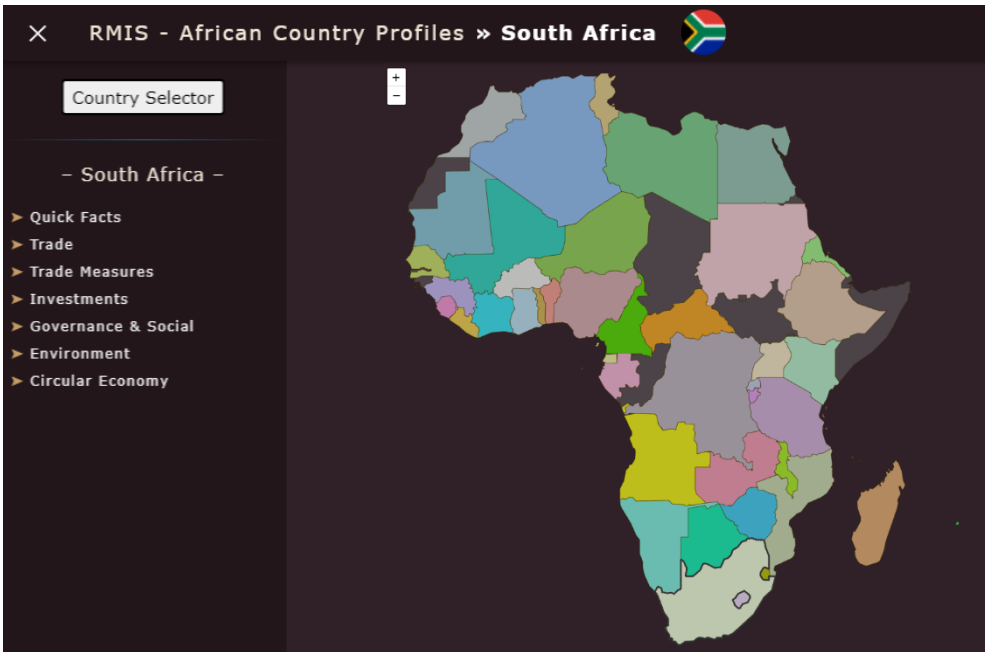
The development of this brand-new module is, also, to assist interactions with e.g. delegations and the building of the EU-Africa partnerships on sustainable raw materials value chains that could promote the:

- development of strategic partnerships for EU-Africa industrial value chains' integration, covering exploration, extraction, processing, refining and recycling (if refining capacity is in place);
- improvement of sustainability (especially environmental and social aspects) in the mining and metal recycling sectors in Africa;
- contribution to eradicating illegal and ethically doubtful supply chains and activities, for example waste trafficking and unsafe recycling;
- development of knowledge on raw materials potential in Africa that will facilitate investment and business decisions;
- reduction of EU vulnerabilities in raw materials sourcing, inter alia, by diversifying EU supply chains from third countries for raw materials, especially for critical raw materials;
- connection with different stakeholders of raw materials value chains, including final users;
- responsible mining practices, in particular those related to the sustainable development of the informal sector (Artisanal and Small Scale Mining), which has become of strategic relevance in this field;
- strengthening of good governance.

([54]) https://africa.qis-ninja.eu/
([55]) the Emission Database for Global Atmospheric Research: https://edgar.jrc.ec.europa.eu/
([56]) https://eiti.org/
([57]) https://publications.jrc.ec.europa.eu/repository/handle/JRC107753

The module is country specific, divided into 6 sections (a draft of the structure is presented hereafter), with an introductory page focusing on the 'Quick facts' about the selected country, including information on the country's mining contribution to the value added of the economy, and the main country's raw materials produced.

Figure 4. African country profiles' homepage example for South Africa



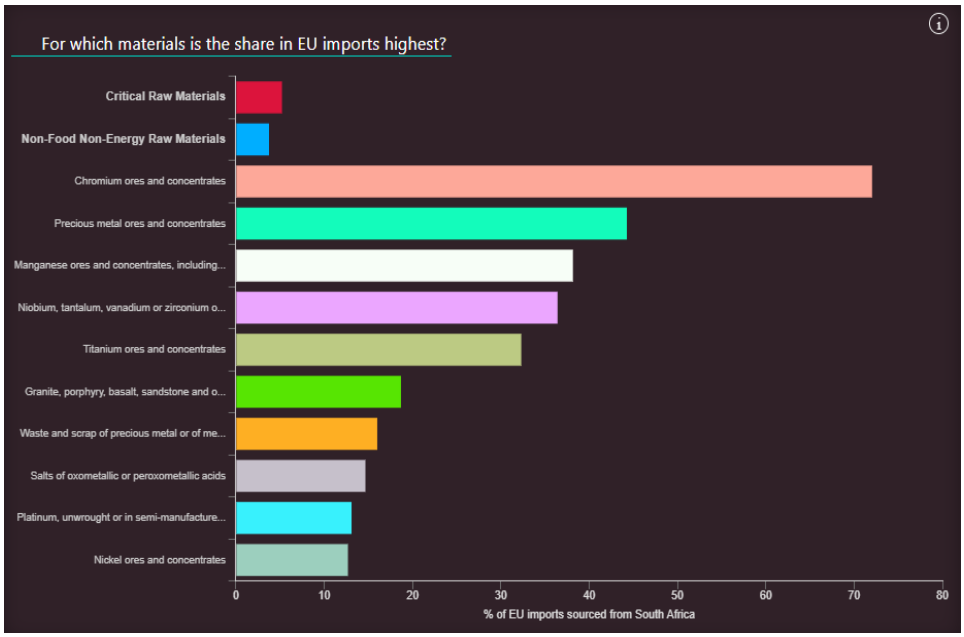
Source: JRC

The African country profiles' structure is presented hereafter:

I) TRADE

The *Trade* module provides an environment where the user can extract and filter information about the African country exports' type and destination, with a focus on but not restricted to critical raw materials. It also provides a snapshot of the most relevant EU imports from the specific country.

Figure 5. Example of visualization of South Africa's share in EU imports

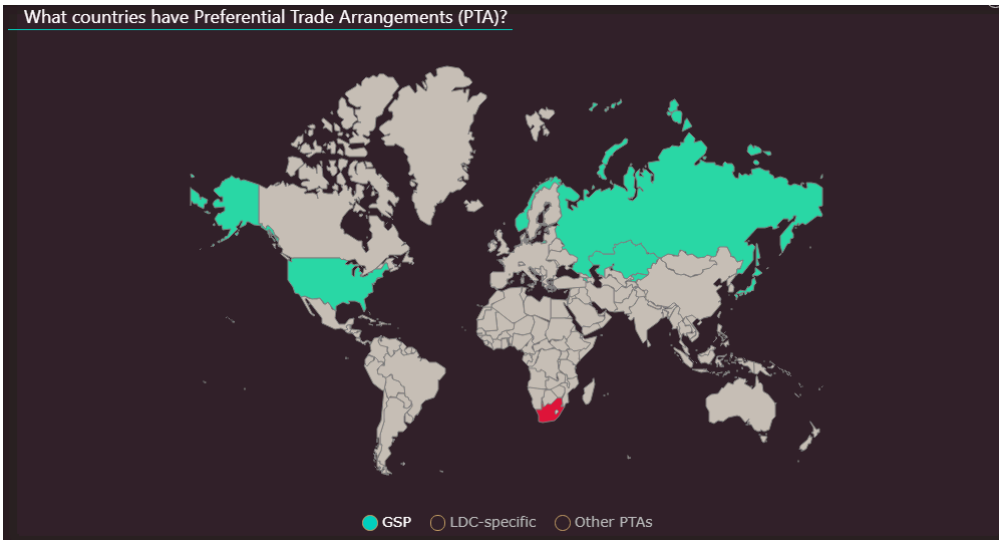


Source: JRC

II) TRADE MEASURES

The *Trade measures* module presents the local and international measures that affect the free trade of raw materials, that is, the trade agreements and export restrictions that involve and are applied by the African country.

Figure 6. Example of visualization of South Africa's Preferential Trade Arrangements

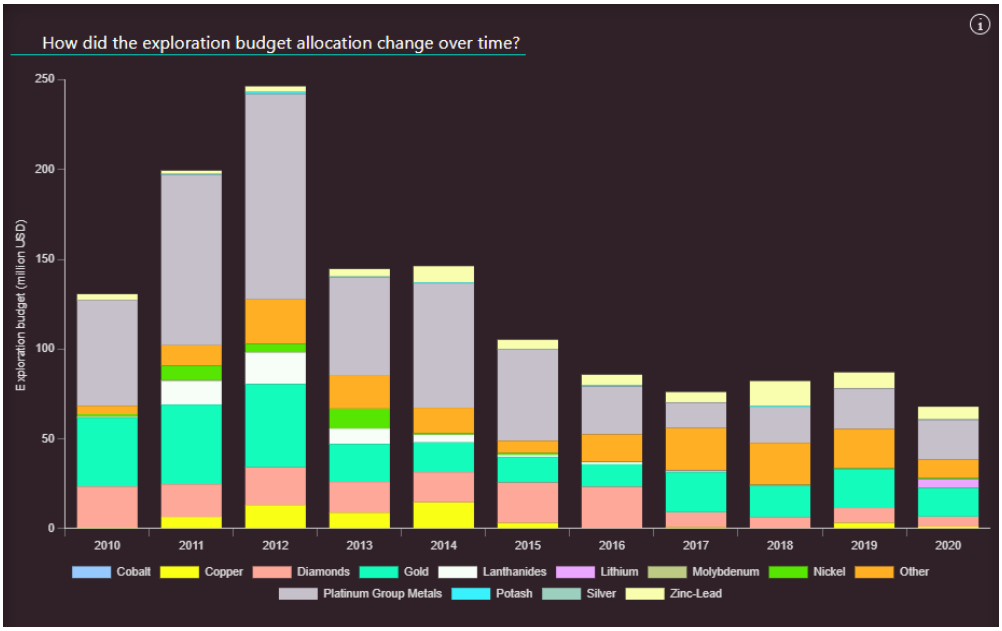


Source: JRC

III) INVESTMENTS

Focusing on foreign and mining exploration investments, this module offers a view on the overall international investment to the country, with a focus on the companies that do exploration on the African land.

Figure 7. Example of visualization of South Africa's exploration budget allocation by material

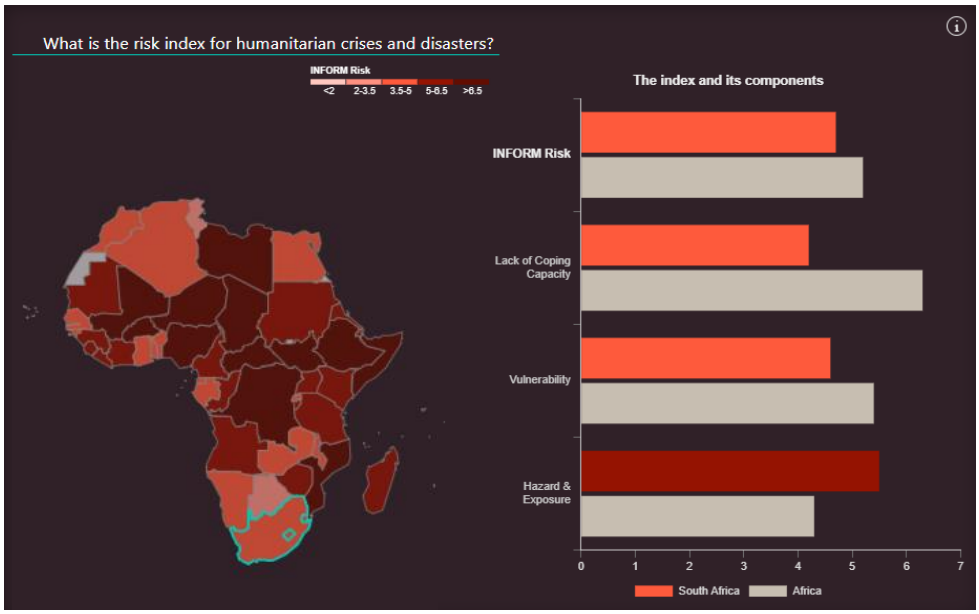


Source: JRC

IV) GOVERNANCE & SOCIAL

Historically, as with others, the African continent has faced national and humanitarian crises and wars connected (among other things) to the exploitation of natural resources. This module features country-specific indicators about the natural resource governance, the humanitarian risk, the poverty, and mining workers conditions.

Figure 8. Example of visualization of South Africa's risk index for humanitarian crises and disasters

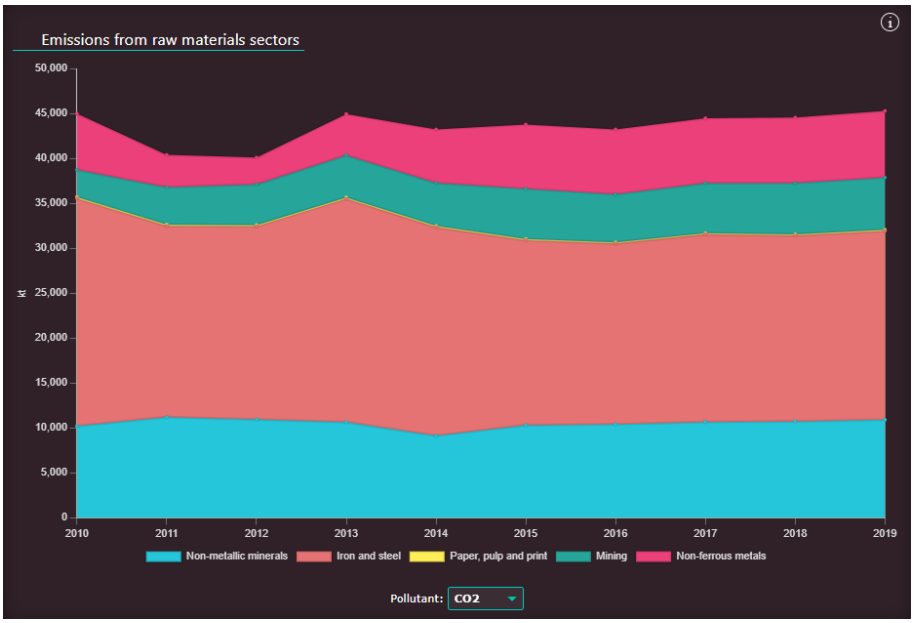


Source: JRC

V) ENVIRONMENT

As sustainability has come to the forefront of public and policy attention, it is essential to consider the environmental implications of exploiting African raw materials. A map visualization will enable users to consider the location of mines in connection with natural aspects like protected areas, or areas with deforestation or high flooding risk. Moreover, it will show the amount of greenhouse gases and air pollutant emissions by raw materials sector.

Figure 9. Example of visualization of South Africa's absolute emissions' values by raw materials sectors

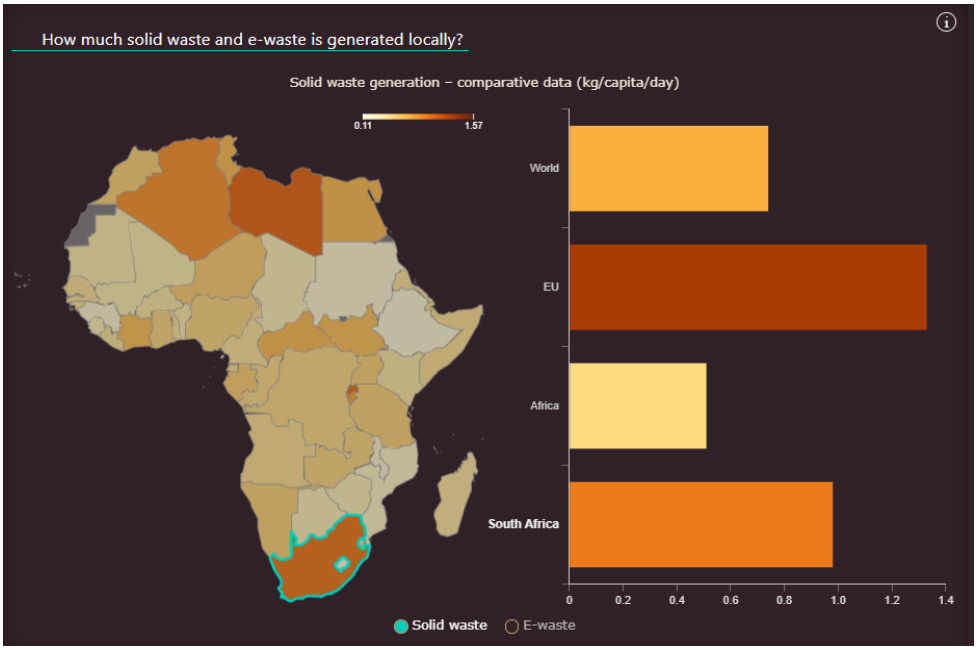


Source: JRC

VI) CIRCULAR ECONOMY

Circular economy is increasingly important also in Africa, a continent with mineral resources and emerging economies ([58]). This section collects information on the local waste generation and collection, as well as on the legal and illegal waste trade flows.

