INTRAW DELIVERABLE D2.7

REPORT ON CROSS-CUTTING SYNERGIES, EMERGING SCENARIOS AND THEIR POTENTIAL IMPACT ON INTERNATIONAL COOPERATION ON RAW MATERIALS

Summary:

INTRAW Deliverable 2.7 aims to explore how the actions delivered in the four INTRAW Action Plans can be combined and implemented in synergetic ways to create additional values and opportunities. To identify possible synergies between the individual actions, a complementary set of qualitative and quantitative methods were deployed to outline "Cooperation Agendas" i.e. portfolios of actions that are relevant on a bilateral, and occasionally on a multilateral basis. During the definition of these Agendas special emphasis was given to recommend a portfolio of actions that together are i) synergetic (i.e. can potentially create additional values), ii) altogether "future-proof" (i.e. applicable across the future scenarios that have been investigated for INTRAW) and iii) mutually beneficial (i.e. consider reference country priorities, strengths, as well as opportunities with regards to cooperation with the EU).

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement nº 642130.

Lead beneficiary:	La Palma Research Centre S.L.		
Other beneficiaries:	EFG, CSIR, UNEXE, FRA, FCT, ASM, ATSE, GeoZS, UM, PERC, MinPol, RFM, RCI, AGI		
Due date:	31/01/2018		
Nature:	Report		
Diffusion	Public		
Revision history	Author	Delivery date	Summary of changes
Version 1.0	*Balázs Bodo* *Edine Bakker* *Luís Lopes* *Tamas Miklovic* *Marco Konrat Martins*	27.12.2017	

Approval status			
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LIST OF ABBREVATIONS

CMMI	Capability maturity model integration
CRM	Critical raw materials
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DG	Directorate-General
E&O	Education and outreach
EIP	European Innovation Partnership
EIT	European Institute of Technology
EPR	Extended producer responsibility
EU	European Union
FEAST	European-Australian science and technology cooperation
I&T	Industry and trade
JRC	Joint Research Centre
JSTCC	Joint Science and Technology Cooperation Committee
KIC	Knowledge and Innovation Communities
METS	Mining equipment, technology and services
MNU	Multinational corporation
OECD	Organisation for Economic Co-operation and Development
RC	Reference Countries
R&I	Research and innovation
R&S	Recycling and substitution
RM	Raw materials
RMIS	Raw Materials Information System
SME	Small and medium size enterprise
SRM	Secondary raw materials
WEEE	Waste Electrical and Electronic Equipment
WP	Work Package

1. EXECUTIVE SUMMARY

This report aims to explore how the actions delivered in the four INTRAW[1] Action Plans[2] can be combined and implemented in synergetic ways to create additional values and opportunities. To identify possible synergies between the individual actions, a complementary set of qualitative and quantitative methods were deployed so that this report could give tangible recommendations for pursuing cooperation agendas between the EU and the reference countries - Australia, Canada, Japan, South Africa and the United States.

The resulting "Cooperation Agendas" are portfolios of actions that are relevant on a bilateral, and occasionally on a multilateral basis. During the definition of these Agendas special emphasis was given to recommend a portfolio of actions that together are i) synergetic (i.e. can potentially create additional values), ii) altogether "future-proof" (i.e. applicable across the future scenarios that have been investigated for INTRAW) and iii) mutually beneficial (i.e. consider reference country priorities, strengths as well as opportunities with regards to cooperation with the EU).

During the development of this work previous studies and deliverables from WP1 and WP2 were used as baseline. The four individual Action Plans and the three INTRAW Scenarios were used in a complementary manner together with reference country perspectives collected during the International Expert Workshop in Brussels on 8 November 2017. Input from these resources were used for the creation of the following eight Cooperation Agendas: CA1) International Raw Materials Data Platform, CA2) Securing raw materials supply, CA3) Stabilising workforce, CA4) Interdisciplinary approaches, CA5) Encouraging investment, CA6) Technological innovation, CA7) policies and frameworks, and CA8) Multilateral agreements.

All these Cooperation Agendas were defined on a bilateral/multilateral basis, considering synergetic effects as well as reference country priorities, strengths & opportunities with regards to cooperation with the EU. The Agendas considered the INTRAW scenarios and formulated recommendations in such a way that the Agendas are expected to remain robust and applicable across different possible futures. In particular, D2.2 "Roadmap for the implementation of the Action Plans" was used as an important point of reference to ensure that the action portfolios in the Cooperation Agendas are developed in a balanced way, consisting of actions that are always applicable in at least two future scenarios. This, together with the additional benefits to be generated from the synergetic implementation of the actions, are expected to make the Agendas resistant to future change.

The resulting recommendations for Cooperation Agendas are cross-cutting because they promote the synergetic implementation of a limited number of actions where these together are likely to generate maximum return on investment on a bilateral or multilateral basis. They are meant to outline a cost-efficient alternative to the simultaneous implementation of all four Action Plans, in case there are only limited funds available to pursue international cooperation on raw materials with technologically advanced countries.

[1] The 36-month International Cooperation on Raw Materials (INTRAW) project started in February 2015, funded by the European Commission's Horizon 2020 programme for research and innovation.

[2] D2.3 Action Plan to enhance international research and innovation activities on raw materials; D2.4 Action Plan to enhance international education and outreach activities on raw materials; D2.5 Action Plan to enhance cooperation on International Industrial & Trade Policies on raw materials; D2.6 Action Plan for the management, recycling and substitution of strategic raw materials

2. INTRODUCTION

2.1 Forming Synergies

This deliverable aims to explore synergetic opportunities that can arise from the implementation of the actions described in the four action plans also taking into account the constraints defined in the Roadmap for their implementation (D2.2). This necessitates a brief review of what is meant by "synergy" and how synergetic actions can result in an impact that is larger than the sum of the individual impacts.

The word synergy comes from the Greek *synergia*, meaning *joint work, working together, cooperation*, and has been used as *advanced effectiveness as a result of cooperation* starting from 1957 (Online Etymology Dictionary). Synergy is the creation of a whole that is greater than the sum of its parts. Usually the need for (or the advantage of) a synergetic approach arises when two or more parties realise that their joint actions serve their vision more effectively than working separately, in isolation. The chosen methodology is usually case specific, but it always includes strong cooperation, partnership, value and skill sharing, joint efforts, communication and interaction. The outcomes are usually increased effectiveness in achieving common goals, cost efficiency and common value creation. Considering the different parties involved, a synergetic approach for cooperation can be developed between organizations (Independent Science & Partnership Council and Global Forum on Agricultural Research and Innovation, GFAR, 2004[3]), working groups (e.g. EIP on Active and Healthy Aging[4]), countries (e.g. China-Australia free trade agreement MCA, 2015[5]) and research and innovation cooperation between EU and Norway (NMRE Strategy, 2014[6]), generations (nursing house with free student rooms[7]), and disciplines (Knowledge triangle: education, research and innovation). Many other cases exist, but synergies between disciplines are the main focus of this report as we are investigating synergies between actions in the four fields targeted by INTRAW: Research and Innovation, Education and Outreach, Industry and Trade, and Recycling and Substitution. Some case studies related to these broad fields were examined and are explained in detail below.

A good example of synergy is the cooperation between industry and education through joint programs. Industry needs qualified graduates, who have not only the academic background but also the basis of practical knowledge in the profession. The universities can attract more students and funding if their program is recognised by industry. The EIP Raw Materials Academy facilitates this synergy-creation and promotes the following joint educational programs: Emerald (Master in Georesources Engineering), AMIS (Master in Functional Advanced Materials and their Engineering Innovation), SUMA (Master in Sustainable Materials), IDS-FunMat-INNO (International Doctoral School in Functional Materials), FEMP (Federation of European Mineral Programs). These industry-focused educational programs connect universities and industry, within the scope of Master's Education, PhD Education, Lifelong Learning, and Wider Society Learning. During these 1-2-year programs, students can learn at multiple universities, while keeping a close contact with industrial partners. Because of the education and industry synergy, the students can attend the best classes offered by the

[3] http://www.fao.org/docs/eims/upload/215027/Cross-cutting_issues_synergies_GFAR-CGIAR-SC.pdf

[4] https://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/bousquet_synergies.pdf

[5] http://www.minerals.org.au/file_upload/files/media_releases/Media_Release_BP_New_chAFTA_publication_from_MCA_17_June_2015_FINAL.pdf

[6] https://www.regjeringen.no/contentassets/4c96155c697f47cabc2c4ea23e0507ec/strategy-for-research-and-innovation-cooperation-with-the-eu-horizon-2020-and-era.pdf

[7] http://www.pbs.org/newshour/rundown/dutch-retirement-home-offers-rent-free-housing-students-one-condition/

universities and gain practical knowledge directly from industry through this close joint cooperation. This example justifies the need for more interaction between industry and education.

Synergies can also be developed between financial instruments, such as Horizon 2020 programme and European Structural and Investment Funds (ESIF). The European Parliament and the Council recognised that the synergetic approach between these funds is no longer "nice-to-have", but rather a "need-to-implement", in order to meet the increasing competitive pressure from global markets and maximise impact/efficiency of public funding (REGIO DG 02 - Communication, 2014[8]). However, the implementation of these funds belongs to different entities (Horizon 2020: European Commission, ESIF: Member States' shared management), which makes synergy creation challenging. A study has been published to tackle this challenge by a working group co-chaired by DG Regional and Urban Policy and DG Research and Innovation. From this, synergy has been defined as *joint or coordinated efforts to achieve greater impact and efficiency*. These efforts would amplify the research and innovation investments and their impacts on competitiveness, jobs and growth. Synergies can be achieved within the same projects, successive projects that build on each other or through parallel projects that are complementary with each other. The study also showcases a detailed list of recommended actions for National/Regional Policy-makers, Managing Authorities and intermediaries, on how to enable synergies at the different organizational levels. One important lesson learned from this study is that preparation and effort are required from all parties involved at all levels: strategic, programme design and implementation are needed.

It is also worth investigating the indirect synergetic behaviour of different fields. The Organisation for Economic Co-operation and Development (OECD) examined the impact of trade and investment on innovation (Onodera, 2008). It is established that innovation is a key determinant for economic growth. The study looked at the various effects of trade and investment on innovation (process, product, organisation, marketing) and provided five case studies (Finland's telecommunication equipment sector, Korea's ICT sector, New Zealand's agriculture sector, Sri Lanka's garment sector and South Africa's agriculture sector). In most of these cases, trade and investment promote innovation as freer technology transfer through import, increased incentives through enhancing competitive pressure, opening new markets and spill overs (learning from exporting, learning by investing). However, trade and investment can have negative effects on innovation. Restrictive trade and investment have been used to promote the development of domestic industries. Switching to a free trade environment, when entering the global value chain, businesses have to compete with markets which have cheaper labour, supply and manufacturing conditions. The effects of trade and investment in diffusion of innovation are critical when innovation addresses global challenges, such as climate change. As a conclusion, trade and investment are important factors of the different stages of innovation, the generation of new ideas, and on their implementation and diffusion.

Other studies (Feinstein et al., 2006; Groot and Maassen van den Brink, 2006) from OECD investigated the impact of education on health, as two important components of human capital: their economic value is the impact on productivity and well-being. The positive causal effect of education extends over general health conditions, healthy behaviour, risky avoidance, use of preventive health care to prevent illnesses or diseases, extended life expectancy, and happiness and well-being. Freinstein at al. (2006) showed that there are significant spill over effects between education and health, which justify the need for a synergetic approach between these specific fields. Investing in education has not only positive health effects on society, but also an economic payoff. The League of European Research Universities (LERU) quantified the economic contribution of their universities. Reports indicate[9,10] that the 21 member universities generated a total economic value of €71.2 billion

[8] http://ec.europa.eu/regional_policy/sources/docgener/guides/synergy/synergies_en.pdf
[9] http://www.leru.org/files/publications/LERU_Economic_Contribution_-_Report.pdf

in Gross Value Added and 900,065 jobs across Europe in 2014. This contribution is coming from their core activities (staff employment, expenditure on supplies), student related contributions (student expenditure, employment, placements, volunteering), knowledge transfer (enterprise, commercialization and innovation activities), and tourists' contribution. Other studies attempted to quantify the causal impact of education on economic growth (Aghion et al., 2009) describing the overall positive, but rather not self-evident relation between these fields. The above-mentioned synergetic examples prove that education is has a strong effect in seemingly unconnected fields, such as economic growth and health, thus becoming a key area to invest and to further investigate its relationship with other fields.

One of EIT's main purposes is to create an ecosystem in Europe, in which world class businesses can emerge. EIT is a platform that links the knowledge triangle elements (Research and Technology, Higher Education, Innovation and Entrepreneurship) across Europe and into the wider world (Allinson et. al, 2012). The knowledge triangle is a way to capture knowledge creation, through the synergistic links among the three pillars. It also highlights the added values when different field are closely linked and harmonised. Education provides key skills to Research/Technology and to Innovation/entrepreneurship. In return Research generates new knowledge which improves education intelligence. Innovation and Entrepreneurship, in other ways, create new knowledge on market development, which is important feedback for education to develop relevant competencies for the labour market. Creation of new knowledge serves as a source of innovation and new ideas for entrepreneurships. In another direction, business opportunities allow identification of new research avenues. These interconnected links are displayed in *Figure 1*. Higher education also contributes to jobs and growth, and its international attractiveness, when effective links are established among the three sides of the knowledge triangle. The knowledge triangle has also been embedded in the 2020 vision for the European Research Area[11].

Another relevant example is the Kyoto protocol, an international treaty and a large scale global cooperation attempt reflecting on the challenge of global warming caused by human activity. The protocol was adopted in 1997 and entered into force in 2005. There are currently 192 parties involved in the protocol[12]. The treaty extends the United Nations Framework Convention on Climate Change (UNFCCC) that commits the State Parties to reduce greenhouse gas emissions (GHG). It places a heavier burden on the developed countries, due to the intense industrial activity of the last 150 years. After the first commitment period (2008-2012), the "Doha Amendment to the Kyoto Protocol" was adopted, which added new commitments to the second period (2012-2020) and revised the list of greenhouse gases. During the second commitment period, parties signed to reduce GHG emissions by at least 18 % below 1990 levels. In order to monitor the commitments, the Protocol applies a registry system, reporting, adaptation fund and compliance framework[13]. The Kyoto Protocol is a good example of global collaboration with a common vision to regulate and reduce greenhouses gases emission to fight against global warming.