Figure 10. Example of visualization of South Africa's solid waste production



Source: JRC

4.2.3 Raw Materials' profiles

Raw Materials Profiles have been refurbished to provide a visually attractive, dashboard-like information, and additional insights aligned with new EU policies and priorities, as well as with other complementary products (e.g. the RM Factsheets([59]) developed under the triennial EU CRM exercise). The new design approach is modular, with all materials developed horizontally in each module (Fig. 11). A solid underlying database of processed and validated data is built, which is capable of feeding other analytical tools too. The below screenshot represents an example of the copper profile.

([58]) https://pacecircular.org/african-circular-economy-alliance;; https://www.weforum.org/reports/fa73a7fa-b353-499a-a6e2-99fc6d00a0d1; https://www.unep.org/switchafricagreen/news-and-stories/news/circular-economy-africas-pathway-greener-and-sustainable-recovery ; https://www.afdb.org/en/documents/lithium-cobalt-value-chain-analysis-mineral-based-industrialization-africa;

([59]) https://rmis.jrc.ec.europa.eu/?page=factsheets-2020-dfe63e

Figure 11. Dashboard of key indicators of copper being prepared for RM Profiles in the RMIS.

Source: JRC

Complementing the above dashboard of key indicators, a series of reports is foreseen addressing aspects related to environmental and social sustainability, as well as circular economy. A pilot example for Aluminium([60]) has recently been published and is available in the RMIS[61].

Moreover, to provide a complete set of information, on the side of the new Raw Materials Dashboard, it is possible to access the "*Mineral Inventory*" sub-tile([62]). Based on the successful interaction with the EU funded project Mintell4EU([63]), the new sub-tile provides an interactive map of mineral occurrences, and mines within Europe. More specifically:

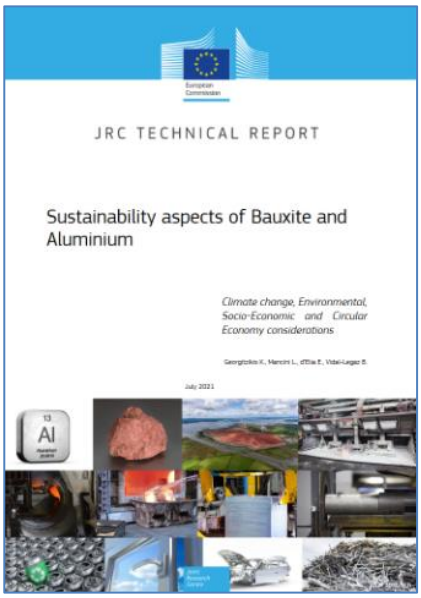
"*The map shows in two layers mine locations and mineral occurrences throughout the European Union (21 Member States covered so far).*

The layer "geological occurrences" shows sites with elevated concentrations of singular or several minerals suited for raw material extraction. They are shown per raw material (commodity) and classified according to the importance (size) of the deposit.

The layer "mines" shows mines of any operational status (operating, under preparation, or already closed). The data differentiates the various mining activities, like underground mining, open pit mining etc."

Additional modules, complementing the dashboard, are being considered for inclusions in the RM Profiles, as presented in the following sub-chapters. The feasibility and timing of such additional developments will have to be evaluated in time, depending on the resources that will be made available for this purpose.

Figure 12. Cover page of the technical report: Sustainability aspects of Bauxite and Aluminium



Source: JRC

I) RESOURCES AND RESERVES

In addition to the interactive map of non-energy mineral occurrences and mines within Europe (recently published, as presented above([64])), the idea is to:

([60]) https://publications.jrc.ec.europa.eu/repository/handle/JRC125390
([61]) https://publications.jrc.ec.europa.eu/repository/handle/JRC125390
([62]) https://rmis.jrc.ec.europa.eu/?page=geological-data-157d8a
([63]) https://geoera.eu/projects/mintell4eu7/
([64]) https://rmis.jrc.ec.europa.eu/?page=geological-data-157d8a

1) Ensure a good coverage of exploration projects in the EU. This can be achieved through a map viewer and charts showing the ongoing exploration and mine development projects with relevant information.

2) Include World non-energy mineral resources and reserves with a map viewer (See Fig.13).

Figure 13. Example of map viewer for World non-energy mineral resources

Source: JRC

3) Include EU domestic non-energy mineral resources and reserves. The module is foreseen to show information at country level in the form of a map viewer, as well charts with compiled/processed data.

II) PRODUCTION

Submodules may include:

- extraction;
- processing/refining, covering also intermediate stages (e.g. alumina in the case of aluminium);
- semi-finished products, in the case of base metals e.g. aluminium;
- recycling, including recycling indicators and supply from secondary materials.

The presentation of the information will comprise long-term trends and the structure of supply per country, both worldwide and in EU.

III) TRADE

The scope of this module could include trade for primary raw materials, processed/refined raw materials, semi-finished products, scrap and waste in accordance with the standard international and ESTAT statistical categories and entries.

Various visualizations are foreseen to present long-term trends and the main EU importing and exporting countries per product category. Destination and source countries for extra and intra EU imports/exports per product category will be made available.

IV) DEMAND

The module will provide information organised in three submodules and will present indicators related to the security of supply/strategic autonomy and their evolution in time, e.g., import reliance, self-sufficiency.

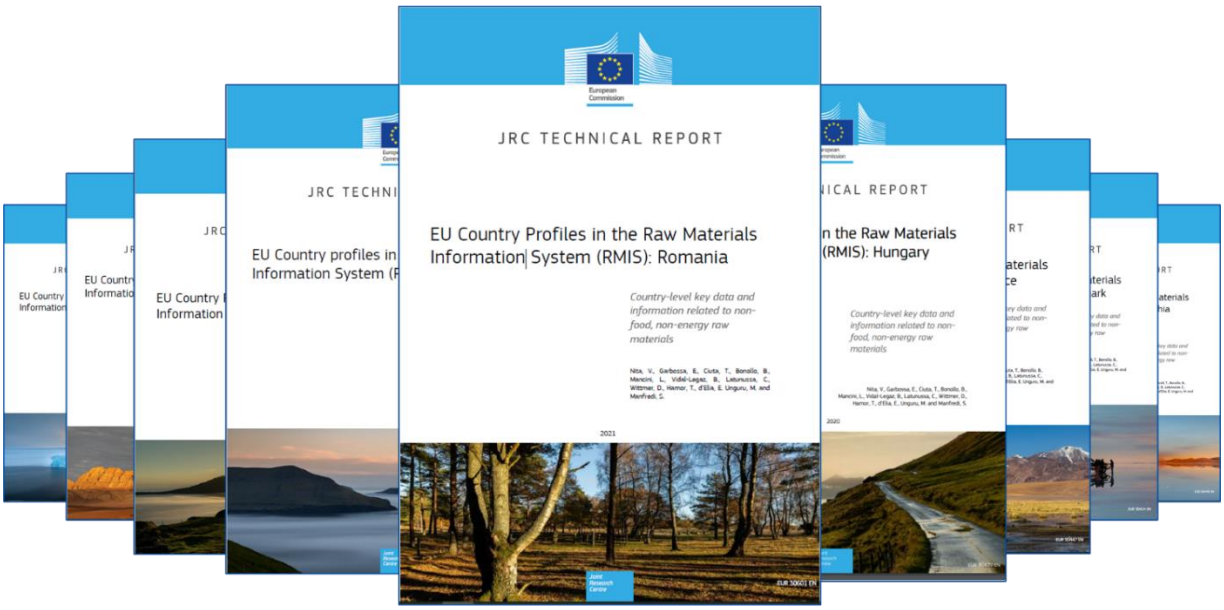
The Value Chain Analysis submodule will facilitate a comprehensive mapping of the value chains associated with each RM by mapping the CPA classification of products, the NACE-4 digit economic activities requiring RM as well as the flows of RM in these complex networks.

4.2.4 EU Country Profiles

The EU Country Profiles module([65]) in the RMIS provides country-specific knowledge for non-food, non-energy raw materials.

This module is undergoing significant updates; recently all EU Member States profiles have been completed, and as a complement to the online profiles, it includes a country specific report (at the time being 9 country reports (Austria, Belgium, Bulgaria, Croatia, Czechia, Denmark, Greece, Hungary, Romania) are already available in the RMIS for download) (Fig. 14).

Figure 14. Cover pages of the published EU country profiles reports



Source: JRC

These country profiles and associated reports synthetize key data, information and indicators related to raw materials. This is achieved by either using data from established providers (e.g., Eurostat, IMF, World Bank, UNIDO, UN Statistics) or by JRC elaboration, based on the mentioned official data (e.g., data on country's trade in raw material commodities, country's exports of mining equipment product groups, etc.).

The reports start with key insights for the specific country in the **Introduction**, followed by tables and charts with short definitions and methodologies applied.

The structure mirrors the RMIS Country Profile chapter, grouping the indices in nine thematic sections:

1) Key indicators
2) Investment and regulatory framework
3) Research, development and innovation
4) Resources and reserves,
5) Supply
6) Raw material use
7) Trade
8) Environment
9) Social & Policy

Key Indicators (section 1) and **Research, development and innovation** (section 3) include both selected economy-wide indicators (e.g., industrial competitiveness, contribution of mining sector to national economies, industry and manufacturing value added as share of GDP) and data on the economic performance of relevant industrial sectors (e.g. value added, employment, labour productivity, as well as magnitude of research and development expenditure).

([65]) https://rmis.jrc.ec.europa.eu/?page=country-profiles

Indicators on investments at country- and sector-level (e.g., share of total investment in GDP, country's total flows and stocks of foreign direct investments ([66]); exploration budget in metals and mining), as well the specificities of countries' mining legislative frameworks are presented in **Investment and regulatory framework** (section 2). Data relating to a country's estimated mineral resources and reserves are provided in **Resources and reserves** (section 4).

Supply (section 5) presents data on a country's volume of imported goods, domestic extraction by broad category of materials, production value of selected mining and manufacturing sectors, and country's production of minerals.

Raw material use (section 6) focuses on utilization of raw materials, presenting data on country's volume of goods exported and domestic consumption by broad category of materials.

Trade (section 7) presents country data on trade in non-food, non-energy raw materials (i.e. Top 20 non-food, non-energy raw material commodities imported in 2017 ([67]), by relevant material category, by product cluster, and by selected Harmonized System (HS) chapter and subheading. Based on the methodology developed within the framework of Raw Materials Scoreboard 2018 ([68]) and applied also for the 2021 Scoreboard ([69]), this section also shows data on a country's exports of mining equipment.

Environment section (section 8) includes tables and charts of selected environmental performance indicators in relevant industrial sectors, such as emissions of greenhouse gases and particulate matter, and generation of waste.

Finally, several social and policy indicators are included in **Social & Policy** (section 9); specifically: governance quality, country risk and occupational safety.

4.2.5 Trade-related profiles for selected non-EU countries

Presented in a recently published report([70])(Nita et al., 2021), trade-related profiles for selected non-EU countries have been developed, as a starting point for additional countries to follow in time.

Specifically, these profiles highlight the main trade patterns and trade polices of selected countries that are relevant non-food, non-energy raw materials trade partners for the EU: Australia, Chile, China, Indonesia, South Africa, Ukraine and USA. These profiles expand and/or update a series of trade-related country fiches in the Raw Materials Information System's Economics & Trade module([71]).

The data and indicators employed highlight both the geographical and product structure of these countries' NFNERM trade, and points to the most relevant NFNERM in their relationship with the EU. Finally, a summary of the trade measures and investment outlook linked to raw materials complements the trade patterns analysis.

4.2.6 Trade module

Under the **Economics & Trade** tile, the Trade application will be extended by a separate visualization tool for countries' trade in primary raw materials and intermediates (processed materials, semi-products).

In time, this will be linked to a new sustainable sourcing map viewer application that visualizes environmental and social indicators of the given countries.

4.2.7 Knowledge Gateway

The tile Raw Materials Knowledge Gateway (RMKG) serves as an access point to raw materials knowledge produced in a European context. The RMIS team perceive the re-structuring of the present RMKG tile as an important step towards ensuring a more extensive and systematic coverage of the most relevant and recent knowledge on raw materials – especially with respect to the outputs from EU funded projects on raw materials.

European projects, such as Horizon 2020 projects (and forthcoming Horizon Europe) and EIT projects, are among the most important knowledge providers to the RMIS. Through the RMIS, the JRC supports longevity, mapping,

([66]) https://rmis.jrc.ec.europa.eu/?page=fdi-stocks-and-flows-86abca
([67]) https://rmis.jrc.ec.europa.eu/?page=trade-flows
([68]) https://rmis.jrc.ec.europa.eu/?page=scoreboard2018#/
([69]) https://rmis.jrc.ec.europa.eu/?page=scoreboard2021#/
([70]) https://rmis.jrc.ec.europa.eu/uploads/JRC126172_NFNERM_trade_fiches.pdf
([71]) https://rmis.jrc.ec.europa.eu/?page=trade-related-country-profiles-0fdee1

structuring and making further sense of this knowledge, so that raw materials knowledge needs identified by EU policy can be met rapidly and systematically.

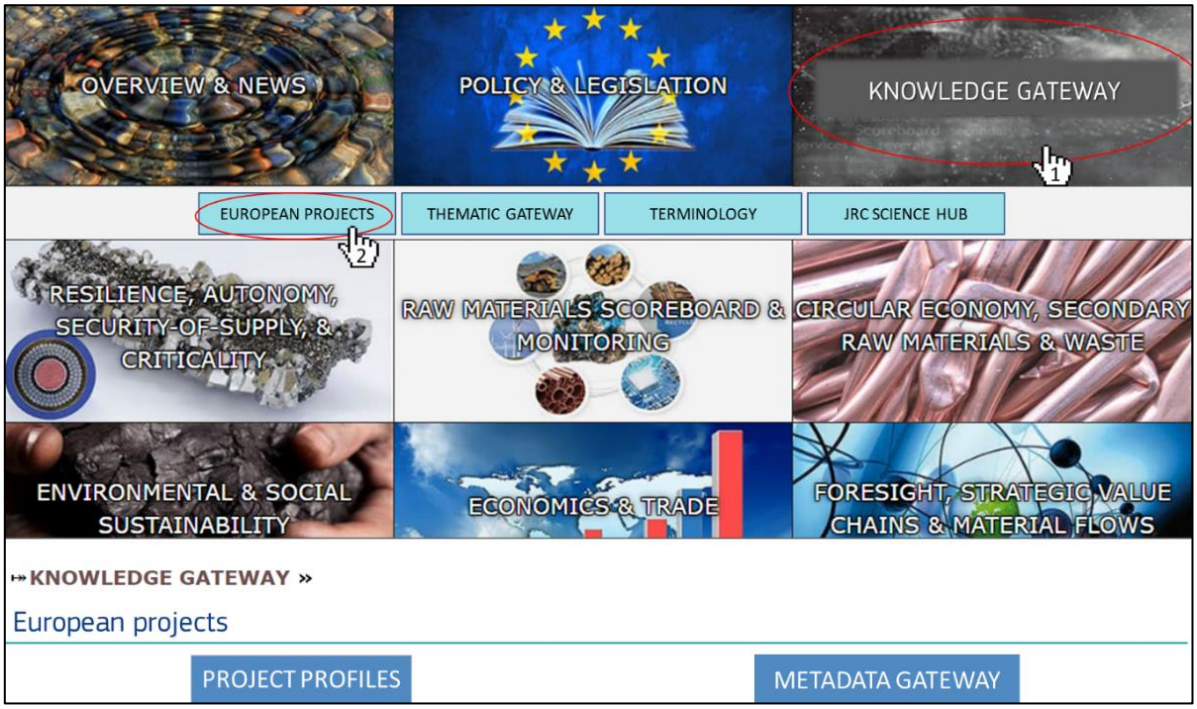
Projects are developing knowledge that is an important input to the EC's aims. At the same time, pro-active work remains needed to develop, disseminate, and ensure the durability of project knowledge outputs in a coordinated manner. The RMIS was, hence, explicitly cited in relation to specific Horizon 2020 calls and, thus, considered in proposals and their evaluations to facilitate these strategic needs (Manfredi et al., 2019b).

In 2021, following the momentum generated by the December 2020 RMIS workshop, a number of projects approached the RMIS team seeking to establish links and synergies between the RMIS and the key projects' results, complementing those with whom the JRC already has good interactions. It is therefore foreseen to continue these focused workshops together with HaDEA. However, more focused efforts are needed on the short and long terms together by JRC, GROW, and HaDEA to optimise this linkage between the RMIS and EU-funded projects on raw materials. This could also be extended to e.g. interactions with EIT-RM, ERMA, as well as other key EU bodies of relevance.

Short term plans (achievable during 2021 Q4 / 2022 Q1)

- Under the tile "Knowledge Gateway", the proposed sub-tiles structure is (Fig. 15):
- EUROPEAN PROJECTS, under which:
    - PROJECT PROFILES (the same as the current "EU funded projects", where the template provided to the projects will be improved);
    - METADATA GATEWAY (descriptions and links to HaDEA, EIT RM, ERMA, GeoERA, EGS, RFCS, IRENA, REA, CORDIS etc. metadata sets).
- LIBRARY (the current LIBRARY moved from top-right tile. The filter/screening criteria of its search engine should show the number of documents in the library that meet the given criteria.
- TERMINOLOGY (legal and technical glossary moved from top-right tile).
- JRC SCIENCE HUB (moved from top-right tile).