[10] http://www.leru.org/index.php/public/news/investing-in-research-innovation-and-education-really-pays-off-/

[11] http://ec.europa.eu/research/era/index_en.htm

[12] https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-a&chapter=27&lang=en

[13] http://unfccc.int/kyoto_protocol/items/2830.php

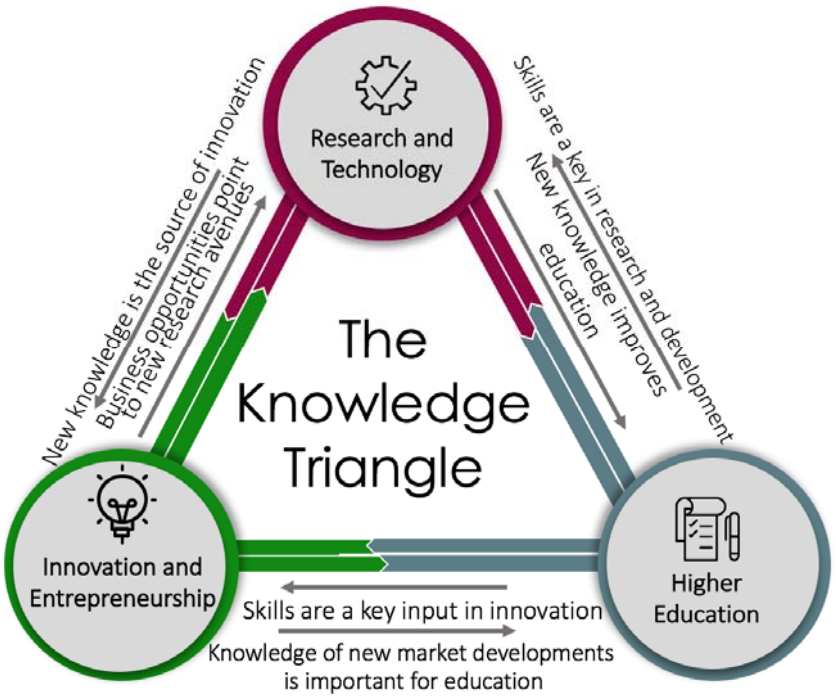


Figure 1: The Knowledge Triangle. Source: Allinson et al. (2012) and Lappalainen and Markkula (2013).

Translating these approaches into the purpose of Task 2.6, our aim has been the identification of synergies, understood as a combination of actions, which represent added values as demonstrated in the previous examples. Such added values include, for example cost reduction, greater efficiency, combined strengths-weaknesses, shared knowledge, increased feasibility, cooperative research, joint momentum, amplified impact when a combination of actions are implemented together. The thematic fields (Education & Outreach, Industry & Trade, Research & Innovation, Recycling & Substitution) are not isolated individual topics, but instead are highly interconnected. These connections are partly obvious, partly hidden. Therefore, the development of the synergies described in this report must cross-cut these thematic fields and integrate the most relevant components to strengthen the common vision of a given synergy.

2.2 Development of the INTRAW project

INTRAW has aimed to map best practices and boost cooperation opportunities related to raw materials between the EU and 5 technologically advanced non-EU countries (Australia, Canada, Japan, South Africa and the United States), also referred to as the Reference Countries, or shortly, RCs.

To achieve the proposed goals, in Work Package 1 (Mapping), INTRAW extensively studied the Reference Countries through a contextual analysis (D1.2), covering 49 explanatory factors, grouped into five main categories:

- Geo & Environmental (6 factors);
- Socio-Cultural (11 factors);
- Economic (14 factors);
- Political and Legal (14 factors); and
- Technological (4 factors).

These factors allowed the INTRAW project to understand these countries' historical economic development during the 20th and 21st century in general and in relation to primary raw materials management. Parallel to this, three transactional reports have been produced (D1.3, D1.4, D1.5), focusing on Research and Innovation, Industry and Trade, Education and Outreach systems related to mining & mineral supply within the Reference Countries. The accumulated knowledge from Work Package 1 have been used throughout Work Package 2 (Programming).

The first report from Work Package 2, D2.1 - *Strategic plan for international knowledge-sharing,* covered three important aspects:

- *Strategic overview* of the RCs and the EU considering six key fields: mineral resources availability; raw materials policy and legal frameworks; research and innovation; education and outreach; industry and trade; and management, recycling and substitution of strategic raw materials;
- *Gap analysis* of the best practices between the EU and the RCs, based on the above key fields,
- *Pathways* that are recommended to close gaps, and that act as a base for the development of action plans on international cooperation that were designed in the next stage of Work Package 2. The pathways are grouped according to the four action fields.

Based on the strategic overview, gap analysis and pathways, four action plans were developed, on the overlapping thematic fields of

- Research and Innovation (D2.3),
- Education and Outreach (D2.4),
- Industry and Trade (D2.5), and
- Recycling and Substitution (D2.6).

In the action plans the goals, the target groups, the responsible institutions and the available instruments are identified for each action. The related actual collaboration maturity level and the interlinkage with other actions are also defined. Each action is allocated to a time horizon and one (or more) of the three different scenarios which project the raw materials management by 2050.

The work continued, already parallel to this report, with D2.2 - Roadmap for the implementation of the Action Plans, related to the four key strategic fields (*Figure 2*). Actions were provisionally allocated to an institution that may have the capacity to drive the realisations of the actions (International Raw Materials Observatory and the European Commission), and timeframes were defined (short, medium and long time horizons). The timing and the output-input linkages of the actions are provided in a graphic visualisation.

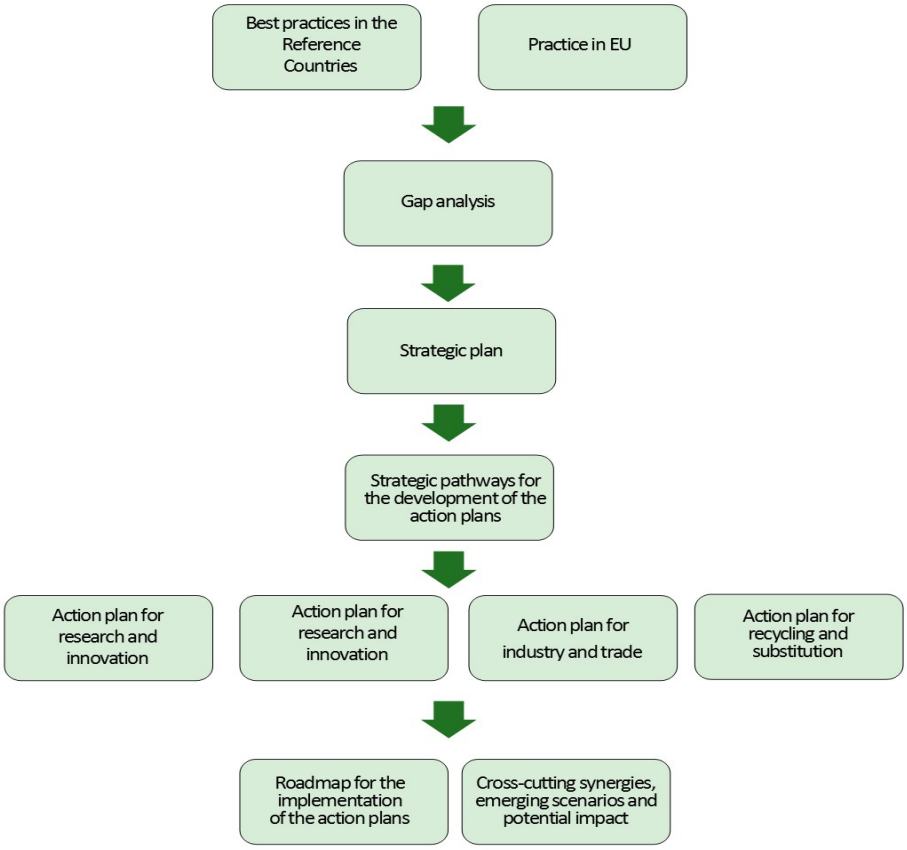


Figure 2: Methodology for developing the action plans and the roadmap and relation between work phases in WP2.