Figure 15. RMIS homepage update in a short-term



Source: JRC

The above plans complement the JRC interaction with different projects in relation to selected developments, as well as in relation to inputs to different thematic tiles of the RMIS (such as knowledge on responsible sourcing, circularity, criticality, etc.). Previous calls in Horizon 2020 included an explicit link to the RMIS, which was supported by a guidance for different modes for developing/linking project knowledge outputs to the RMIS. The guidance will be updated, in the context, of the aforementioned developments and other potential interactions. At the same time, JRC will discuss with HaDEA and DG GROW if/how to best re-establish this explicit link with

calls to ensure there remains a strong connection to the RMIS in proposals and in their planned outputs/dissemination.

The IT technical progress makes it feasible that the RMIS will now accommodate numerous virtual gateways to relevant JRC information sources (e.g. the renewed European Platform on Life Cycle Assessment([72])) and external partner services (e.g. EGDI, MINTELL4EU, MICA, ProSUM). For the periodical updates of the above virtual gateways, API (Application Programming Interface) links will be set by major data suppliers, in close cooperation with the RMIS IT architect.

Long term plans (2022-2023 in case external resources are provided, e.g. through a dedicated AA) (Fig. 16):

- Dedicated resources (1 person full time plus IT support) to pro-actively follow and interact with projects/calls in relation to EC interests for development, dissemination, and durability of project knowledge-based deliverables. This person will also have a key role in facilitating the integration of selected relevant knowledge outputs into the appropriate RMIS tiles.
- Developing a new function as part of the METADATA GATEWAY, a smart API to CORDIS, with an intelligent search capacity (see next bulletpoint) that could harvest/link all key deliverables from relevant EU funded projects.
- Developing a new second level tile (under the 'KNOWLEDGE GATEWAY' main tile), called SCIENTIFIC GATEWAY. This is a new tool for the identification/discoverability of all international scientific publications on raw materials available on Scopus, Science Direct or others using a semantic text search analysis tool, e.g. the SeTa (Semantic Text Analysis Tool) of JRC([73]). However, it is to be examined whether it should serve the public with a visualization tool similar, or identical what the JRC developed in the frame of the H2020 MICA project([74]).
- Developing a new second level tile (under the 'KNOWLEDGE GATEWAY' main tile), called KNOWLEDGE COMMUNITY, the Gateway for the RMIS knowledge management and stakeholders' network (CoP or KC or Observatory), which would complement the current set of RMIS workshops and RM Week knowledge base events.

Figure 16. RMIS homepage update in case of long-term plans scenario

Source: JRC

([72]) https://eplca.jrc.ec.europa.eu/
([73]) https://publications.jrc.ec.europa.eu/repository/handle/JRC116152
([74]) http://www.mica-project.eu/, Currently inactive, as accessed on 1st July 2021

4.3 The Competitive Projects outputs in the RMIS

The general operation and development of the RMIS is reliant on the **JRC institutional work programme**.

Beyond this source, as shown in the Table 2 hereafter, targeted developments are supported by a number of EC internal arrangements, as well as knowledge exchanges with EU-funded projects (such as H2020 and EIT Raw Materials projects).

Hence, RMIS development objectives are largely dependent on these two factors.

Table 2. Overview of potential future knowledge inputs to the RMIS arising from competitive activities and EU-funded projects

Source of input (project)	Expected knowledge outputs	Host RMIS tiles / sub-tiles
AA CEAP n.1 (JRC.D/B – ENV.B2)(*)	1. "New collection model for MSW": Environmental knowledge arising from impact assessment of new/improved waste collection model and targets. Timing: 2022-2023 2. "Revision of the definition of recycling of MSW": knowledge related to recovery of SRMs from certain municipal waste streams. Knowledge relative to e.g. climate change impacts associated to the revised definition of recycling. Timing: 2022-2024 3. "EU targets on use of recycled plastics in new cars (EoL Vehicles Directive): further knowledge on fleets of vehicles. Timing: 2022 4. "Separate collection of (portable) batteries": knowledge on stocks and flow of RM in batteries (and losses). Timing: 2023-2024	1. SRM & CE / SMR in specific industry sector 2. Strategic value chains / RM in the battery value chain 3. Environmental sustainability
AA CT-EII (JRC.C7+C1+D3 – GROW.C)(*)	Foresight report (based on demand/supply analysis) related to selected technologies associated with renewable energy, transport, space, defence, and electronics. Timing: 2023	Strategic Value Chains / Foresight Analysis
AA RM-EIP II (JRC.D – GROW.C)(*)	Raw Materials Scoreboard 2020: quantitative knowledge related to key aspects of EU raw materials sector also in global context, and with links to the Circular Economy indicators. Timing: 2021	RM Scoreboard and Monitoring
	Material System Analyses updates and advancements: knowledge on EU stocks and flow of specific RM (9 CRMs)	Strategic Value Chains & Material Flows
	Build a predictive and parameterized stock and flow model for raw materials contained in batteries in the EU, considering both primary and secondary raw materials. Timing: 2021	1. Strategic Value Chains / RM in the battery value chain 2. SRM & CE / SMR in specific industry sector
	Update of information on the regulatory framework in EU Member States. Timing: 2021, annual updates foreseen	Policy & Legislation
	Proposal on a guidance document on EIA for the extraction of non-energy minerals. Timing: 2021	Environmental & Sustainability
AA on battery regulation(*)	Knowledge on stocks and flow of RM in batteries (recycled content, recycling, losses). Timing: 2023-2024	Strategic value chains / RM in the Battery Value Chain

Source of input (project)	Expected knowledge outputs	Host RMIS tiles / sub-tiles
ILLUMINEATION	Data and analyses related to the need for digitalization of the mining sector in order to improve its sustainability performance (along the three pillars of sustainability)	1. Social & Environmental Sustainability 2. RMKG
MINTELL4EU	European mineral deposits and extraction sites. Timing: 2021 onwards annually updated	1. Country /Raw Material Profiles 2. RMKG
RESOURCING (H2020)	Data and analyses that are relevant towards identifying responsible sourcing practices across the mineral value chains of three sectors: renewable energy, mobility, electronics. Timing: 2021/2022-	1. Responsible Sourcing 2. RMKG
CERA 4in1	Sustainable raw materials certification scheme	1. Social & Environmental Sustainability 2. Policy & Legislation 3. RMKG
SCRREEN II	Additional knowledge related to 80+ RMs (incl. CRMs) and their value chains, relative to key parameters used in the EU CRM assessment. Timing: 2023. In the context of the RMIS, key links are envisaged with: • Knowledge Management, aiming at establishing technical/IT links between the SCRREEN database/data-system and the RMIS. • Market Analysis, Trade and Prices • Supply / Demand Outlook & Perspective - outlook of the development of the market and value chains, including Circular Economy aspects, of the materials screened. Aspects covered: future supply and demand, policy and technology gaps, innovation potential.	1. CRMs 2. Strategic Value Chains / Foresight Analysis
SUMEX	Knowledge and data relevant towards establishing a sustainability framework for the EU extractive. Timing: 2023-	1. Policy & Legislation 2. Environmental & Social Sustainability 3. RMKG
Support to JRC.C1 on sustainability assessment of hydrogen value chain(*)	Knowledge on RMs and resource efficiency of fuels cell technologies. Timing: 2021-2022	1. Environmental Sustainability 2. SRM (sustainable carbon neutral mobility)
TRADE4EU (JRC.D-TRADE)(*)	1. Analysis of knowledge destined to negotiating free RMs trade agreements with 3rd countries 2. Market information on RMs commodities, analysis of trends and foresight analysis of trade measures effects. 3. Country fiches focused on trade-related aspects for products of major interest along strategic RM value chains	1. Economics and Trade 2. EU Country Profiles

(*) projects based on EC inter-service bilateral administrative arrangement
Source: JRC

4.4 Dialogue with key Directorate Generals (DGs)

4.4.1 Context & purpose

The RMIS' overarching purpose is to support knowledge needs on non-food non-energy raw materials identified by the EC. This makes it crucial to establish uninterrupted dialogues with key players in the raw materials sector, starting with the relevant policy DGs. This has recently become even more important as policy priorities and needs (also for raw materials) have markedly been refined/revised in the last few years: e.g. with the European Green Deal, the new Circular Economy Action Plan, and the new Industrial Strategy for Europe([75]). It is thus vital for the existence and usefulness of the RMIS to continue the dialogue with relevant DGs, with a view of identifying key knowledge needs and discussing how the RMIS can best facilitate such needs.

The following sections summarise the key outcome from the meetings held during the corse of 2021 (until September 2021) with selected policy DGs. These explicit dialogues are foreseen to continue in the coming months with DG DEFIS and DG TRADE. They will be repeated on a regular basis, in addition to frequente adhoc interactions.

4.4.2 DG GROW

GROW acknowledged the work of JRC in developing RMIS to its current level. RMIS is in the core of the raw materials knowledge management for the EC, and it directly supports many pillars, objectives and targeted actions of the Raw Materials Initiative and the European Innovation Partnership on Raw Materials. GROW proposed to carry out a survey on the composition of its users in order to further fine tune the content and style of RMIS chapters. The figures on visitors and the visited chapters shall be disclosed, at least for the DGs.

GROW welcomed the pilot version of the Raw Materials Dashboard and called for its harmonization with the needs of the critical raw materials factsheets and the supporting database architecture.

GROW supported the idea of developing a more sophisticated service on scientific and technical information delivered by EU projects, and, at a later stage, by international literature through automated search capacities in the frame of the restructured Knowledge Gateway. In an ideal case it shall be supported by a search engine with a capacity for high-resolution thematic selection of attributes.

4.4.3 DG INTPA

For DG INTPA, the envisaged development plan for the new Africa chapter of RMIS is highly important. Dialogue with the JRC in relation to this development shall take place on a continuous base. INTPA suggested also that the scope of the work could/should include major countries involved in investments in the raw materials sector in Africa (e.g. China, South America and the Caribbean countries). This aspect shall be considered when extending the country profiles to non-EU countries.

With regard to climate policy, DG INTPA calls for taking into account the OECD low carbon transition plans when setting priorities in RMIS developments([76]). In the context of responsible sourcing, the sound presentation of the EITI (Extractive Industry Transparency Initiative) is recommended for consideration.

4.4.4 DG ENV

The JRC work and RMIS functions on Foresight are highly interesting to ENV, and the JRC provides a number of indicators in the foresight dashboard to monitor the transition to a green economy. The consumption footprint should/could be coherent with the Environmental Footprint analyses in JRC (EPLCA([77]), PEF([78])).

In the framework of the new circular economy action plan, the feasibility of the market observatory for secondary materials will be assessed, in co-operation with the EEA.

With regard to African country profiles for countries in focus, GROW, ENV and INTPA helped to identify the prioritization of the countries to analyse and display in RMIS. In this context the idea is to work horizontally (with modular approach, where each module covers all countries), publishing all African countries at the same time.

([75]) COM(2018)29; SWD(2018)17; COM(2019)640; COM(2020)98; COM(2020)102; COM(2021)350
([76]) https://www.oecd.org/dev/Workplan_Low_Carbon_Transition_formatted.pdf
([77]) https://eplca.jrc.ec.europa.eu/
([78]) https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

The work on Africa will be connected with the African Observatory platform([79]). A layer of information on raw materials is planned to be included into the overarching JRC Africa Knowledge Platform (AKP), and the RMIS will provide direct access to such platform (specifically in the Environmental section of the African country profiles). At the same time, the RMIS provides information necessary to build a Story Map on CRM/WEEE, sustainable resourcing and circular economy that will be connected directly to the RMIS.

([79]) https://africa-eu-partnership.org/sites/default/files/userfiles/africamainreportonline_0.pdf

5 A review of EC and JRC knowledge management

In the frame of the 2020 JRC institutional work programme, knowledge management tools and administrative formats were mapped and compared in order to support potential next RMIS development steps. From that study, to which the public access is restricted, it is hereafter presented a schematic extract of the information collected.

The chapter gives an overview of the different Knowledge Management possibilities, with a top-down approach from the European Commission's knowledge management to JRC's and reaching the RMIS knowledge community and communication. Whilst the previous chapters described the plans of RMIS development in structure- and content-wise, this chapter is a strategic discussion of the broader knowledge management context on the longer term, with multiple options, a decision support study.

5.1 EC knowledge management

5.2.1 CIRCABC

In CIRCABC (Communication and Information Resource Centre for Administrations, Businesses and Citizens) platform([80]) EC staff can create collaborative spaces where users can work together, sharing information and resources. With CIRCABC, the users can distribute and manage documents in any format, several languages and with version control. CIRCABC is financed by the ISA programme (Interoperability Solutions for European Public Administrations) and the DG DIGIT is responsible for coordinating its development and its user community.

CIRCABC OSS, the Open-Source-Software version of CIRCABC, can be downloaded through the EUPL (European Union Public Licence)([81]). The EUPL is the first European Free/Open Source Software (F/OSS) licence, created on the initiative of the European Commission([82]).

CIRCABC is accessible to any user inside or outside of the European institutions, including businesses, international, national or local administrations, and associations of citizens. Users can manage their own CIRCABC by downloading the OSS version. Access is possible with ECAS authentication, users' rights depend on their profile. The set of services are:

- Information: here you present your group of interest as if it were a single website.
- Library: the repository where your documents are stored.
- Members: lists the members of your group of interest.
- Events: to schedule and manage your events and meetings.
- Newsgroups: to take part in or raise discussions through forums (potentially moderated).
- Administration: to administer your personal account and memberships.

Some interest groups are public, this means that one can visit them without logging in. Some spaces are reserved for members only. The creation of a CIRCABC interest group can be initiated by EU institutions.

Currently, the JRC has 45 different groups of interest on CIRCABC([83]).

Similar to CIRCABC, JOINUP([84]) is a collaborative platform created by the European Commission and funded by the EU via the *Interoperability solutions for public administrations, businesses and citizens* (ISA^2)([85]) programme.

It offers several services aiming at helping e-Government professionals to exchange experiences between each other, and to help find, choose, re-use, develop and implement interoperability solutions.

Concluding remarks

CIRCABC is a traditional facility to store and share information among invited experts of certain policy or scientific and technical fields. However, CIRCABC is not capable of managing dynamic multilateral discussions and knowledge share. It is more a library in character, therefore not an optimal tool for RMIS knowledge management and networking, although JRC is an active user of this facility.

([80]) https://circabc.europa.eu/ui/welcome
([81]) https://joinup.ec.europa.eu/software/page/eupl
([82]) https://joinup.ec.europa.eu/software/circabc/home
([83]) https://circabc.europa.eu/ui/explore
([84]) https://joinup.ec.europa.eu/
([85]) https://ec.europa.eu/isa2/home_en

5.2.2 EC Working Groups

The major source of information on specialist experts is provided by the Register of Commission Expert Groups and Other Similar Entities([86]). This register was set up by the Commission to ensure transparency on expert groups assisting the Commission in relation to:

- The preparation of legislative proposals and policy initiatives.
- The preparation of delegated acts.
- The implementation of EU legislation, programmes and policies, including coordination and cooperation with EU MSs and stakeholders in that regard.
- Where necessary, the early preparation of implementing acts, before submission to the committee in accordance with Regulation (EU) No 182/2011.

The Register distinguishes between *Commission expert groups* and *other similar entities*. The *Register* also includes relevant documents discussed and produced by groups. Gathering expertise from various sources may include gathering the views of various stakeholders.

There are 2 types of Commission expert groups:

- *Formal*: set up by Commission decision.
- *Informal*: set up by an individual Commission department that has obtained the agreement of the Commissioner and Vice-President responsible and of the Secretariat-General.

Commission expert groups are subject to the rules established by Commission Decision C(2016)3301([87]) this decision should be read in conjunction with the Commission Communication C(2016)3300([88]).

"Other similar entities" include advisory bodies set up by the European Union legislator, which have a similar or identical role to that of Commission expert groups. The bodies not covered by Commission rules on expert groups are:

- Comitology committees.
- Independent experts helping the Commission evaluate proposals and monitor projects in the implementation of activities in the area of *research and technological development.*
- *Social dialogue committees.*
- *Joint entities* set up by *international agreements* to supervise their implementation.
- *One-off events*, such as meetings or conferences.

Expert groups are set up to provide a forum for discussion on a given subject and on the basis of a specific mandate involving high-level input from a wide range of sources and stakeholders that takes the form of opinions, recommendations and reports. This input is not binding on the Commission, which remains fully independent regarding the way it takes into account the expertise and views gathered.

Concluding remarks

Establishing a Commission expert group is a lengthy procedure with remarkable administrative limitations which makes these forms of knowledge share less compatible with the overall needs of RMIS. However, in the long term, especially if the raw materials policy field will face Community level legislative initiatives or its implementation, this form may have relevance to consider.

([86]) https://ec.europa.eu/transparency/regexpert/
([87]) Also available at: https://ec.europa.eu/transparency/regexpert/PDF/C_2016_3301_F1_COMMISSION_DECISION_PLUS_ANNEXES_EN.pdf
([88]) Also available at: https://ec.europa.eu/transparency/regexpert/PDF/C_2016_3300_F1_COMMUNICATION_TO_COMMISSION_EN.pdf

5.2 Knowledge management at the JRC

Knowledge management is a novel perspective on organizational governance in the knowledge economy. This new economy, based on knowledge, requires specific management methods and practices.

Knowledge management provides models and tools for advancing organizational capability for creating value from knowledge and competence. It is to bring together people, processes, technologies, and governance in order to improve knowledge-based value creation.

New knowledge has to be found quickly and from a combination of a variety of sources, such as:

- Mastery of technological search tools.
- Managing of knowledge overload.
- Analytical and critical thinking, prioritization.
- Enhanced collaboration.
- Social skills and media, networking.
- Computer-mediated communication, collaboration tools.
- Efficient implementation of knowledge, documentation, storage and archiving.
- Curiosity, creativity, learning to learn, entrepreneurial mindset, courage.

The data and information are extracted from many sources from crowd sourcing to universities and from the industry sector to individual experts. Furthermore, it should be noted that the process is 2-ways and dynamic in both the information and the policy making domains.

The Joint Research Centre is the European Commission's in-house science and knowledge service. It creates, manages and makes sense of knowledge, delivering the best scientific evidence and innovative tools for the policies that matter to citizens, businesses and governments.

The Commission Communication on Data, Information & Knowledge Management([89]) allocates sound duties to the JRC in science and technology evidence-based policy support on the Community level.

The JRC not only generates original data but goes beyond it. In fact, most of its knowledge management activity is related to the added value created by performing data collection and re-structuring, filtering and visualization. The serving of meaningful data and resulting policy briefings is direct for the European Commission as much as to other Community level decision makers.

The JRC Knowledge Management Network with its different facility typologies is summarized in the following figure (Fig. 17).

The JRC institutional and instrumental manifestations of the above mandate and strategy are: Directorate D on Knowledge Management, the vertical (thematic) Knowledge Centres, the horizontal (methodology-driven) Competence Centres, and the Communities of Practice (CoP) which are the spontaneous aggregations around scientific topics (Blakstad and Allen, 2008, Pyrko et al., 2016, Serrat, 2017, Smith et al, 2019, Wenger-Trayner and Wenger-Trayner, 2015, JRC Directorate H, 2017). The JRC explicit knowledge is openly accessible ([90]).

To conclude, in policy making, the problem is no longer the lack of information or data, but, on the contrary, the challenge is to give a meaningful information from the openly accessible data.

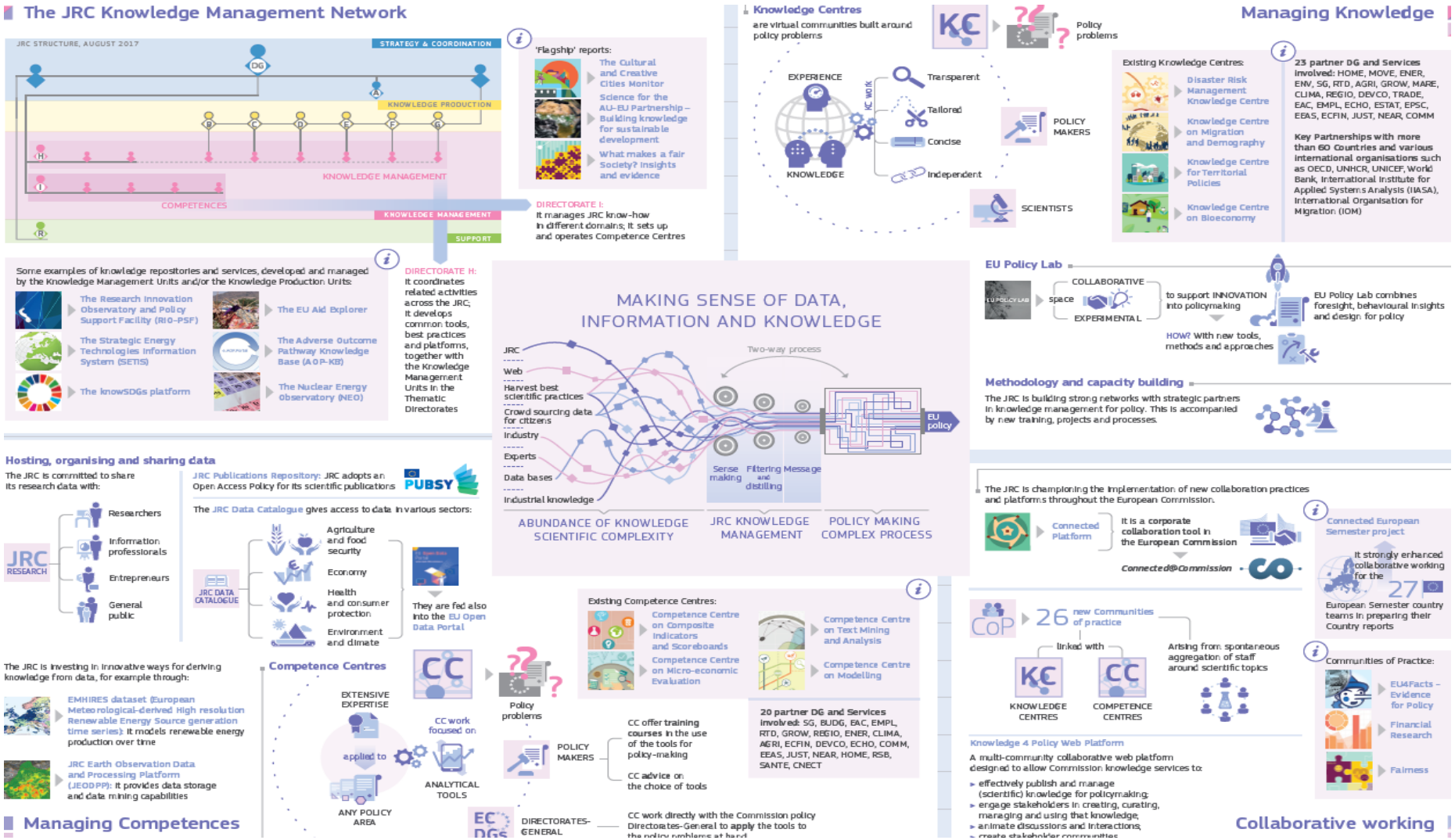
For this reason, the JRC is partnering with policy departments across the EC to operate in Knowledge Centres that bring together expertise and knowledge from different sources. They help policymakers to understand the latest scientific evidence in a transparent, tailored, and concise way.

Another important segment of knowledge management is the JRC Communication network with numerous interlinkages to the core knowledge management facilities, among which the JRC Science Hub and the JRC Knowledge 4 Policy Platform are the major frames and entry points. More information about these segments can be found in the next sub-chapters.

([89]) C(2016) 6626), {SWD(2016) 333 final}

([90]) EU Science Hub: ec.europa.eu/jrc; Twitter: @EU_ScienceHub; Facebook: EU Science Hub - Joint Research Centre; LinkedIn: Joint Research Centre; YouTube: EU Science Hub

Figure 17. JRC Knowledge Management Network



Source: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC110151/2017-12-07_a3-leaflet_km-infographics.pdf

5.2.1 Horizon scanning

Horizon Scanning([91]) is a cross-cutting detection and analysis of weak signals. Horizon scanning is a systematic examination of information from a wide range of sources to identify early signs of future developments. It provides timely awareness of what is new or changing.

It is used as a sort of radar to identify upcoming challenges and opportunities. Through collective sense-making of the scanned signals and validations through further research, issues that could lead to changes in behavior, strategy or policy are identified.

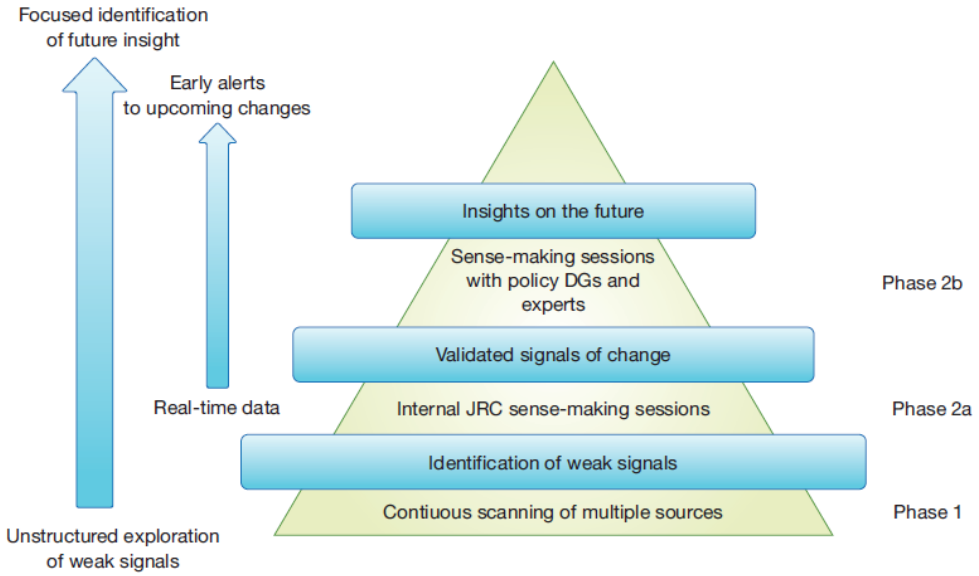
The added value of horizon scanning is to flag issues at the margins of current thinking that may have a significant future impact. It helps entities adapt and prepare for the future.

Horizon scanning can help bridge the gap between anticipatory thinking and evidence-based decision-making by drawing the attention of decision-makers to emerging issues of potential long-term importance (early warning).

It requires credible results and the right type of communication, best achieved through an inclusive process, a clear purpose and a broad range of expertise (Krzysztofowicz et al., 2018).

JRC set up a horizon scanning process([92]) to identify and monitor emerging issues and weak signals of change that might have significant future implications for the EU (Fig. 18).

Figure 18. The JRC horizon scanning process



Source: Albrecht et al., 2020

Horizon scanning may lead to the identification of megatrends and can assist the policy foresight and the resulting implications. Horizon scanning, when a candidate topic had been identified, can be accompanied and complemented by an EU Survey([93]) which is also an efficient tool for obtaining stakeholders' views on a new emerging field.

Concluding remarks

Horizon scanning is a permanent activity of teams active in raw material supply and demand foresight covering the related whole value chain. In a strict sense, this activity shall not be necessarily exposed to the RMIS publication level but should preferably remain at the RMIS expert network communication scale whatever its eventual format will be chosen. Nevertheless, it is of paramount importance in this policy field, to either identify trends and megatrends or induce and assist legislative response and its implementation.

([91]) https://www.oecd.org/site/schoolingfortomorrowknowledgebase/futuresthinking/overviewofmethodologies.htm
([92]) https://ec.europa.eu/jrc/en/research/crosscutting-activities/foresight
([93]) https://ec.europa.eu/eusurvey/

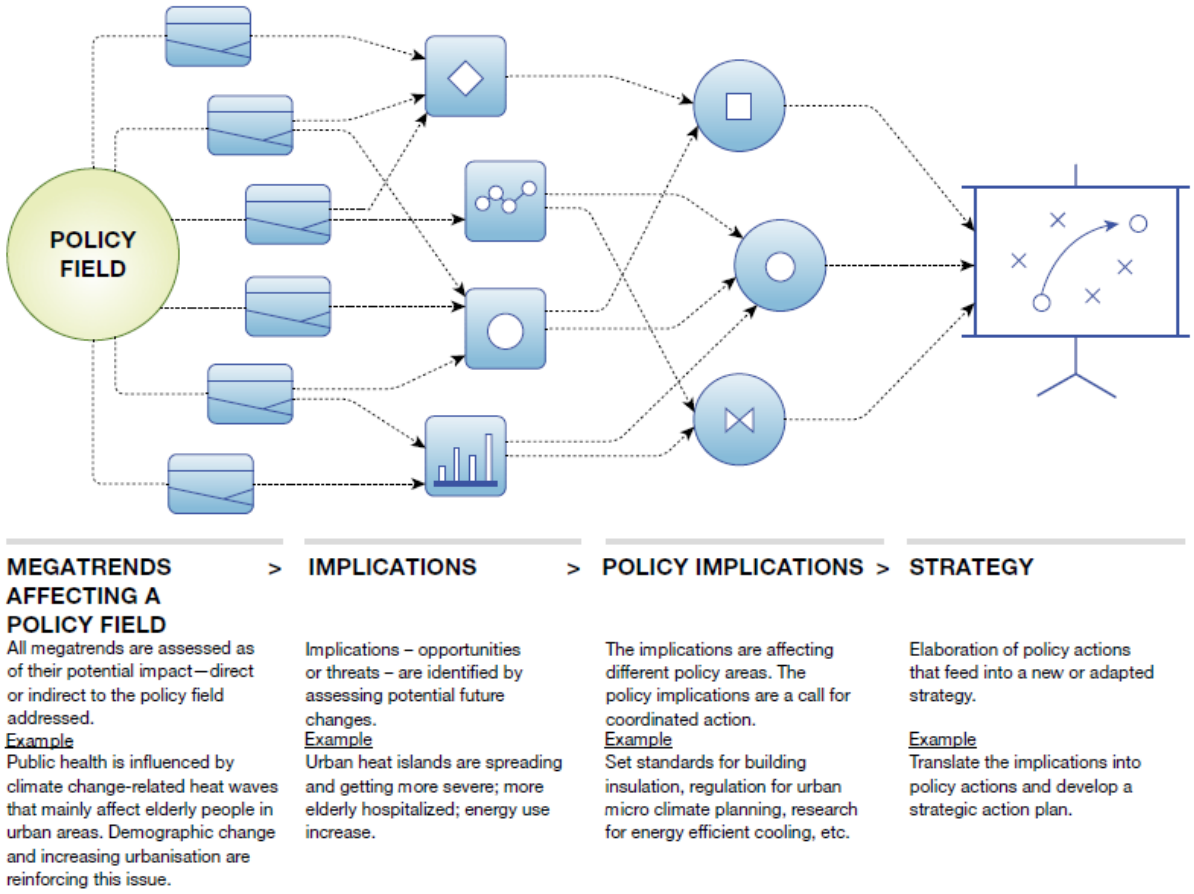
5.2.2 JRC Megatrends Hub

Megatrends are long-term global driving forces that are observable in the present and are likely to continue to have a significant influence for a few decades. They witness large-scale transformations with a broad-ranging scope.

Future developments of megatrends could affect not only their own fields (e.g., education, security, etc.) but also fields that do not seem to be affected at first sight. Given their large dimension, to be better prepared for the future, megatrends require monitoring and anticipatory thinking.

Fig.19 illustrates the megatrends implication analysis approach.

Figure 19. The megatrends implication analysis approach



Source: Albrecht et al., 2020

The European Commission has decided to monitor 14 Global Megatrends relevant for the future of the world, with some focus on Europe.

The Megatrends Hub([94]) is the European Commission's public website where the 14 selected megatrends are presented in a structured way, developed and curated by the Competence Centre on Foresight([95]) of the JRC.

Raw materials related issues are relevant to at least the 6 megatrends (see below: Fig.20) of the current 14 global megatrends:

([94]) JRC-Megatrends@ec.europa.eu

([95]) The Competence Centre on Foresight of the JRC is the infrastructure that supports the dynamic collective intelligence system underlying this foresight initiative. Available at: https://ec.europa.eu/jrc/communities/en/node/2/article/ec-competence-centre-foresight

Figure 20. The 6 global megatrends identified by JRC and relevant to raw materials

Source: https://knowledge4policy.ec.europa.eu/sites/default/files/megatrend_cards-small.pdf

To document a megatrend, the JRC involves experts from its research teams to compile and curate qualitative and quantitative information from a range of authoritative and validated resources. This process is continuous to ensure that the information on the megatrends remains broadly up-to-date.

The content of each megatrend is a concise summary of a broad range of information documenting the past and present evolution of the trend, complemented by an indication of the range of views that various stakeholders might have about its future evolution, a few leads on potential implications and references for further information. As such, it is a tool to support reflection on the future and does not convey any position of the EC. Moreover, the website uses many sources, including, also, research and publications by the EC.

The Megatrends Hub has been designed to make it easy to engage in *Megatrends Impact Analysis,* using the Megatrends Engagement Tools([96]).

This methodology is best applied as a quick and straightforward future reality investigation on any issue of interest in the early stage of the policy cycle. It can be also used at the beginning of a foresight exercise to develop scenarios or test the robustness of a policy and its future-fitness.

The main benefit of these tools is to make it possible to take all relevant megatrends in a multidisciplinary 360° perspective and understand their potential combined impacts on any issue of interest.

This method can be applied by a multidisciplinary team with an understanding of the issue of interest in a half-day participatory workshop, or more extensively with an in-depth analysis of specific trend developments and implications in the preparation phase. All users are invited to send their contributions to the Megatrends Hub editorial team at: JRC-Megatrends@ec.europa.eu.

Concluding remarks

Raw materials are already a focus of many of the identified global megatrends. This itself justifies that the RMIS and its knowledge management system shall consider a closer co-operation and/or unilateral permanent feed-in to the above megatrend hubs, whatever form the RMIS knowledge share network will eventually take.