2.3 Scope of work in Task 2.6 Cross-cutting synergies for raw materials programming

The aim of Task 2.6 has been to continuously monitor the implementation of WP2 with the aim of integrating cooperation schemes for education, research and industry involvement along the raw materials value chain for a better adaptation of strategic goals, action plans and control activities in the international raw materials environment. The specific objectives of this task were as follows:

- Fine-tune action plan implementation by identifying synergies and possible enhancements;
- Assess future scenarios together with drivers and new possibilities for international cooperation against these future scenarios;
- Define guidelines to the adaptation of strategic goals, action plans and control activities to the different scenarios;
- Identify synergies between international applied research and innovation programmes, education and outreach policies and foster industrial activities;
- Development of joint programming actions of multi-sectoral education-research-industry actions on raw materials;

Task 2.6 was launched together with the launch of WP2 and it consisted of the following internal milestones:

1. WP2 kick off meeting in Stuttgart, 5-6 April 2016.
   The meeting aimed to kick-start the work in WP2 - Programming. The host and WP leader explained the work plan to implement this WP. The partners were provided an opportunity to

discuss the presented strategy and structure, to arrive at a common understanding on the work needs to be done.

2. 1st Foresight exercise meeting in Brussels, 1-2 June 2016.
   Before the meeting, an online conference took place, within WP2, where the WP leader explained the basics of the scenario foresight method. During the meeting the partners defined the scenario field and time horizon and selected the influence factors. The influence factors were groups according to PESTEL (Political, Economic, Social, Technological, Environmental, Legislative) categories. The participants performed Cause & Effect analysis between the influence factors to investigate cross cutting relations.
3. 2nd Foresight exercise meeting in Brussels, 4-5 July 2016.
   Following the scenario building exercise, the partners built plausible, mutually exclusive future projections with a definition for each descriptor. During this meeting, the task performed Cross Impact Analysis of the projections. With this data, and software support, three synergetic group of projections were created, which were the "raw" scenarios.
4. Consortium and review meeting in Falmouth, 3-7 October 2016.
   During this meeting the consortium members and the Panel of Experts were fine tuning the scenarios, and worked on the storylines. The Experts worked on each scenario environment and were asked to investigate critical success factors and actions covering the thematic fields (R&I, E&O, I&T).
5. WP2 Scenario Workshop 2016, 28 November – 02 December 2016.
   This workshop, during the 2016 European Raw Materials week, served as a second round of validation and interpretation of the scenarios, which already included the feedback from the Falmouth workshop. The impact of the scenarios on the EU-RCs cooperation were also elaborated.
6. WP2 meeting in La Palma, 11-12 January 2017.
   During these two days, the partners were focusing their efforts on Work Package 2, fine-tuning the Action Plans on R&I, E&O, I&T, R&S of raw materials and cross-referencing the actions with the scenarios.
7. Consortium meeting in Paris, 22-23 March 2017.
   Paris meeting focused on advancing WP2 Programming and WP3 Deployment. In WP2, the work has been focused on an exercise to understand the effect of cross-cutting synergies between different action plans. During this exercise, partners considered different future scenarios and their potential impact on international cooperation on raw materials.
8. Brussels workshop with the Experts, 8th November 2017.
   The aim of the workshop, during the 2017 European Raw Materials week, was to work out tangible cooperation opportunities between the EU and the Reference Countries (Australia, Canada, South Africa, Japan and USA). The results can be translated as input to this ongoing deliverable: a report on cross-cutting synergies, emerging scenarios and their potential impact on international cooperation on raw materials.

3. METHODOLOGY

3.1 Identifying Cross-cutting Synergies

One of the aims of this report is to identify cross-cutting synergies that can occur across the various actions from the four actions fields: Research and Innovation, Education and Outreach, Industry and Trade and Recycling and Substitution. To achieve this, a range of investigative tools and methods were used in a complementary manner. The final methodology to define cross-cutting synergies included structural and thematic analysis and several stages of validation with the consortium partners and experts and has led to the definition of 8 cooperation agendas.

3.1.1 Preliminary Work

The general background for this report is provided by the previously developed deliverables in Work Package 2:

- D2.1 Strategic plan for international knowledge-sharing
- D2.2 Roadmap for the implementation of the Action Plans
- D2.3 Action Plan to enhance international research and innovation activities on raw materials
- D2.4 Action Plan to enhance international education and outreach activities on raw materials
- D2.5 Action Plan to enhance cooperation on International Industrial & Trade Policies on raw materials
- D2.6 Action Plan for the management, recycling and substitution of strategic raw materials

One of the objectives of the last deliverable in WP2 (D2.7 Report on cross-cutting synergies, emerging scenarios and their potential impact on international cooperation on raw materials) is to explore options for the synergetic implementation of actions across the four Action Plans corresponding to Research and Innovation (I&T), Education and Outreach (E&O), Industry and Trade (I&T), and Recycling and Substitution (R&S).

The Action Plans (D2.3, D2.4, D2.5, and D2.6) were reviewed in close cooperation with the authors of D2.2 Roadmap for the implementation of the Action Plans and changes were proposed and implemented. The Action Plans were evaluated for trends and compared to the strategic goals discussed in the INTRAW Strategic Plan (D2.1). Main trends were identified and observations and recommendations for the cross-cutting implementation of the actions were described in line with the identified long term strategic goals. This work resulted in 8 cooperation agenda's that were confirmed to be future-proof as most of the actions (over 80%) that are allocated to each Agenda are applicable in at least two of the INTRAW future scenarios (see Chapter 3.2 Integrating the INTRAW scenarios for further details).

The methodology that ultimately resulted in the development of the Cooperation Agendas is introduced in the following sub-chapters.

3.1.2 Pre-identified interlinkages

Interlinkages between the different actions, were already identified in reports D2.3 (Action plan to enhance international research and innovation activities on raw materials), D2.4 (Action plan to enhance international education and outreach activities on raw materials), D2.5 (Action plan to

enhance cooperation on international industrial & trade policies on raw materials), and D2.6 (Action plan for the management, recycling and substitution of strategic raw materials) by the deliverables' authors for each action described in the four action plans. The authors considered at what points an action is influenced by or influences other actions and the possible connections and common points between them – finding interlinkages. These interlinkages have been processed and plotted in excel as seen in *Figure 3* and *Figure 4* and are displayed graphically in a sunburst diagram in *Figure 5*. In Deliverable 2.2 (Roadmap for implementation of the Action Plans) the interlinkages between actions from the 4 action plans were studied more in-depth, while considering their relationship during the various implementation phases, and different scenarios. This work is presented in the form of input-output linkages in graphic visualizations (*Figure 6*).