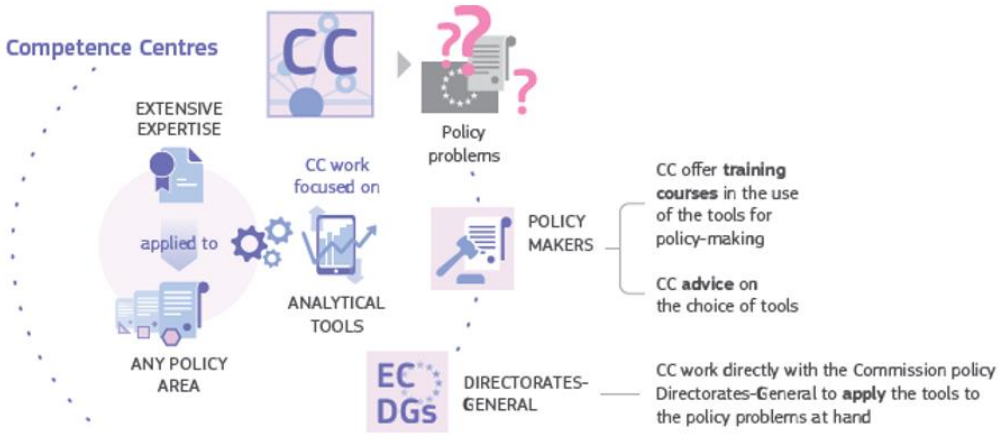
([96]) https://ec.europa.eu/knowledge4policy/foresight/megatrends-engagement-tools_en

5.2.3 JRC Competence Centres

Knowledge Centres (KC) and Competence Centres (CC) are virtual entities bringing together experts, stakeholders and knowledge from inside and outside the EC.

KCs are built around topics, CCs focus on analytical tools; together, they inform policymakers, stakeholders and interested citizens about science relevant to policy problems. They provide contextualised evidence, reviews, data analyses and visualisation, communicated by infographics, web and social media (Fig. 21).

Figure 21. JRC Competence Centres infographics



Source: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC110151/2017-12-07_a3-leaflet_km-infographics.pdf

CCs are centered on analytical tools which can be applied to any policy area, bringing together in one place extensive expertise in the field of interest.

They offer training courses in the use of the tools for policy-making, advise on the choice of tools and also work directly with the Commission policy Directorates-General to apply the tools to the policy problems in hand.

The currently functioning seven JRC CCs are unique suites of services with more than 200 models, 450 datasets, portals, tools and apps, serving 24 DGs.

The JRC CCs are the following:

- Competence Centre on Composite Indicators and Scoreboards([97]).
- Competence Centre on foresight – Megatrends Hub([98]).
- Competence Centre on Microeconomic Evaluation([99]).
- Competence Centre on Modelling([100]).
- Competence Centre on Text Mining and Analysis([101]).
- Competence Centre on Technology Transfer([102]).
- Competence Centre on Behavioural Insights([103]).

Concluding remarks

CCs are methodological networks; the establishment of a future CC on MFA can be considered and its feasibility to be further assessed.

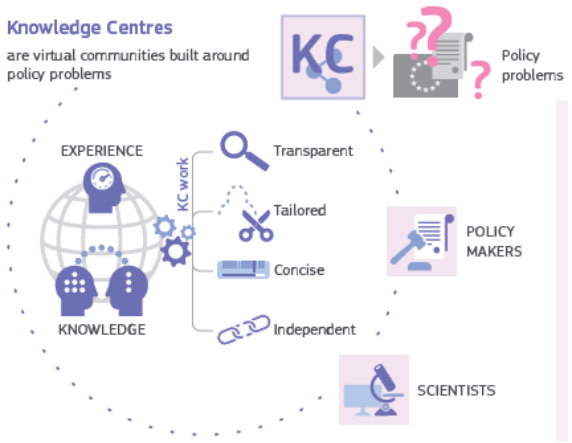
([97]) https://ec.europa.eu/knowledge4policy/composite-indicators_en
([98]) https://ec.europa.eu/knowledge4policy/foresight_en
([99]) https://ec.europa.eu/knowledge4policy/microeconomic-evaluation_en
([100]) https://ec.europa.eu/knowledge4policy/modelling_en
([101]) https://ec.europa.eu/knowledge4policy/text-mining_en
([102]) https://ec.europa.eu/knowledge4policy/technology-transfer_en
([103]) https://ec.europa.eu/knowledge4policy/behavioural-insights_en

5.2.4 JRC Knowledge Centres

Knowledge Centres (KCs) are virtual entities, bringing together experts and knowledge from different locations inside and outside the European Commission.

KCs are meant to inform policymakers in a transparent, tailored and concise manner about the status and findings of the latest scientific evidence (Fig. 22). They are designed to be a "one-stop-shop" in their respective areas and include communities of practice.

Figure 22. JRC Knowledge Centres' characteristics and linkages to policy making



Source: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC110151/2017-12-07_a3-leaflet_km-infographics.pdf

The JRC KCs are the following:

- Knowledge Centre on Earth Observation([104]).
- Knowledge Centre for Bioeconomy([105]).
- Disaster Risk Management Knowledge Centre([106]).
- Knowledge Centre for Food Fraud and Quality([107]).
- Knowledge Centre for Global Food and Nutrition Security([108]).
- Knowledge Centre on Migration and Demography([109]).
- Knowledge Centre for Territorial Policies([110]).
- Knowledge Centre for Biodiversity([111]).

The eight Knowledge Centres serve 26 DGs and Services, involve more than 250 partnerships with national/regional authorities, international agencies, research & standards organisations.

Observatories can be interpreted as a sub-type of Knowledge Centre with a narrower, more specific scope, and perhaps less functional services. There a number of observatories operated by JRC, such as the European Soil Observatory([112]), the Atmospheric Observatory, the Drought Observatory, etc.. In the field of raw materials the former H2020 project INTRAW launched the International Raw Materials Observatory([113]) focusing on the first pillar of the Raw Materials Initiative.

Concluding remarks

KCs are limited to policy fields of outstanding political importance on Community scale. In addition, KCs represent a complex and developed information system. In conclusion, on the longer time horizon, a KC may fit the RMIS knowledge management progress pathway.

([104]) https://knowledge4policy.ec.europa.eu/earthobservation_en
([105]) https://ec.europa.eu/knowledge4policy/bioeconomy_en
([106]) https://ec.europa.eu/knowledge4policy/disaster-risk_en
([107]) https://ec.europa.eu/knowledge4policy/food-fraud_en
([108]) https://ec.europa.eu/knowledge4policy/global-food-nutrition-security_en
([109]) https://ec.europa.eu/jrc/en/migration-and-demography
([110]) https://ec.europa.eu/knowledge4policy/territorial_en
([111]) https://ec.europa.eu/knowledge4policy/biodiversity_en
([112]) https://ec.europa.eu/jrc/en/eu-soil-observatory
([113]) https://intraw.eu/

5.2.5 Community of Practice

The Communication on Data, Information and Knowledge Management at the European Commission emphasizes that better gathering, sharing and use of data, information and knowledge in the Commission are essential to deliver integrated policy work and overcome silo mentalities.

Communities of Practice (CoP)([114]) form an important instrument to reach that goal, stimulating cross-organisation collaboration and knowledge sharing.

Mobilising knowledge, i.e., people and resources, is vital nowadays for the co-creation of policies. One new way of working on it is with communities. These communities can be sometimes referred to as knowledge communities, communities of practice (CoPs) or of interest. What binds them all is the social interaction at their core: they naturally take advantage of social learning and exchange between members.

CoP is a group of individuals who share their interests and problems within a specific topic and gain a greater degree of knowledge and expertise through regular interaction. In other words, CoP can be defined as groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly.

The three main elements define a community of practice are: the shared **domain** of interest, the **community** where members engage in joint activities and discussions and **the practice** which goes beyond a mere interest, as members are practitioners who share a repertoire of resources such as experiences, stories, tools etc. (Wenger and Trayner, 2002).

In a CoP people share and develop their knowledge within a domain, as well as use and develop the community's body of knowledge which includes practices, methods, guidelines and other resources. Communities of practice go beyond just sharing information as practitioners have a desire to build and improve their practice.

As they emerge in the JRC and in the rest of the Commission, CoPs meet the challenge of organising knowledge systematically. CoPs may have a different origin with different tasks and objectives, but their reason for being remains the same.

CoPs co-exist with existing structures of the organisation (such as Units), support each other and steward knowledge across the organisation being contributors to the success of the organisation's activities and deliverables (e.g. Commission's Work Programme).

Currently, within the Commission, a CoP has four possible origins.

1. CoPs can be created following a clear political and policy demand and requiring input from across the Commission (usually established at the request of the Secretary General, for example the Community of Practice on Sustainable Development Goals);
2. CoPs established to support the work of Knowledge and Competence Centres or to prepare the ground for setting up such knowledge hubs;
3. CoPs which naturally emerge based on a cross-JRC and/or cross-Commission business' need, such as the Data for Policy Community of Practice;
4. CoPs established to support the multi-disciplinary approach required for deliverables in the JRC's Work Programme. The evolution of the successful scientific clusters towards Communities of Practice is an example of this type of CoP.

The added value/benefits of a CoP include:

- Easier access to available data, information and knowledge; the general added value of a CoP is sharing of three components of knowledge, data, information and tacit knowledge (= experience). The CoP's specific added value is the access to tacit knowledge by means of networking people.
- Access to knowledge of events organised by the community or relevant to the community.
- Access to multi-disciplinary competences and complementary knowledge.
- Identification of common goals/outputs where pooling of competences/knowledge is required.
- Opportunities to sound-off ideas and propose new or exploratory activities.
- Identification of topics meriting a JRC Science for Policy Brief.
- Identification of joint activities / deliverables (e.g., flagship reports) for insertion in the JRC Work Programme.

([114]) Blakstad and Allen, 2008, Pyrko et al., 2016, Serrat, 2017, Smith et al, 2019, Wenger-Trayner and Wenger-Trayner, 2015, JRC Directorate H, 2017

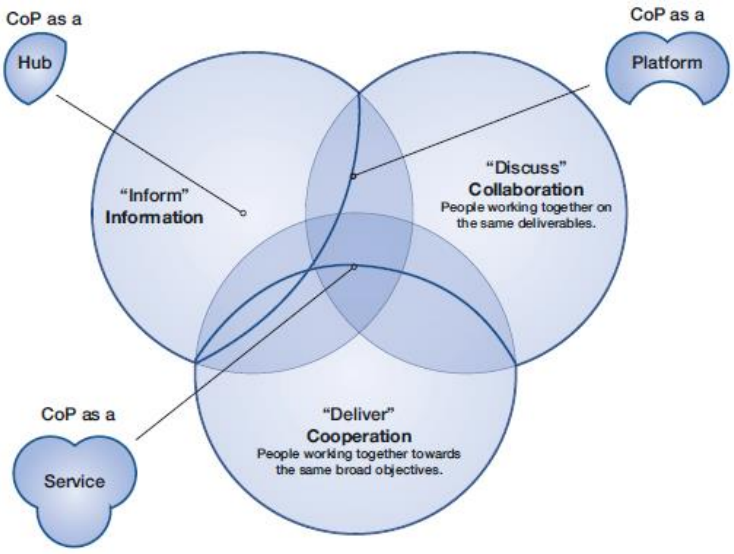
- Identification of gaps and potential new areas of work to be integrated in future JRC Work Programmes to better support EU policies.

JRC and other Commission CoPs have three basic community types (Fig. 23):

1. Hub: CoPs that connect people with knowledge content; the primary value is to inform the organisation around the topic of practice.
2. Platform: CoPs where members collaborate to produce new knowledge; the primary value is discussion and collaboration around the topic of practice.
3. Service: CoPs that provide a service; the primary value is to deliver value and cooperate with the rest of the organisation in the achievement of its goals.

This typology represents a progression of CoP types. CoPs typically begin life as Hubs, then progress to Platforms and then mature into Services. This can be seen as an evolution of value over time, though it should be noted that Hubs and Platforms offer value in their own right; they are not necessarily destined to evolve into the higher value types, even if the potential for this could always be explored.

Figure 23. Typology of EC CoPs



Source: Albrecht et al., 2020

Each CoP must define and have a shared understanding of purpose and desired outcomes. The recommended steps to take for setting up a CoP are (JRC, 2017):

1. Define what a CoP wants to achieve, what is the purpose and why it is important; the purpose of the CoP is ideally defined by the Community and this can be formalised under a "terms of reference" document drafted by the initiator/owner Unit(s) and endorsed by the hierarchy.
2. Identify together with business owner(s) the CoP community managers and provide training, coaching and ad-hoc support to them.
3. Define initial community members and their expected contributions and benefits for the CoP.
4. Determine the potential community members' needs and identify common knowledge needs; both stakeholders' cases and the business cases (organisational goals).
5. Once the CoP has defined its needs, the Connected platform can be used to support main processes/use cases; a request needs to be sent to the Connected@JRC or Connected Commission team.
6. Design the online platform supporting the CoP and implement on Connected; this includes execution of the online community mock-up to be tested and iterated with members (internal and external).
7. Determine an offline activity plan (meetings, lectures, conferences, etc.) to ground and stimulate the online activity; science lectures could be organised in their domain.
8. Launch and populate with content, people and processes. Key is to find people who already network on the topic and help them realize how increased networking and knowledge sharing could be valuable.

Steps are normally worked out in a participatory style, employing design thinking and participatory leadership.

While building the 'beta version' of K4P([115]) (Knowledge for Policy) in 2018, JRC carried out in-depth research to discover what our audiences actually want and need (e.g. Evidence-based policymaking: a story emerges from audience research). Since 2018, the number of Knowledge Services on the K4P platform has grown from 5 to 13, with another 4 on the way. As more Knowledge Services create knowledge brokerage content for policymakers, the knowledge here will become more accessible.

What concerns online communities, in 2020, JRC K4P migrated to a new web publishing software (*Drupal 8*), allowing to start to work on the next major development: online communities. Users will be able to submit knowledge to Knowledge4Policy, ask questions and comment, and even collaborate with Knowledge Services. Digital tools hosting CoPs do not need to be complex, normally requiring functions such as forum, document libraries, expertise finder, teleconferencing and ideally video conferencing and online places where members can edit documents and discuss them. For example, the European Commission uses *SharePoint*, *Yammer* and *Jive* software for hosting internal CoPs and *Confluence*, *Wikis* and *Drupal* for CoPs involving members from outside the organisation. It is possible to find communities run with external partners on the JRC's Science Hub.

Bridging the gap between knowledge production and the knowledge use is a key challenge for the whole policy cycle, from conception to implementation and evaluation. The hardest challenges are not about producing but rather about sharing, using and interconnecting knowledge. There is clear difference between the researchers and policymakers' communities simply because they operate according to different respective work schedules and priorities.

Concluding remarks

The Community of Practice is a well-established and the preferred format of knowledge management at the JRC, suiting potentially to the current objectives, development level and stakeholders' composition of RMIS.

The further assessment of the feasibility and the detailed planning of potentially setting an RMIS CoP is needed.

([115]) https://ec.europa.eu/knowledge4policy/about-knowledge4policy_en ; https://ec.europa.eu/knowledge4policy/

5.3 Knowledge management at RMIS

Knowledge management has been a major functional element of RMIS since its launch. RMIS' knowledge management has been discussed in presentations and as a discussion topic at the annual RMIS workshops, at the European Raw Materials Knowledge Base Events in frame of the annual EU Raw Materials Week(s), and at the joint JRC-EASME workshops in 2019 and 2020, focusing on the integration of H2020 SC5 projects into RMIS.

The need for a European Union Raw Materials Knowledge Base (EURMKB) is highlighted in the Action area no. II.8 of the 2013 Strategic Implementation Plan (SIP) for the European Innovation Partnership (EIP) on Raw Materials.

In addition to the work initiated by DG GROW under the framework of EURMKB([116]), and responding to a specific action of the Commission's Circular Economy Communication([117]) DG Joint Research Centre (JRC) is continuing to further advance the Raw Materials Information System (RMIS).

The first version of the RMIS (hereinafter "RMIS 1.0") was released in 2015 as a permanent website under the JRC Science Hub. The markedly upgraded second version (hereinafter "RMIS 2.0", or simply "RMIS") was announced in the 2017 "*RMIS Roadmap & Progress Report*"([118]) (Manfredi et al., 2017) and was officially launched during the 2017 "Raw Materials Week" event([119]), organised by DG GROW in Brussels.

RMIS 2.0, with the introduction of a new tabloid design, broadened the goal and scope of RMIS 1.0. It significantly expanded the network of its knowledge providers and responded – often in quantitative terms – to the latest policy and knowledge needs on raw materials. In particular, were included important thematic sections such as *raw materials' profiles*, *EU country profiles*, *supply chain viewer* and *raw materials knowledge gateway*.

Further strengthening networking and inflow of knowledge towards RMIS, the EC made it mandatory for Horizon 2020 projects (within the call Societal Challenge 5, Raw Materials, 2018-2020) to contribute to the further development of RMIS([120]).

As presented in this report, key features of the RMIS facilitate the provision of structured knowledge on *material flows & stocks*, *social & environmental sustainability* and *trade & economic* considerations.

5.3.1 The RMIS knowledge community

In order to facilitate a secure and sustainable supply of raw materials and to better manage the resources use, the EU requires, among others, comprehensive knowledge related to entire raw materials value chains, comprising exploration, extraction, processing, refining (including by-product management), production (including product eco-design), use (e.g. consumption), and end-of-life treatment (re-use and recycling, including waste collection, separation, recovery).

Knowledge needs relate to both high-quality data and information. Fulfilling identification of knowledge needs is critical to support factual decision and policy-making in the field of raw materials.