Figure 3: Part of the pre-identified interlinkage table used.

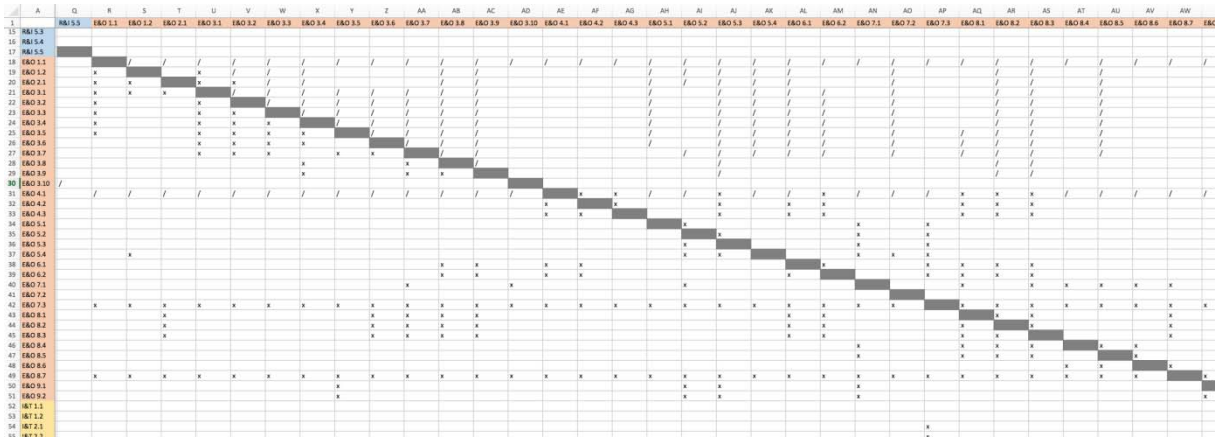


Figure 4: Close-up of the pre-identified interlinkage table used.

Figure 5: Sunburst diagram of pre-identified interlinkages from the 4 action plans (D2.3, D2.4, D2.5 and D2.6). The four fields of the action plans are represented in distinct colours: Research & Innovation – green; Education & Outreach – purple; Industry & Trade – grey; Recycling & Substitution – blue.

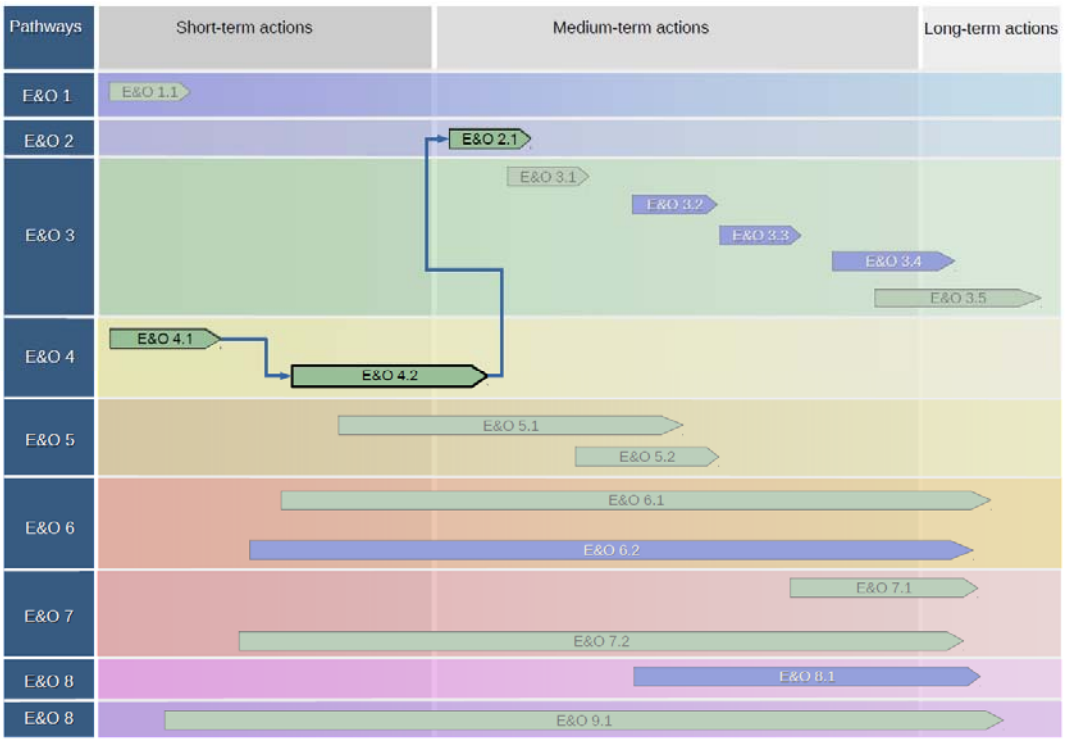


Figure 6: Example of Input and output diagram from Deliverable 2.2 – Roadmap for the implementation of the action plans (links of action E&O 4.2).

The in-depth analysis of the interlinkages including the assessment of the "behaviour" of the different actions in the different future scenarios provided an important component for the definition of the Cooperation Agendas. These interlinkages, however, provide insight only within the individual Action Plans. In addition, their quality and consistency showed some variation across the four deliverables (partly due to thematic limitation and partly due to differences in the sought level of detail and accuracy). For this reason, they were enhanced with the help of other tools and methods using thematic and structural analysis.