The RMIS continues supporting the knowledge needs identified by the Commission in the area of raw materials. Towards this end, RMIS has established extensive synergies with a wide network of knowledge providers.

As observed by the JRC-led Task 5.2 of the ORAMA project on mapping of the relevant EU funded projects and initiatives([121]), there are ca. 500 such projects financed by different EU funds and supervised by several EU agencies (HaDEA, INEA, RFCS, ERC)([122]).

A subsequent thematic screening of the full H2020 database([123]) by the JRC, and the inclusion of the 100+ EIP SIP commitment groups([124]), lead to the conclusion that the overall number of relevant projects can be close to 1000.

([116]) European Union Raw Materials Knowledge Base (EURMKB), 2017, http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/knowledge-base/index_en.htm
([117]) COM(2015) 614 final
([118]) Available online at this address: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC106005/rmis_roadmap__progress_report_-_final_-_final_-_online.pdf
([119]) https://ec.europa.eu/growth/content/raw-materials-week-2017_en
([120]) http://ec.europa.eu/research/participants/data/ref/h2020/wp/2018-2020/main/h2020-wp1820-climate_en.pdf
([121]) https://orama-h2020.eu/downloads
([122]) At the time of mapping no detailed information was publicly available on the 200+ EIT Raw Materials projects, and on the national projects funded by Member States.
([123]) https://data.europa.eu/euodp/en/data/dataset/cordisH2020projects
([124]) https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/call-commitments

The current capacity of the RMIS team does not make it feasible to archive and serve all the knowledge generated by these projects. Nevertheless, the RMIS' Thematic Library is a good candidate to host such an enormous volume of information in a structured way and enables RMIS users to search for the required information in an easy manner.

Moreover, the annual RMIS and HaDEA workshops are designed to mediate the networking of these projects.

Raw materials' knowledge – in terms of both original and re-processed data and information – is being collected and analysed from various sources and by various stakeholders.

Knowledge providers include:

- EU documents and studies, e.g. EURMKB([125]), KBA([126]), MSA([127]) & Minventory([128]), Raw Materials Scoreboard([129]), Criticality analysis([130]).
- EC-funded projects (mainly Horizon 2020), e.g. Minerals4EU, MICA, PANORAMA, PROSUM, ERECON, EURARE, CRM_Innonet, REMOVAL, ERAMIN, ORAMA, SMART GROUND, SCRREEN2, CEWASTE, INTRAW, New Mine, MINATURA2020, MINLEX, MIN-GUIDE, COLLECTORS, INTERMIN, TARANTULA, VERAM, STRADE, MINTELL4EU, RE-SOURCING([131]).
- Institutions providing data at European level (e.g. EIT Raw Materials, EuroGeoSurveys (EGS), Bureau de Recherches Geologiques et Minieres (BRGM), World Mining Data (Austria)) and with support of the national/regional geological surveys, and other relevant entities collecting raw materials related data and information.
- Stakeholders along the value chain, e.g. industry associations, companies, research institutes, research programs.
- EU Member States and their competent entities.
- Non-EU country entities, e.g. the United States Geological Survey - USGS, US COMTRADE, Japan Oil Gas and Metals National Corporation – JOGMEC).
- EC services such as DG JRC([132]) and DG ESTAT([133]), DG GROWTH([134]), DG ENV([135]), DG TRADE([136]), DG DEVCO([137]), EU Agencies (e.g. European Environment Agency (EEA)([138]), EASME([139])).
- International bodies (e.g. UNEP Resource Panel, OECD) are also key sources of data and analyses, and commercial services (e.g. SNL-S&P Global-).

In 2020, in preparation for the JRC-EASME Technical Workshop "Channelling knowledge from European projects into the Raw Materials Information System (RMIS)" the following list of projects was selected by the JRC and EASME (Table 3), and actively participated to the workshop by giving a presentation on their project, and how it could be linked to the RMIS.

([125]) European Union Raw Materials Knowledge Base (EURMKB), 2017, http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/knowledge-base/index_en.htm
([126]) DG for Internal Market, Industry, Entrepreneurship and SMEs, 2015, KBA - European Raw Material Knowledge Base Architecture, Final Report, Brussels, 322 p.
([127]) European Commission Raw Material System Analysis, https://ec.europa.eu/jrc/en/scientific-tool/msa
([128]) European Commission, 2016, Minventory, https://ec.europa.eu/jrc/en/scientific-tool/minventory
([129]) European Commission, 2016, Raw Materials Scoreboard, http://bookshop.europa.eu/en/raw-materials-scoreboard-pbET0215541/
([130]) European Commission, 2015, 'Critical Raw Materials', https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en
([131]) A comprehensive overview of Horizon 2020 projects relevant in the context of raw materials is provided in the "Bi-annual report, 1st semester 2017" by the Executive Agency for Small and Medium-sized Enterprises (EASME).
([132]) https://ec.europa.eu/info/departments/joint-research-centre_en
([133]) https://ec.europa.eu/info/departments/eurostat-european-statistics_en
([134]) https://ec.europa.eu/info/departments/internal-market-industry-entrepreneurship-and-smes_en
([135]) https://ec.europa.eu/info/departments/environment_en
([136]) https://ec.europa.eu/info/departments/trade_en
([137]) https://ec.europa.eu/info/departments/international-cooperation-and-development_en
([138]) https://www.eea.europa.eu/
([139]) https://ec.europa.eu/easme/en

Table 3. Projects presenting at the JRC-EASME Technical Workshop "Channelling knowledge from European projects into the Raw Materials Information System (RMIS)"

Name of the project	Funding scheme	Years	Thematic Section
PANORAMA	EIT RM	2019-2021	Knowledge base
ORAMA	CSA	2016-2019	Knowledge base
MINLAND	CSA	2017-19	Framework conditions
COLLECTORS	CSA	2017-20	Reuse, recycling and recovery
CEWASTE	CSA	2018-2021	Reuse, recycling and recovery
INTERMIN	CSA	2017-2021	International cooperation
RE-SOURCING	CSA	2019-23	Responsible sourcing
MIN-GUIDE	CSA	2016-2019	Framework conditions
REMOVAL	IA	2018-22	Processing
TARANTULA	RIA	2019-23	Processing
Mintell4EU	Geo-ERA	2018-21	Knowledge base
ERA-MIN3	ERA-NET	2021-2025	International cooperation / knowledge base

Source: JRC

5.3.2 The RMIS communication

5.3.2.1 The RMIS newsletter

In 2019, in response to the feedback by stakeholders on the functioning of RMIS, the RMIS team launched a series of newsletters each semester. The newsletter is created in order to fill the communication gap in between the annual workshops and knowledge base events, as well as documenting the changes and indicating our updated future plans in between the bi-, tri-annual Roadmaps.

With more than 1400 recipients, the newsletter reaches a wide public of stakeholders both experts in the sectors, enthusiasts, and EU officers of different DGs and EU agencies.

So far, 4 Newsletters have been published (Fig. 24).

Figure 24. Newsletters' cover page

Source. JRC

5.3.2.2 The international RMIS workshops

To further strengthen communication and knowledge sharing with the broad range of stakeholders within the raw materials sector, annual workshops are organized by the RMIS team.

The 1st international RMIS workshop (March 2017) brought together key stakeholders of the raw materials sector and RMIS knowledge providers.

The 2nd workshop (May 2018) facilitated the further development of key RMIS thematic sections, including raw materials' profiles([140]), country profiles([141]), and the knowledge gateway([142]).

The 3rd RMIS workshop was held on 11-12 June 2019. It attracted 70+ participants from some 20 countries, 4 European Commission Directorates General (JRC, GROW, ENV, DEVCO), 2 EU agencies (EASME, EEA) and the EIT Raw Materials. Discussion topics included social and environmental issues associated with raw materials supply chains, national legislation, good governance, and a more in-depth focus on secondary raw materials.

The 4th RMIS workshop named "*Channeling knowledge from European projects into the Raw Materials Information System (RMIS)"* was held virtually on December 3rd, 2020.

It was co-organized by the Joint Research Centre (JRC) and the Executive Agency for Small and Medium-sized Enterprises (EASME), for the first time. This represented an important step forward to the already well-established dialogue between the JRC and the EU-funded projects consortia in relation to the RMIS.

The overarching aim of the workshop was to facilitate a technical dialogue to support efficient knowledge transfers from EU projects (H2020 + EIT RM) into RMIS, and to make sure that project's outputs best contribute to RMIS & EU policy objectives.

For this reason, different EU projects were involved in the event, specifically: 12 projects were participating as speakers presenting their projects in the dedicated session, and 11 projects as expert observers. The workshop had more than 80 participants, representatives of European projects, experts from different EC departments, and high level speakers (d'Elia et al., 2020).

([140]) http://rmis.jrc.ec.europa.eu/?page=rm-profiles#/
([141]) http://rmis.jrc.ec.europa.eu/?page=country-profiles#/
([142]) http://rmis.jrc.ec.europa.eu/?page=rmkg

Figure 25. First RMIS International workshop's participants

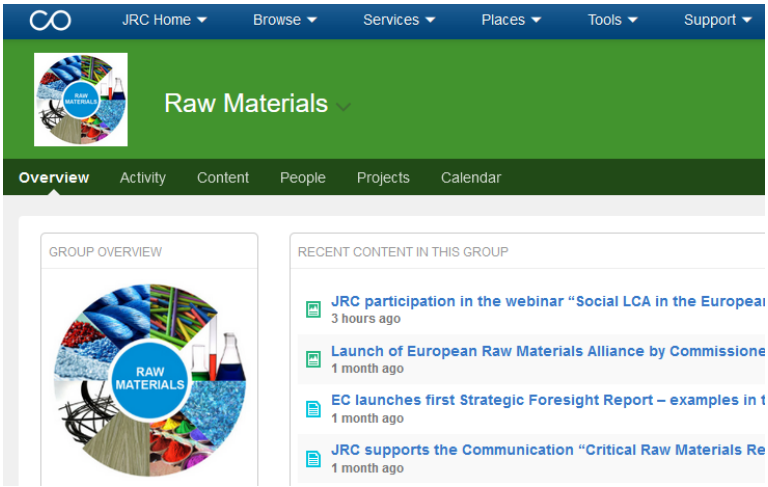
5.3.2.3 Raw Materials Group on CONNECTED

CONNECTED is the internal communication platform of the European Commission.

The RMIS partialy contributes to the Raw Materials group as an additional dimension of RMIS knowledge management. The contribution shall be reinforced though.

The communication plan below supports this objective, as a more disciplined and regulated approach for the systematic and permanent presence of the raw materials activities and outputs on this major EC communication platform.

Figure 26. Raw Materials on CONNECTED

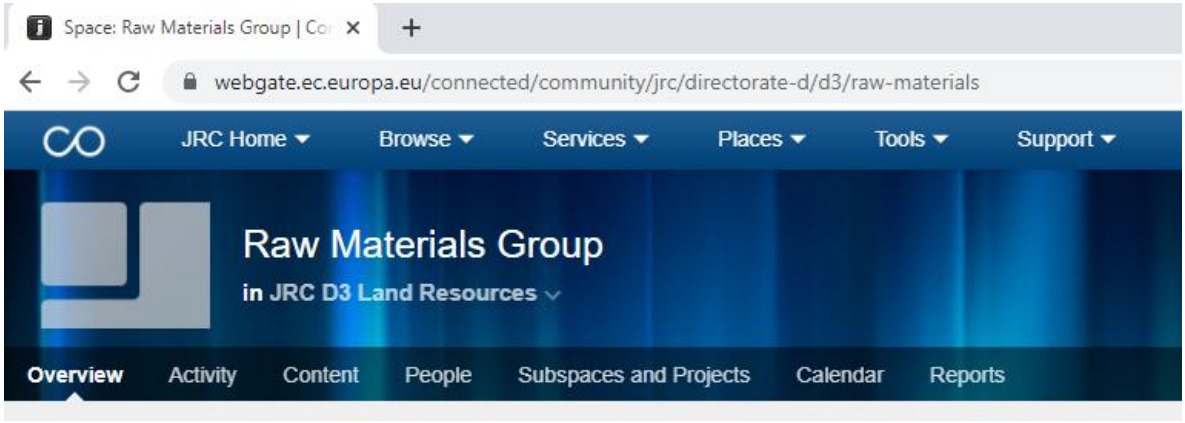


Source: http://webgate.ec.europa.eu/connected/groups/raw-materials

The targeted higher visibility of raw material and RMIS activities requires a relatively continuous presence in CONNECTED. There are two distinct groups on raw materials. The wider one, involving all EC internal stakeholders is the CONNECTED group "Raw Materials"([143]) (see Fig. 26). The other, with more limited audience is that of the JRC D3 Raw Materials Team appearing in accordance with the JRC structural hierarchy (Fig. 27).

([143]) "Raw Materials" is not a well-defined "entity" on CONNECTED yet which may irritate other colleagues inside the Commission. The title appears in CONNECTED as "Raw Materials" – not as "Raw Materials within JRC". There is no delineation of the scope, so – as CONNECTED is an EC wide platform – JRC claims implicitly a kind of "ownership" for the "Raw Materials" EC-wide. Others may join the group and will be able to upload content. For this reason, more detailed rules might be needed.

Figure 27. JRC D3 Raw Materials Team on CONNECTED



Source: http://webgate.ec.europa.eu/connected/community/jrc/directorate-d/d3/raw-materials

The procedure for publishing on the Raw Materials Team news is as follows:

1. All/any of the RMT members may propose news, announcements etc. to be published. They send the proposal to the RMIS project leader, with the portfolio leader, the Deputy Head of Unit, and the Head of Unit (HoU) in cc.
2. The RMIS project leader examines whether the topic requires a further professional quality check.
3. The communication officer of D3 or the RM Team takes care of uploading the news to CONNECTED.
4. Nevertheless, all Team members are entitled and encouraged to comment on the news on their personal expert ground.

In order to achieve a higher visibility in the CONNECTED group "Raw Materials" a set of periodical communications is listed below. These may keep the attention of the external followers, and may enlarge the audience within EC ([144]).

The plan envisages to publish approximately one news per week on average. This frequency may ensure the due attention whilst not degrading the news impact.

The potential **news categories** in focus are:

- RMIS workshop (frequency: annual; type of comm.: promo with agenda, outcome summary).
- Raw Material Knowledge Base conference (frequency: annual; type of comm.: promo with agenda, outcome summary).
- JRC- HaDEA workshop (frequency: annual; type of comm.: promo with agenda, outcome summary).
- Release of RMIS newsletter (frequency: each semester; type of comm.: promo with copy).
- Other major events and presentations (frequency: occasional; type of comm.: summary and link).
- Legislation and Commission Communication reviews (frequency: quarterly; type of comm: list of docs).
- Major reports and publications (frequency: occasional; type of comm.: summary and link).
- Other news release (frequency: occasional; type of comm.: news release and/or summary with link).

The planning of these news, in case of lack of ad hoc news, is the task of the RMIS project leader, and discussing it with the Head of Unit (the editor-in-chief). The programming shall be prepared on a monthly basis by the 5th of the given month, as a provisional deadline.

([144]) Note: This communication plan refers to the open space of the Raw Materials on CONNECTED used for disseminating and communicating relevant news and achievements to any stakeholder in the EC interested in raw materials. This communication plan **does not refer** to the closed internal CONNECTED group "Raw Materials Team" that is used solely for informal communication within the RMT of Unit D.3.

6 Conclusions

The Raw Materials Information System (RMIS), a permanent website of the JRC Science Hub, is a commitment in the 2015 Circular Economy Action Plan([145]). Since 2015, the RMIS acts as the EC's reference knowledge platform on non-energy, non-food raw materials from primary to secondary sources, along the entire raw materials value chains and considering the full material life cycle.

Building on a Concept Note and related discussions, this report provides an overview of the 2021+ short and mid-term RMIS development priorities and key foreseen milestones, as well as a decision support assessment of available options to stengthen RMIS knowledge management functions.

The preliminary finding is that the Knowledge Centre (incl. an Observatory) and the Community of Practice are the most suitable facilities to enhance its networking capacity and inclusiveness. Proposed plans include the further strenthening of foresight analyses, the further development and integration of material-specific and country specific profiles (also for African countries), the introduction of the Thematic Gateway, and opening of new subchapters such as Sustainability Certification, among others.

The confirmation of these conclusions and proposals shall be further re-assurred through consultation with RMIS stakeholder interest group.

([145]) COM(2015) 614

7 References

Albrecht et al. (2020) Albrecht, D., et al., *Science for Policy Handbook*, Edited by V. Šucha and M. Sienkiewicz, Elsevier Limited, 2020.

Blakstad et al. (2008) Blakstad, S., and R. Allen, 'Communities of Practice and Centres of Excellence', *FinTech Revolution: Universal Inclusion in the New Financial Ecosystem*, 2008, pp. 365–373.

D'Elia et al. (2021) D`Elia, E., De Sousa Gloria E Valadares Souto, A., Hamor, T., Manfredi, S. and Petrov, L., Channelling knowledge from European projects into the Raw Materials Information System (RMIS), Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-30795-2, doi:10.2760/854874, JRC124216.

EC (2013) European Commission, '*Strategic Implementation Plan for the European Innovation Partnership on Raw Materials Part I*', 2013.

EC (2017) European Commission, *Study on the Review of the List of Critical Raw Materials, Criticality Assessments*, 2017.

Hamor et al. (2018) Hamor, T., J. Huisman, K. Georgitzikis, L. Herreras, and M. Anta, *Mapping of Relevant EU Funded Projects, Initiatives and Identification of Synergies – ORAMA Project Report No. 5.2*, 2018.

Hamor et al. (2019) Hamor, T., Manfredi, S., Mathieu, S., Aaltonen, R., Dinis, P. C., Doyle, E., Endl, A., Grandi, S., Horvath, Z., Hostmark, S., Jürjens, E., Marchan, C, Persson Nilsson, K., Schoofs, R., Varvitsioti, E., Gottenhuber, S. L., Berger, G., Pennington, D., *Updating Knowledge on EU Member States' Regulatory Framework of Minerals - Proceedings of the Session "Updating Knowledge on Member States' Governance of Exploration and Mining" of the Third International Workshop on the European Union Raw Materials Information System*, Publications Office of the European Union, Luxembourg, 2019, doi: 10.2760/109151,

JRC (2017) JRC Directorate H, *Communities of Practice: Concept and Practical Guidance for their Management*, Publications Office of the European Union, Luxembourg, 2017, Ref. Ares(2017)2634536

Krzysztofowicz et al. (2018) Krzysztofowicz, M., Goudeseune, L., Bontoux, L., Balian, E., *Workshop on Horizon Scanning: From Interesting to Useful from Practice to Impact,* European Commission, Brussels, 2018, JRC112992.

McDermott et al. (2010) McDermott, R. and Archibald, D., 'Harnessing your staff's informal networks', *Harvard Business Review*, Vol. 88, No 3, 2010, pp. 82-89

Mancini et al. (2021) Mancini, L., Eslava, N. A., Traverso, M., Mathieux, F., Assessing impacts of responsible sourcing initiatives for cobalt: Insights from a case study, Resources Policy, V71.

Manfredi et al. (2019a) Manfredi, S., Hamor, T., Blengini, G., Bonollo, B., Ciupagea, C., Ciuta, T., Eynard, U., Garbossa, E., Georgitzikis, K., Huisman, J., Latunussa, C., Mancini, L., Mathieu, S., Mathieux, F., Nita, V., Pennington, D., Torres De Matos, C., Unguru, M., Vidal Legaz, B., Wittmer, D., *Raw Materials Information System (RMIS): 2019 Roadmap & Progress Report - Context, content & foreseen priorities*, Publications Office of the European Union, Luxembourg, 2019, doi:10.2760/658948.

Manfredi et al. (2019b) Manfredi, S., T. Hamor, L., Manicini, S. Mathieu, F. Mathieux, D. Pennington, and B. Vidal Legaz, *Third International Workshop of the Raw Materials Information System (RMIS),* Publications Office of the European Union, Luxembourg, 2019, doi:10.2760/059206

Manfredi et al. (2019c) Manfredi, S., T. Hamor, B. Vidal Legaz, V. Nita, J. Huisman, and S. Mathieu, *Raw Materials Information System (RMIS) Newsletter No 1*, 2019

Manfredi et al. (2017) Manfredi S., Hamor T., Wittmer D., Nuss P., Solar S., Latunussa C.E.L., Tecchio P., Nita V., Vidal, B., Blengini G.A., Mancini L., Torres de Matos C., Ciuta T., Mathieux F., Pennington D., *Raw Materials Information System (RMIS): Towards v2.0 – An interim progress report & roadmap.*, EUR 28526 EN, Publications Office of the European Union, Luxembourg, 2017, doi:10.2760/119971.

Manfredi et al. (2020a) Manfredi, S., Wittmer, D., D'Elia, E., Bonollo, B., Unguru, M., Blengini, G., Raw Materials Information System (RMIS) Newsletter No 3, Publications Office of the European Union, Luxembourg, 2020, JRC121705

Manfredi et al. (2020b) Manfredi, S., D'Elia, E., Mancini, L., Wittmer, D., Torres De Matos, C., Thibaut, M., Nita, V., Bonollo, B., Raw Materials Information System (RMIS) Newsletter No 4, Publications Office of the European Union, Luxembourg, 2020, JRC124552

Nita et al. (2020a) Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal-Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., d`Elia, E., Unguru, M. and Manfredi, S., "EU country profiles in the Raw Materials Information System (RMIS): Hungary", JRC Technical Report, JRC122508, 2020.

Nita et al. (2020b) Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal-Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., d`Elia, E., Unguru, M. and Manfredi, S., "EU country profiles in the Raw Materials Information System (RMIS): Greece", JRC Technical Report, JRC122328, 2020.

Nita et al. (2020c) Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal-Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., d`Elia, E., Unguru, M. and Manfredi, S., "EU country profiles in the Raw Materials Information System (RMIS): Denmark", JRC Technical Report, JRC122321, 2020.

Nita et al. (2020d) Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal-Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., d`Elia, E., Unguru, M. and Manfredi, S., "EU country profiles in the Raw Materials Information System (RMIS): Czechia", JRC Technical Report, JRC122320, 2020.

Nita et al. (2020e) Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal-Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., d`Elia, E., Unguru, M. and Manfredi, S., "EU country profiles in the Raw Materials Information System (RMIS): Bulgaria", JRC Technical Report, JRC122066, 2020.

Nita et al. (2020f) Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal-Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., d`Elia, E., Unguru, M. and Manfredi, S., "EU country profiles in the Raw Materials Information System (RMIS): Austria", JRC Technical Report, JRC122064, N 2020.

Nita et al. (2020g) Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal-Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., d`Elia, E., Unguru, M. and Manfredi, S., "EU country profiles in the Raw Materials Information System (RMIS): Belgium", JRC Technical Report, JRC122065, 2020.

Nita et al. (2020h) Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal-Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., d`Elia, E., Unguru, M. and Manfredi, S., "EU country profiles in the Raw Materials Information System (RMIS): Croatia", JRC Technical Report, JRC122067, 2020.

Pyrko et al. (2016) Pyrko, I., V. Dörfler, and C. Eden, 'Thinking Together: What Makes Communities of Practice Work?', *Human Relations*, Vol. 70, No. 4, 2016, pp. 389–409.

Serrat (2017) Serrat, O., 'Building Communities of Practice', *Knowledge Solutions: Tools, Methods, and Approaches to Drive Organizational Performance*, 2017, pp. 581–588.

Smith et al.(2019) Smith, S., S. Kempster, and E. Wenger-Trayner, 'Developing a Program Community of Practice for Leadership Development', *Journal of Management Education*, Vol. 43, No. 1, 2019, pp. 62–88.

Quest (2021) Quest, S., A modern JRC in a modern Commission, Presentation, Brussels, 6th April, 2021

Vidal-Legaz et al. (2018) Vidal-Legaz, B., G. A. Blengini, F. Mathieux, C. Latunussa, L. Mancini, V. Nita, T. Hamor, F. Ardente, P. Nuss, C. Matos, D. Wittmer, Laura T. Peiró, E. Garbossa, C. Pavel, P. Dias, D. Blagoeva, S. Bobba, J. Huisman, U. Eynard, F. Persio, H. Gervasio, C. Ciupagea, D. Pennington 2018: Raw Materials Scoreboard - European Commission, Luxembourg, 120 p.; ISBN 978-92-79-89746-7 doi:10.2873/13314.

Vidal-Legaz et al. (2019) Vidal-Legaz, B., Pennington, D., Blengini, G., Mathieux, F., Mancini, L., Unguru, M., Nita, V., Latunussa, C., Ardente, F., Hamor, T., Wittmer, D., Torres De Matos, C., Alves Dias, P. and Pavel, C., Raw Materials Scoreboard - review of clusters and indicators. JRC Technical Report, European Commission, 2019, JRC117514

Wenger-Trayner et al. (2015) Wenger-Trayner, E., and B. Wenger-Trayner, 'Communities of Practice a Brief Introduction', *Communities of Practice a Brief Introduction*, 2015, p. 8.

8 List of figures

Figure 1. RMIS and its current policy drivers....8
Figure 2. RMIS homepage()....10
Figure 3. Major EC foresight reports on resilience and critical raw materials....15
Figure 4. African country profiles' homepage example for South Africa....17
Figure 5. Example of visualization of South Africa's share in EU imports....17
Figure 6. Example of visualization of South Africa's Preferential Trade Arrangements....18
Figure 7. Example of visualization of South Africa's exploration budget allocation by material....18
Figure 8. Example of visualization of South Africa's risk index for humanitarian crises and disasters....19
Figure 9. Example of visualization of South Africa's absolute emissions' values by raw materials sectors....19
Figure 10. Example of visualization of South Africa's solid waste production....20
Figure 11. Dashboard of key indicators of copper being prepared for RM Profiles in the RMIS.....21
Figure 12. Cover page of the technical report: Sustainability aspects of Bauxite and Aluminium....21
Figure 13. Example of map viewer for World non-energy mineral resources....22
Figure 14. Cover pages of the published EU country profiles reports....23
Figure 15. RMIS homepage update in a short-term....25
Figure 16. RMIS homepage update in case of long-term plans scenario....26
Figure 17. JRC Knowledge Management Network....34
Figure 18. The JRC horizon scanning process....35
Figure 19. The megatrends implication analysis approach....36
Figure 20. The 6 global megatrends identified by JRC and relevant to raw materials....37
Figure 21. JRC Competence Centres infographics....38
Figure 22. JRC Knowledge Centres' characteristics and linkages to policy making....39
Figure 23. Typology of EC CoPs....41
Figure 24. Newsletters' cover page....46
Figure 25. First RMIS International workshop's participants....47
Figure 26. Raw Materials on CONNECTED....47
Figure 27. JRC D3 Raw Materials Team on CONNECTED....48

9 List of tables & boxes

Table 1. Summary of RMIS content and development milestones, as of November 1st, 2021 4

Table 2. Overview of potential future knowledge inputs to the RMIS arising from competitive activities and EU-funded projects 27

Table 3. Projects presenting at the JRC-EASME Technical Workshop "Channelling knowledge from European projects into the Raw Materials Information System (RMIS)" 45

Box 1. RMIS development: overview of policy context & key milestones 11

ANNEX 1: List of publications

Complete citation	Year of publication
Sakao Tomohiko; Wasserbaur Raphael; Mathieux Fabrice. A methodological approach for manufacturers to enhance value-in-use of service-based offerings considering three dimensions of sustainability. Cirp Annals-Manufacturing Technology No. 1 Vol. 68, 2019, Pages 33-36. 10.1016/j.cirp.2019.04.084	2019
Moraga Gustavo; Huysveld Sophie; Mathieux Fabrice; Blengini Giovanni; Alaerts Luc; Van Acker Karel; De Meester Steven; Dewulf Jo. Circular economy indicators: what do they measure? Resources Conservation And Recycling Vol. 146, July 2019, Pages 452-461. 10.1016/j.resconrec.2019.03.045	2019
Nita, Viorel & Garbossa, Elisa & Godlewska, Lidia & Pennington, David. (2019). Country-level data and indicators of trade in raw materials for Australia, Chile, Indonesia and New Zealand. 10.2760/944562.	2019
Cusenza, M., Bobba, S., Ardente, F., Cellura, M. and Di Persio, F., Energy and environmental assessment of a traction lithium-ion battery pack for plug-in hybrid electric vehicles, JOURNAL OF CLEANER PRODUCTION, ISSN 0959-6526 (online), 215, 2019, p. 634-649, JRC112384.	2019
Bobba, S., Mathieux, F. and Blengini, G., How will second-use of batteries affect stocks and flows in the EU A model for traction Li-ion batteries, RESOURCES CONSERVATION AND RECYCLING, ISSN 0921-3449 (online), 145, 2019, p. 279-291, JRC113537.	2019
Mancini, L., Vidal Legaz, B., Vizzarri, M., Wittmer, D., Grassi, G. and Pennington, D., Mapping the role of Raw Materials in Sustainable Development Goals, EUR 29595 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-08385-6, doi:10.2760/026725, JRC112892.	2019
Blagoeva, D., Pavel, C., Wittmer, D., Huisman, J. and Pasimeni, F., Materials dependencies for dual-use technologies relevant to Europe`s defence sector, EUR 29889 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-16658-0 (online), doi:10.2760/977597 (online), JRC118394.	2019
Mayer, A., Haas, W., Wiedenhofer, D., Krausmann, F., Nuss, P. and Blengini, G., Measuring progress towards a Circular Economy - a monitoring framework for economy-wide material loop closing in the EU28, JOURNAL OF INDUSTRIAL ECOLOGY, ISSN 1088-1980 (online), 23 (1), 2019, p. 62-76, JRC110701.	2019
Manfredi, S., Hamor, T., Vidal Legaz, B., Nita, V., Huisman, J. and Mathieu, S., Raw Materials Information System (RMIS) Newsletter No 1, Publications Office of the European Union, Luxembourg, 2019, JRC117930.	2019
BLENGINI Giovanni; MATHIEUX Fabrice; MANCINI Lucia; NYBERG Maria; CAVACO VIEGAS Helena (Eds.). Salminen Justin; Garbarino Elena; Orveillon Glenn; Saveyn Hans; Mateos Aquilino Veronica; Llorens González T; García Polonio F; Horckmans Liesbeth; D'hugues Patrick; Balomenos Efthymios; Dino Giovanna; De La Feld Marco; Mádai Ferenc; Földessy Janos; Mucsi Gabor; Gombkötő Imre; Calleja I. Recovery of critical and other raw materials from mining waste and landfills. 2019. Publications Office of the European Union. JRC116131. ISBN 978-92-76-08568-3. https://publications.jrc.ec.europa.eu/repository/handle/JRC116131 ; 10.2760/60077510.2760/174367.	2019
Ardente, F., Latunussa, C. and Blengini, G., Resource efficient recovery of critical and precious metals from waste silicon PV panel recycling, WASTE MANAGEMENT, ISSN 0956-053X (online), 91, 2019, p. 156-167, JRC113258.	2019
Alonso Raposo, M., Ciuffo, B., Alves Dias, P., Ardente, F., Aurambout, J., Baldini, G., Baranzelli, C., Blagoeva, D., Bobba, S., Braun, R., Cassio, L., Chawdhry, P., Christidis, P., Christodoulou, A., Corrado, S., Duboz, A., Duch Brown, N., Felici, S., Fernandez Macias, E., Ferragut Martinez Vara De Rey, J., Fulli, G., Galassi, M., Georgakaki, A., Gkoumas, K., Grosso, M., Gomez Vilchez, J., Hajdu, M., Iglesias Portela, M., Julea, A., Krause, J., Kriston, A., Lavalle, C., Lonza, L., Rocha Pinto Lucas, A., Makridis, M., Marinopoulos, A., Marmier, A., Marques Dos Santos, F., Martens, B., Mattas, K., Mathieux, F., Menzel, G., Minarini, F., Mondello, S., Moretto, P., Mortara, B., Navajas Cawood, E., Paffumi, E., Pasimeni, F., Pavel, C., Pekar, F., Pisoni, E., Raileanu, I., Sala, S., Saveyn, B., Scholz, H., Serra, N., Tamba, M., Thiel, C., Trentadue, G., Tecchio, P., Tsakalidis, A., Uihlein, A., Van Balen, M. and Vandecasteele, I., The future of road transport, EUR 29748 EN, Publications Office of the European Union,	2019