3.1.3 Pathway matrix

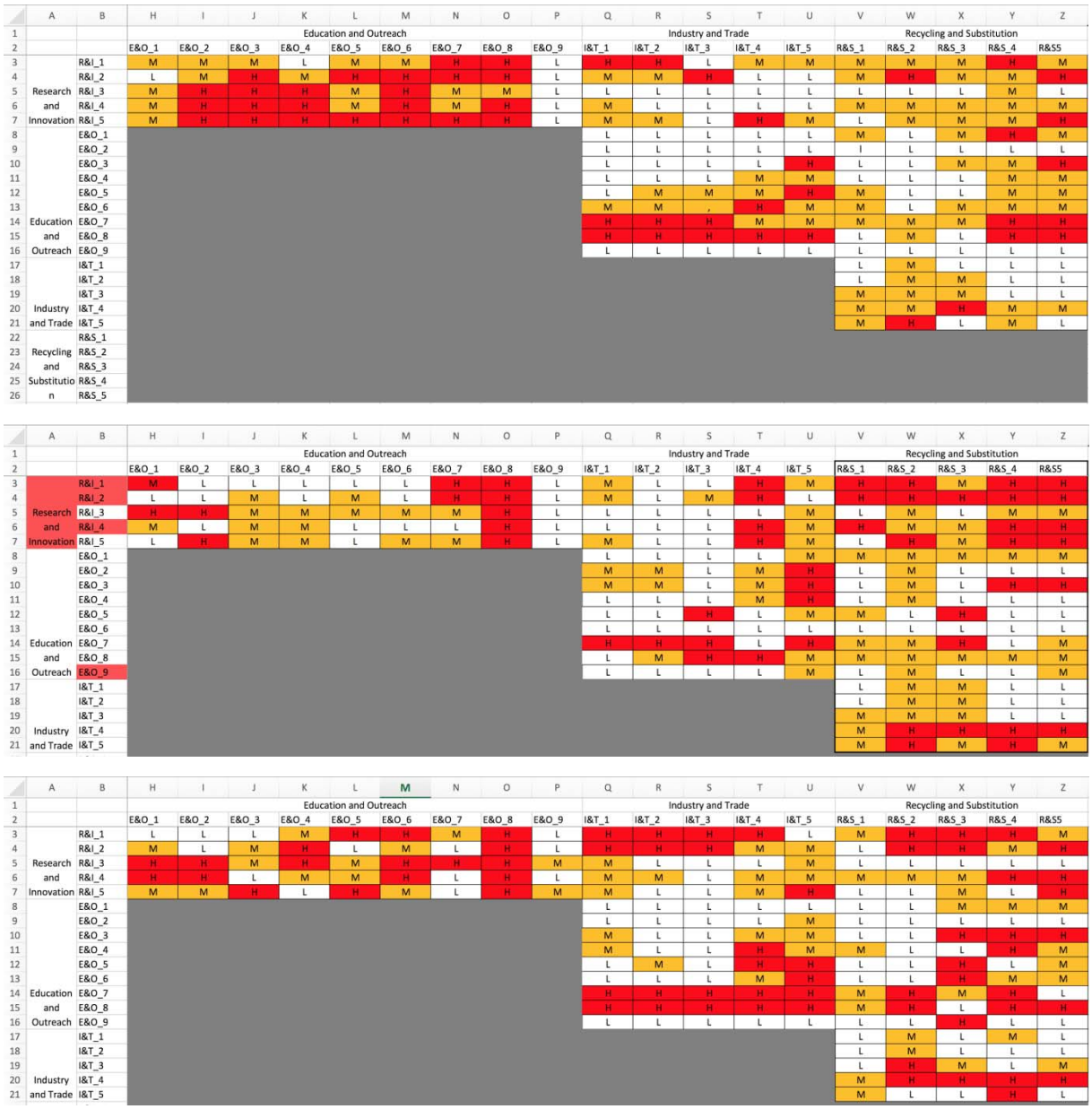
A proven method to identify and classify synergies is the use of matrixes, as it has been seen in other works from different fields: EIP on AHA Synergies (European Innovation Partnership on Active and Healthy Ageing, Synergies Task Force[14]; Bousquet et al., 2017) and An Excel Solver-VBA Application for R&D Project Selection and Portfolio Optimization (Henriksen & Palocsay, 2006). To find possible links and see the relationships between the 24 different action pathways (*Table 1*) developed in D2.1 from each action field, the pathways were plotted against each other in a matrix-like table (*Figure 7*).

The matrix was created during an in-house workshop during which values of L (low), M (medium) or H (high) were assigned to the possible present and/or future relation of two different pathways. This operation was carried out by three experts independently during the same exercise. Pathways within the same action field were not considered and thus not plotted, as it is assumed they have a high relation already. Colours were given to the values to help in visualization (L - white, M - orange, H - red).

[14] https://ec.europa.eu/research/innovation-union/pdf/active-healthy-ageing/bousquet_synergies.pdf

Table 1: List of the pathways identified in D2.1 along which the action plans were developed.

Strategic field	Pathway
Research and innovation	**R&I 1** - Robust raw materials planning on bilateral and multilateral bases
	R&I 2 - Integration of research and knowledge in the raw material strategy and policy on a common approach with the Reference Countries
	R&I 3 - Developing young researchers/professionals career schemes on an international basis
	R&I 4 - Finding synergies and streamlining advanced research programmes with international cooperation
	R&I 5 - Strengthen the international cooperation between research institutions and industry
Education and outreach	**E&O 1** - Joint educational programmes with the Reference Countries
	E&O 2 - Developing an international qualification framework for mining engineering programmes
	E&O 3 - Increased interaction and collaboration between industry and universities on an international base
	E&O 4 - Joint international technical and vocational training in English
	E&O 5 - Raising interest in geosciences at primary and secondary schools
	E&O 6 - Professional structures and recognition
	E&O 7 - Mineral diplomacy
	E&O 8 - International policy
	E&O 9 - Raising interest in geosciences & mining at primary and secondary school level
Industry and trade	**I&T 1** - Bilateral agreements for mineral resource production and buy-ins
	I&T 2 - Widening and strengthening trade agreements on raw materials with the Reference Countries
	I&T 3 - Increase of EU integration on minerals policy making and harmonising legal, administrative and fiscal policies following the best practices in the Reference Countries
	I&T 4 - International cooperation on technology integration, management systems and solutions
	I&T 5 - Financing technological research and development in developing countries
Recycling and substitution of strategic raw materials	**R&S 1** - Reducing uncertainties and data gaps on secondary raw materials within the EU and internationally, with a special regard to the Reference Countries
	R&S 2 - Integrating recycling into waste management
	R&S 3 - Complementing primary mineral resource databases with data on secondary raw materials in cooperation with the Reference Countries
	R&S 4 - Joint research and innovation programmes on recycling
	R&S 5 - Cooperation on substitution research and technologies



			Education and Outreach									Industry and Trade					Recycling and Substitution				
			E&O_1	E&O_2	E&O_3	E&O_4	E&O_5	E&O_6	E&O_7	E&O_8	E&O_9	I&T_1	I&T_2	I&T_3	I&T_4	I&T_5	R&S_1	R&S_2	R&S_3	R&S_4	R&S5
		R&I_1	M	M	M	L	M	M	H	H	L	H	H	L	M	M	M	M	M	H	M
		R&I_2	L	M	H	M	H	H	H	H	L	M	M	H	L	L	M	H	M	M	H
	Research and Innovation	R&I_3	M	H	H	H	M	H	M	M	L	L	L	L	L	L	L	L	L	M	L
		R&I_4	M	H	H	H	M	H	M	H	L	M	L	L	L	L	M	M	M	M	M
		R&I_5	M	H	H	H	H	H	H	H	L	M	M	L	H	M	L	M	M	M	H
		E&O_1										L	L	L	L	L	M	L	M	H	M
		E&O_2										L	L	L	L	L	I	L	L	L	L
		E&O_3										L	L	L	L	H	L	L	M	M	H
		E&O_4										L	L	L	M	M	L	L	L	M	M
		E&O_5										L	M	M	M	H	M	L	L	M	M
		E&O_6										M	M	,	H	M	M	L	M	M	M
	Education and Outreach	E&O_7										H	H	H	M	M	M	M	M	H	H
		E&O_8										H	H	H	H	H	L	M	L	H	H
		E&O_9										L	L	L	L	L	L	L	L	L	L
		I&T_1															L	M	L	L	L
		I&T_2															L	M	M	L	L
		I&T_3															M	M	M	L	L
	Industry and Trade	I&T_4															M	M	H	M	M
		I&T_5															M	H	L	M	L
		R&S_1																			
	Recycling and Substitution	R&S_2																			
		R&S_3																			
		R&S_4																			
		R&S_5																			