Luxembourg, 2019, ISBN 978-92-76-14318-5 (online),978-92-76-14319-2 (print), doi:10.2760/668964 (online),10.2760/524662 (print), JRC116644.	
Alonso Raposo, M., Ciuffo, B., Alves Dias, P., Ardente, F., Aurambout, J., Baldini, G., Baranzelli, C., Blagoeva, D., Bobba, S., Braun, R., Cassio, L., Chawdhry, P., Christidis, P., Christodoulou, A., Corrado, S., Duboz, A., Duch Brown, N., Felici, S., Fernandez Macias, E., Ferragut Martinez Vara De Rey, J., Fulli, G., Galassi, M., Georgakaki, A., Gkoumas, K., Grosso, M., Gomez Vilchez, J., Hajdu, M., Iglesias Portela, M., Julea, A., Krause, J., Kriston, A., Lavalle, C., Lonza, L., Rocha Pinto Lucas, A., Makridis, M., Marinopoulos, A., Marmier, A., Marques Dos Santos, F., Martens, B., Mattas, K., Mathieux, F., Menzel, G., Minarini, F., Mondello, S., Moretto, P., Mortara, B., Navajas Cawood, E., Paffumi, E., Pasimeni, F., Pavel, C., Pekar, F., Pisoni, E., Raileanu, I., Sala, S., Saveyn, B., Scholz, H., Serra, N., Tamba, M., Thiel, C., Trentadue, G., Tecchio, P., Tsakalidis, A., Uihlein, A., Van Balen, M. and Vandecasteele, I., The future of road transport, EUR 29748 EN, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-14318-5 (online),978-92-76-14319-2 (print), doi:10.2760/668964 (online),10.2760/524662 (print), JRC116644.	2019
CIUTA, Theodor a Constantin CIUPAGEA. The raw materials supply chain viewer: designing and developing a data-driven graphbased application for RMIS. Luxembourg: Publications Office of the European Union, 2019. JRC technical reports. ISBN 978-92-76-01968-8.	2019
Manfredi, S., Hamor, T., Mancini, L., Mathieu, S., Mathieux, F., Vidal Legaz, B. and Pennington, D., Third international workshop of the Raw Materials Information System (RMIS), Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09561-3 (online), doi:10.2760/059206 (online), JRC117418.	2019
Manfredi, S., Hamor, T., Mancini, L., Mathieu, S., Mathieux, F., Vidal Legaz, B. and Pennington, D., Third international workshop of the Raw Materials Information System (RMIS), Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09561-3 (online), doi:10.2760/059206 (online), JRC117418.	2019
Hamor, T., Manfredi, S., Mathieu, S., Aaltonen, R., Dinis, P., Doyle, E., Endl, A., Grandi, S., Horvath, Z., Hostmark, S., Jürjens, E., Marchan, C., Persson Nilsson, K., Schoofs, R., Varvitsioti, E., Gottenhuber, S., Berger, G. and Pennington, D., Updating knowledge on European countries' regulatory framework of minerals, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09886-7 (online),978-92-76-10931-0 (print), doi:10.2760/109151 (online),10.2760/54936 (print), JRC117753.	2019
Hamor, T., Manfredi, S., Mathieu, S., Aaltonen, R., Dinis, P., Doyle, E., Endl, A., Grandi, S., Horvath, Z., Hostmark, S., Jürjens, E., Marchan, C., Persson Nilsson, K., Schoofs, R., Varvitsioti, E., Gottenhuber, S., Berger, G. and Pennington, D., Updating knowledge on European countries' regulatory framework of minerals, Publications Office of the European Union, Luxembourg, 2019, ISBN 978-92-76-09886-7 (online),978-92-76-10931-0 (print), doi:10.2760/109151 (online),10.2760/54936 (print), JRC117753.	2019
Front Matter, Editor(s): Vannessa Goodship, Ab Stevels, Jaco Huisman, In Woodhead Publishing Series in Electronic and Optical Materials,Waste Electrical and Electronic Equipment (WEEE) Handbook (Second Edition),Woodhead Publishing,2019,ISBN 9780081021583, https://doi.org/10.1016/B978-0-08-102158-3.01001-6.	2019
Vidal Legaz, B., Pennington, D., Blengini, G., Mathieux, F., Mancini, L., Unguru, M., Nita, V., Latunussa, C., Ardente, F., Hamor, T., Wittmer, D., Torres De Matos, C., Alves Dias, P. and Pavel, C., Raw Materials Scoreboard - review of clusters and indicators. JRC Technical Report, European Commission, 2019, JRC117514	2019
Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU Country profiles in the Raw Materials Information System (RMIS): Austria, EUR 30396 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-22986-5, doi:10.2760/517792, JRC122064.	2020
Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU Country Profiles in the Raw Materials Information System (RMIS): Belgium, EUR 30397 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-23026-7 (online), doi:10.2760/27414 (online), JRC122065.	2020
Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU Country Profiles in the Raw Materials Information System (RMIS): Bulgaria, EUR 30394 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-22973-5 (online), doi:10.2760/113492 (online), JRC122066.	2020

Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU Country profiles in the Raw Materials Information System (RMIS): Croatia, EUR 30395 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-22976-6 (online), doi:10.2760/17 (online), JRC122067.	2020
Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU Country profiles in the Raw Materials Information System (RMIS): Czechia, EUR 30449 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-25321-1 (online), doi:10.2760/530675 (online), JRC122320.	2020
Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU Country profiles in the Raw Materials Information System (RMIS): Denmark, EUR 30424 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-24518-6 (online), doi:10.2760/72796 (online), JRC122321.	2020
Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU country profiles in the Raw Materials Information System (RMIS): Greece, EUR 30447 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-25318-1 (online), doi:10.2760/87478 (online), JRC122328.	2020
Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU country profiles in the Raw Materials Information System (RMIS): Hungary, EUR 30477 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-26841-3 (online), doi:10.2760/187479 (online), JRC122508	2020
Schrijvers, D., Hool, A., Blengini, G., Chen, W., Dewulf, J., Eggert, R., Van Ellen, L., Gauss, R., Goddin, J., Habib, K., Hagelüken, C., Hirohata, A., Hofmann-Amtenbrink, M., Kosmol, J., Le Gleuher, M., Grohol, M., Ku, A., Lee, M., Liu, G., Nansai, K., Nuss, P., Peck, D., Reller, A., Sonnemann, G., Tercero Espinoza, L., Thorenz, A. and Wäger, P., A review of methods and data to determine raw material criticality, RESOURCES CONSERVATION AND RECYCLING, ISSN 0921-3449 (online), 155, 2020, p. 104617, JRC118455.	2020
Beylot Antoine; Ardente Fulvio; Penedo De Sousa Marques Alexandra; Mathieux Fabrice; Pant Rana; Sala Serenella; Zampori Luca. Abiotic and biotic resources impact categories in LCA: development of new approaches. 2020. Publications Office of the European Union. JRC120170. ISBN 978-92-76-17227-7. https://publications.jrc.ec.europa.eu/repository/handle/JRC120170; 10.2760/23283910.2760/815673, 10.2760/815673	2020
Bobba, S., Tecchio, P., Ardente, F., Mathieux, F., Marques Dos Santos, F. and Pekar, F., Analysing the contribution of automotive remanufacturing to the circularity of materials, PROCEDIA CIRP, 2020, ISSN 2212-8271 (online), 90, p. 67-72, JRC121656.	2020
Bobba, S., Bianco, I., Eynard, U., Carrara, S., Mathieux, F. and Blengini, G., Bridging tools to better understand environmental performances and raw materials supply of traction batteries in the future EU fleet, ENERGIES, ISSN 1996-1073 (online), 13 (10), 2020, p. 2513, JRC120482	2020
Di Noi, C., Ciroth, A., Mancini, L., Eynard, U., Pennington, D. and Blengini, G., Can S-LCA methodology support responsible sourcing of raw materials in EU policy context, INTERNATIONAL JOURNAL OF LIFE CYCLE ASSESSMENT, ISSN 0948-3349 (online), 25, 2020, p. 332–349, JRC120192.	2020
Godoy Leòn, M.F., Blengini, G. and Dewulf, J., Cobalt in end-of-life products in the EU, where does it end up - The MaTrace approach, RESOURCES CONSERVATION AND RECYCLING, ISSN 0921-3449 (online), 158, 2020, p. 104842, JRC118457.	2020
Bobba, Silvia & Carrara, S & Huisman, Jaco & Mathieux, Fabrice & Pavel, Claudiu. (2020). Critical Raw Materials for Strategic Technologies and Sectors in the EU - A Foresight Study. 10.2873/58081.	2020
Vidal Legaz, B., Environmental information in the Raw Materials Information System (RMIS), EUR 30384 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-22419-8 (online),978-92-76-22420-4 (print), doi:10.2760/007891 (online),10.2760/270188 (print), JRC121961.	2020
Di Persio, F., Huisman, J., Bobba, S., Alves Dias, P., Blengini, G. and Blagoeva, D., Information gap analysis for decision makers to move EU towards a Circular Economy for the lithium-ion battery value chain, EUR	2020

30315 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-20885-3 (online), doi:10.2760/069052 (online), JRC121140.	
Torres De Matos, C., Ciacci, L., Godoy Leon, M.F., Lundhaug, M., Dewulf, J., Müller, D.B., Georgitzikis, K., Wittmer, D. and Mathieux, F., Material System Analysis of five battery-related raw materials: Cobalt, Lithium, Manganese, Natural Graphite, Nickel, EUR 30103 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-16411-1 (online),978-92-76-16410-4 (print), doi:10.2760/519827 (online),10.2760/755440 (print), JRC119950.	2020
Horta Arduin, R., Mathieux, F., Huisman, J., Blengini, G., Charbuillet, C., Wagner, M., Balde, K. and Perry, N., Novel indicators to better monitor the collection and recovery of (critical) raw materials in WEEE: Focus on screens, RESOURCES CONSERVATION AND RECYCLING, ISSN 0921-3449 (online), 157, 2020, p. 104772, JRC116174.	2020
Carrara, S., Alves Dias, P., Plazzotta, B. and Pavel, C., Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system, EUR 30095 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-16225-4 (online), doi:10.2760/160859 (online), JRC119941.	2020
Manfredi, S., Wittmer, D., D`elia, E., Bonollo, B., Unguru, M. and Blengini, G., Raw Materials Information System (RMIS) - RMIS Newsletter n.3 (September 2020), Publications Office of the European Union, Luxembourg, 2020, JRC121705.	2020
Manfredi, S., Hamor, T., Mancini, L., Nita, V. and Huisman, J., Raw Materials Information System (RMIS) Newsletter n.2 (April 2020) , Publications Office of the European Union, Luxembourg, 2020, JRC120353.	2020
Mancini, L., Eslava, N., Traverso, M. and Mathieux, F., Responsible and sustainable sourcing of battery raw materials, EUR 30174 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17950-4 (online), doi:10.2760/562951 (online), JRC120422.	2020
Mancini, L. and Nuss, P., Responsible materials management for a resource-efficient and low-carbon society, RESOURCES, 2020, ISSN 2079-9276 (online), 9 (6), p. 68, JRC120447.	2020
Torres De Matos, C., Wittmer, D., Mathieux, F. and Pennington, D., Revision of the material system analyses specifications, EUR 30091 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-10734-7 (online), doi:10.2760/374178 (online), JRC118827.	2020
Huisman, J., Ciuta, T., Mathieux, F., Bobba, S., Georgitzikis, K. and Pennington, D., RMIS – Raw materials in the battery value chain, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-13854-9 (online), doi:10.2760/239710 (online), JRC118410.	2020
Blengini, Gian & Latunussa, Cynthia & Eynard, Umberto & Matos, Cristina & Georgitzikis, Konstantinos & Pavel, Claudiu & Carrara, Samuel & Mancini, Lucia & Unguru, Manuela & Blagoeva, Darina & Mathieux, Fabrice & Pennington, David. (2020). Study on the EU's list of Critical Raw Materials (2020) Final Report. 10.2873/11619.	2020
Blengini, Gian & Latunussa, Cynthia & Eynard, Umberto & Matos, Cristina & Georgitzikis, Konstantinos & Pavel, Claudiu & Carrara, Samuel & Mancini, Lucia & Unguru, Manuela & Blagoeva, Darina & Mathieux, Fabrice & Pennington, David. (2020). Study on the EU's list of Critical Raw Materials (2020) Final Report. 10.2873/11619.	2020
Eynard, Umberto & Georgitzikis, Konstantinos & Wittmer, Dominic & Latunussa, Cynthia & Matos, Cristina & Mancini, Lucia & Unguru, Manuela & Blagoeva, Darina & Bobba, Silvia & Pavel, Claudiu & Carrara, Samuel & Mathieux, Fabrice & Pennington, David & Blengini, Gian. (2020). Study on the EU's list of Critical Raw Materials (2020) Non-Critical Raw Materials Factsheets. 10.2873/587825.	2020
Mathieux, F., Ardente, F. and Bobba, S., Ten years of scientific support for integrating circular economy requirements in the EU ecodesign directive: overview and lessons learnt, In: Life Cycle Engineering Conference 2020, 13-15 May 2020, Grenoble (France), PROCEDIA CIRP, 2020, ISSN 2212-8271 (online), 90, p. 137-142, JRC118356.	2020

Alves Dias, P., Bobba, S., Carrara, S. and Plazzotta, B., The role of rare earth elements in wind energy and electric mobility, EUR 30488 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-27016-4 (online), doi:10.2760/303258 (online), JRC122671.	2020
IRP (2020). Mineral Resource Governance in the 21st Century: Gearing extractive industries towards sustainable development. Ayuk, E. T., Pedro, A. M., Ekins, P., Gatune, J., Milligan, B., Oberle B., Christmann, P., Ali, S., Kumar, S. V, Bringezu, S., Acquatella, J., Bernaudat, L., Bodouroglou, C., Brooks, S., Buergi Bonanomi, E., Clement, J., Collins, N., Davis, K., Davy, A., Dawkins, K., Dom, A., Eslamishoar, F., Franks, D., Hamor, T., Jensen, D., Lahiri-Dutt, K., Petersen, I., Sanders, A. R. D. A Report by the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya., 374 p., ISBN: 978-92-807-3779-0, https://resourcepanel.org/reports/mineral-resource-governance-21st-century	2020
Nita, V., Garbossa, E., Ciuta, T., Bonollo, B., Mancini, L., Vidal Legaz, B., Latunussa, C., Wittmer, D., Hamor, T., D`elia, E., Unguru, M. and Manfredi, S., EU Country Profiles in the Raw Materials Information System (RMIS): Romania, EUR 30601 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-30474-6 (online), doi:10.2760/068038 (online), JRC123822.	2021
Bielewski, M., Blagoeva, D., Cordella, M., Di Persio, F., Gaudillat, P., Hildebrand, S., Mancini, L., Mathieux, F., Moretto, P., Paffumi, E., Paraskevas, D., Ruiz Ruiz, V., Sanfelix Forner, J.V., Villanueva Krzyzaniak, A. and Zampori, L., Analysis of sustainability criteria for lithium-ion batteries including related standards and regulations, EUR 30597 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-30284-1 (online), doi:10.2760/811476 (online), JRC123925.	2021
Mancini, L., Eslava, N.A., Traverso, M. and Mathieux, F., Assessing impacts of responsible sourcing initiatives for cobalt: Insights from a field study, RESOURCES POLICY, ISSN 0301-4207 (online), 71, 2021, p. 102015, JRC121719.	2021
D`elia, E., De Sousa Gloria E Valadares Souto, A., Hamor, T., Manfredi, S. and Petrov, L., Channelling knowledge from European projects into the Raw Materials Information System (RMIS), Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-30795-2 (online),978-92-76-30796-9 (print), doi:10.2760/854874 (online),10.2760/660446 (print), JRC124216.	2021
Nita, V., Bonollo, B. and Unguru, M., Data and indicators of Brazil's trade in non-food, non-energy raw material commodities, EUR 30679 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-36250-0, doi:10.2760/103627, JRC124652.	2021
Nita, V., Bonollo, B. and Unguru, M., Data and indicators of Canada's trade in non-food, non-energy raw material commodities, EUR 30627 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-31827-9 (online), doi:10.2760/760116 (online), JRC124038	2021
Wagner, M.A., Huisman, J., Lovik, A.N., Habib, H., Maehlitz, P., van der Voet, E., 2021, Methodology to Prospect Electronics Compositions and Flows, illustrated by material trends in Printed Circuit Boards, Journal of Cleaner Production, page 127164 https://doi.org/10.1016/j.jclepro.2021.127164	2021
Manfredi, S., D`elia, E., Mancini, L., Wittmer, D., Torres De Matos, C., Maury, T., Nita, V. and Bonollo, B., Raw Materials Information System (RMIS) Newsletter n.4, March 2021, Publications Office of the European Union, Luxembourg, 2021, JRC124552.	2021
Bobba, S., Marques Dos Santos, F., Maury, T., Tecchio, P., Méhn, D., Weiland, F., Pekar, F., Mathieux, F. and Ardente, F., Sustainable use of Materials through Automotive Remanufacturing to boost resource efficiency in the road Transport system (SMART), EUR 30567 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-28645-5 (online), doi:10.2760/84767 (online), JRC123261.	2021
Dewulf Jo; Hellweg Stefanie; Pfister Stephan; Godoy Leon Maria Fernanda; Sonderegger Thomas; Torres De Matos Cristina; Blengini Giovanni; Mathieux Fabrice. Towards sustainable resource management: identification and quantification of human actions that compromise the accessibility of metal resources. Resources Conservation And Recycling Vol. 167, April 2021, 105403, 10.1016/j.resconrec.2021.105403	2021
Torres De Matos, C., Devauze, C., Planchon, M., Wittmer, D., Ewers, B., Auberger, A., Dittrich, M., Latunussa, C., Eynard, U. and Mathieux, F., Material system analysis of nine raw materials: Barytes, Bismuth, Hafnium, Helium, Natural Rubber, Phosphorus, Scandium, Tantalum and Vanadium, EUR 30704 EN, Publications	2021

Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-37768-9, doi:10.2760/677981, JRC125101.	
Georgitzikis, K., Mancini, L., D`elia, E. and Vidal Legaz, B., Sustainability aspects of Bauxite and Aluminium, EUR 30760 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-40039-4 (online),978-92-76-40040-0 (print), doi:10.2760/702356 (online),10.2760/862494 (print), JRC125390.	2021
Huisman, J. and Bobba, S., "Available for Collection" study on alternative collection targets for waste portable and light means of transport batteries, EUR 30746 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-39442-6, doi:10.2760/163961, JRC125615.	2021
Hamor, T.; Vidal-Legaz, B.; Zampori, L., Eynard, U.; Pennington, D., A review of European Union legal provisions on the environmental impact assessment of non-energy minerals extraction projects, EUR 30743 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-38988-0 , doi:10.2760/705726, JRC125111.	2021
Nita, V., Bonollo, B., and Unguru, M., Selected countries' data and indicators of trade in non-food, non-energy raw material commodities, EUR 30792 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-40681-5, doi:10.2760/20353, JRC126172	2021

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

- at the following standard number: +32 22999696, or

- by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from EU Bookshop at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

KJ-NA-30931-EN-N

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub

ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

Publications Office of the European Union

doi:10.2760/46345

ISBN 978-92-76-45477-9