			Education and Outreach									Industry and Trade					Recycling and Substitution				
			E&O_1	E&O_2	E&O_3	E&O_4	E&O_5	E&O_6	E&O_7	E&O_8	E&O_9	I&T_1	I&T_2	I&T_3	I&T_4	I&T_5	R&S_1	R&S_2	R&S_3	R&S_4	R&S5
		R&I_1	M	L	L	L	L	L	H	H	L	M	L	L	H	M	H	H	M	H	H
		R&I_2	L	L	M	L	M	L	H	H	L	M	L	M	H	L	H	H	H	H	H
	Research and Innovation	R&I_3	H	H	M	M	M	M	M	H	L	L	L	L	L	M	L	M	L	M	M
		R&I_4	M	L	M	M	L	L	L	H	L	L	L	L	H	M	H	M	M	H	H
		R&I_5	L	H	M	M	L	M	M	H	L	M	L	L	H	M	L	H	M	H	H
		E&O_1										L	L	L	L	M	M	M	M	M	M
		E&O_2										M	L	L	M	H	L	M	L	L	L
		E&O_3										M	M	L	M	H	L	M	L	H	H
		E&O_4										L	L	L	M	H	L	M	L	L	L
		E&O_5										L	L	H	L	M	M	L	H	L	L
		E&O_6										L	L	L	L	L	L	L	L	L	L
	Education and Outreach	E&O_7										H	H	H	L	H	M	M	H	L	M
		E&O_8										L	M	H	H	M	M	M	M	M	M
		E&O_9										L	L	L	L	M	L	M	L	L	M
		I&T_1															L	M	M	L	L
		I&T_2															L	M	M	L	L
		I&T_3															M	M	M	L	L
	Industry and Trade	I&T_4															M	H	H	H	H
		I&T_5															M	H	M	H	M

			Education and Outreach									Industry and Trade					Recycling and Substitution				
			E&O_1	E&O_2	E&O_3	E&O_4	E&O_5	E&O_6	E&O_7	E&O_8	E&O_9	I&T_1	I&T_2	I&T_3	I&T_4	I&T_5	R&S_1	R&S_2	R&S_3	R&S_4	R&S5
		R&I_1	L	L	L	M	H	H	M	H	L	H	H	H	H	L	M	H	H	H	M
		R&I_2	M	L	M	H	L	M	L	H	L	H	H	H	M	M	L	H	H	M	H
	Research and Innovation	R&I_3	H	H	M	H	M	H	H	H	M	M	L	L	L	M	L	L	L	L	L
		R&I_4	H	H	L	M	M	H	L	H	L	M	M	L	M	M	M	M	M	H	H
		R&I_5	M	M	H	L	H	M	L	H	M	M	L	L	M	H	L	L	M	L	H
		E&O_1										L	L	L	L	L	L	L	M	M	M
		E&O_2										L	L	L	L	M	L	L	L	L	L
		E&O_3										M	L	L	M	M	L	L	H	H	H
		E&O_4										M	L	L	H	M	M	L	L	H	M
		E&O_5										L	M	L	H	H	L	L	H	L	M
		E&O_6										L	L	L	M	H	L	L	H	M	M
	Education and Outreach	E&O_7										H	H	H	H	H	M	H	M	H	L
		E&O_8										H	H	H	H	H	M	H	L	H	H
		E&O_9										L	L	L	L	L	L	L	H	L	L
		I&T_1															L	M	L	M	L
		I&T_2															L	M	L	L	L
		I&T_3															L	H	M	L	M
	Industry and Trade	I&T_4															M	H	H	H	H
		I&T_5															M	L	L	H	L

Figure 7: Pathway correlation matrices created during an in-house workshop by 3 participants.

The outcomes from the three independent matrixes were then harmonised by attributing values of 1, 2 and 3 to the values of L, M and H, respectively, resulting in a new matrix (*Figure 8*), that consisted of the sum of values of the three matrixes. The final values of this matrix vary between 3 (sum of L + L + L = 1 + 1 + 1) and 9 (sum of H + H + H = 3 + 3 + 3). Colours were attributed to the final values to help in visualization (values of 3-4 - white, values of 5 to 7 - yellow, values of 8-9 - red).

			Education and Outreach									Industry and Trade					Recycling and Substitution				
			E&O_1	E&O_2	E&O_3	E&O_4	E&O_5	E&O_6	E&O_7	E&O_8	E&O_9	I&T_1	I&T_2	I&T_3	I&T_4	I&T_5	R&S_1	R&S_2	R&S_3	R&S_4	R&S5
		R&I_1	6	4	4	4	6	6	8	9	3	8	7	5	8	5	7	8	7	9	7
		R&I_2	4	4	7	6	6	6	7	9	3	7	6	8	6	4	6	9	8	7	9
	Research	R&I_3	8	9	7	8	6	8	7	8	4	4	3	3	3	5	3	4	3	5	4
	and	R&I_4	7	7	6	7	5	7	4	9	3	5	4	3	6	5	7	7	6	8	8
	Innovation	R&I_5	5	8	8	6	7	7	6	9	4	6	4	3	8	7	3	3	6	6	9
		E&O_1										3	3	3	3	4	5	4	6	7	6
		E&O_2										4	4	3	4	6	3	4	3	3	3
		E&O_3										5	4	3	5	8	3	4	6	8	9
		E&O_4										4	3	3	7	7	4	4	3	6	5
		E&O_5										3	5	6	6	8	5	3	7	4	5
		E&O_6										4	4	4	6	6	4	3	6	5	5
	Education	E&O_7										9	9	9	6	8	6	7	7	7	6
	and	E&O_8										7	8	9	9	8	5	7	4	8	8
	Outreach	E&O_9										3	3	3	3	4	3	4	3	3	4
		I&T_1															3	6	4	4	3
		I&T_2															3	6	5	3	3
		I&T_3															5	7	6	3	4
	Industry	I&T_4															6	8	9	8	8
	and Trade	I&T_5															6	7	4	8	4

Figure 8: Combined pathway correlation matrix.

This exercise helped to further identify possible linkages between different pathways from different action fields. In red are represented the combination of two pathways where common points are strongly evident and the emergence of some type of synergy can be expected (e.g. R&I 1 and R&S 4, *Figure 8*), in yellow where common points are evident and a synergy is probable (e.g. R&I 3 and E&O 5, *Figure 8*) and in white where common points are low and a synergy is unlikely or not likely at all (e.g. R&I 5 and I&T 3, *Figure 8*).

3.1.4 Thematic analysis

The thematic analysis technique is a widely used method for the quantitative analysis of qualitative data and was applied to the actions as described by Braun & Clarke (2006). It intends to identify common themes in a system by applying coding to qualitative input. The method was applied to both the pathways and actions described in the action plans of deliverables 2.3, 2.4, 2.5 and 2.6. Actions that are addressing a common topic, theme and/or goal have common points and are more prone to result in some form synergy. The definition of themes is the base for the thematic analysis. Based on this premise, several themes and subthemes within the action plans and pathways were identified. First, the eight topics that give name to the action fields were selected. Additional themes were selected through the reiteration process of thematic analysis and internal discussions on the descriptions of the action plans. These themes were then validated with other WP2 participants of the INTRAW consortium. Nine additional topics were identified during this process. The resulting themes that later formed the basis for the thematic analysis can be seen in *Table 2*.

Table 2: Themes identified from the action plans by thematic analysis.

Main themes	Additional themes
Research	Jobs and Workforce
Innovation	Technology
Education	Data gaps and databases
Outreach	Finance and investment
Industry	Sustainable supply of Raw Materials / Supply risks
Trade	Environment
Recycling	Policy and strategy
Substitution	Agreements
	Infrastructures and services

The additional themes defined also have some sub-themes associated to them, thus englobing more subjects, than the ones than the name suggests. These so-called sub-themes were agreed upon during a series of discussions between WP2 participants to cover all the topics discussed in the action plans' deliverables. They are as follows:

- Jobs and workforce: Knowledge and skills, Qualification and recognition, Workforce planning;
- Technology: Integration of technologies from other sectors, Equipment, Mineral processing techniques, Mining and exploration methods;
- Data gaps and databases: Data gaps filling, Database creation;
- Finance and Investment: Financing structures, Financing workforce;
- Sustainable supply of Raw Materials / Supply risks: Mineral production, Stockpiling scheme, Exploration, Critical raw materials, Secondary raw materials;
- Infrastructures and services: Joint programmes, Exchange programmes, Training centres, Joint ventures, Exchange programs
- Agreements: Bilateral and multilateral agreements, trade agreements

The themes "Environment" and "Policy and Strategy" do not have any sub-themes associated.

The topics/themes defined were also aligned with the themes specified in the Raw Materials Scoreboard 2016 (EIP on Raw Materials, European Commission)[15]. This document analyses and classifies a series of themes related to the Raw Materials sector and considers 5 main big themes: Raw materials in the global context, Competitiveness and innovation, Framework conditions for mining, Circular economy and recycling and Environmental and social sustainability. In addition to these, a total of 24 sub-themes, allocated inside the main themes were defined (*Figure 9*).

[15] https://publications.europa.eu/en/publication-detail/-/publication/1ee65e21-9ac4-11e6-868c-01aa75ed71a1

The thematic analysis carried out for the INTRAW actions eventually considered 17 topics (*Table 2*). These topics are in-line with the themes and sub-themes defined in the Raw Materials Scoreboard 2016, which acted as a quality-control measure in the establishment of the actions' related themes.

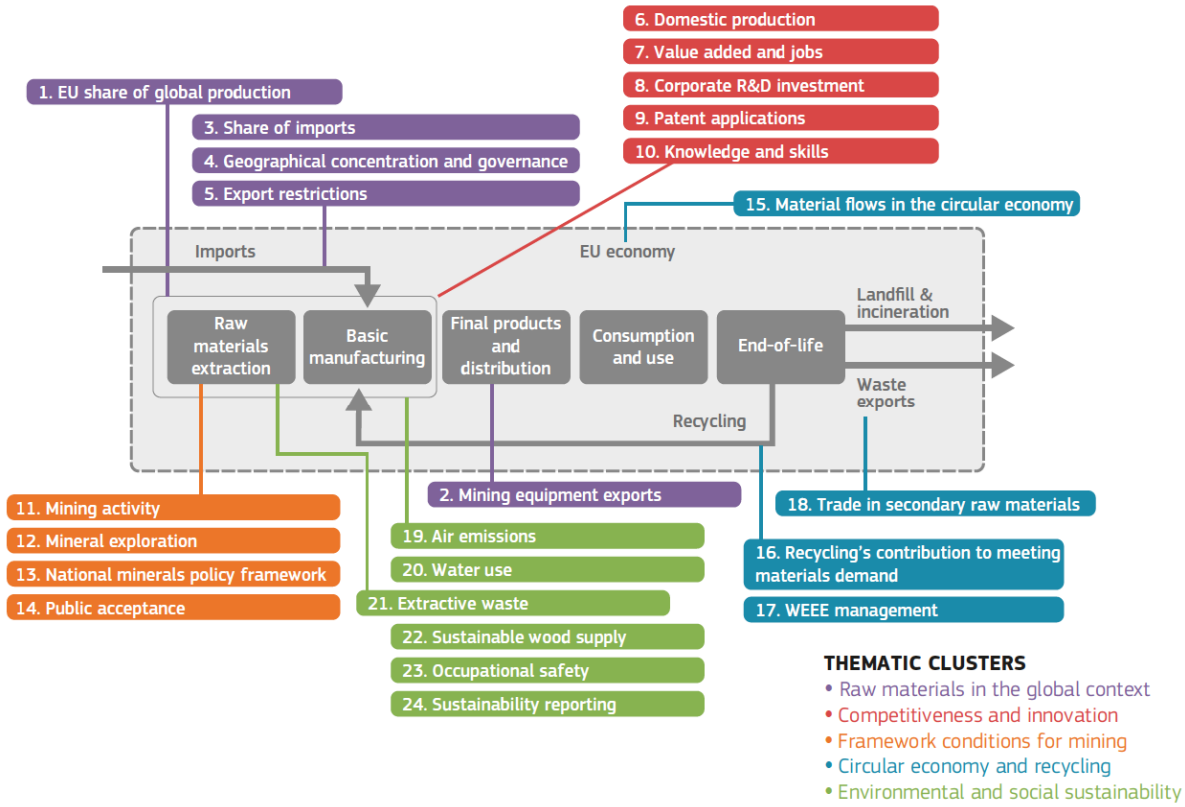


Figure 9: The *raw materials scoreboard at a glance.* Source: The Raw Materials Scoreboard (2016), EIP on Raw Materials, European Commission.

To assess the themes identified and to link them with the various actions, a matrix was constructed (*Figure 10*). In this matrix, all the actions were plotted versus the identified themes. Other parameters such as action timeframe (short, medium, high term), suggested action mandate (European Commission, International Observatory of Raw Materials) and working scenario(s) (Sustainability alliance, Unlimited trade, National walls) were also considered for each action. The assigned values were ranging from 0 (theme not relevant to an action plan) to 3 (theme very relevant to an action plan). The information on timeframe, suggested action mandate and the working scenarios were all taken from the other Deliverables produced in WP2.

An example of the action scoring is given by the thematic analysis of E&O 7.1 (Educate regulators, legislators, politicians and other stakeholders to improve EU wide RM and mining policy development) in *Table 3*.

Table 3: Example of thematic analysis for action E&O 7.1 with relevance (0-3) assigned to the different themes.

Research	Innovation	Education	Outreach	Industry	Trade	Recycling	Substitution	Jobs and workforce	Investment	Technology	Data gaps and databases	Sustainable supply of Rm	Environment	Policy and Strategy	Agreements	Structures and services
0	0	3	0	0	0	0	0	0	0	0	2	2	2	3	2	0

In the above example of the thematic analysis of E&O 7.1, the themes that can be considered as important to this specific action are Education, Databases and data gaps, Sustainable supply of Raw Materials, Environment, Policy and Strategy and, finally, Agreements. The values of 2 and 3 suggest a strong relation from the planned action and these specific themes. Synergies are more likely to arise with other actions that show similar values on the same topics - as they will share common points.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
1	Action	Research	Innovation	Education	Outreach	Industry	Trade	Recycling	Substitution	Jobs and workforce	Investment	Technology	Data gaps and databases	Sustainable supply of RM	Environment	Policy and Strategy	Agreements	Infrastructures and services	*Sum*	Timeframe	Responsible	With whom	Scenario	Target group
2	E&O 1.1	1	1	3	0	1	0	1	0	2	0	0	1	1	0	0	0	0	11	Short	Observatory	RC/EU	All	All stakeholders concerned by collabor
3	E&O 2.1	0	0	3	0	2	0	0	0	2	0	0	0	0	0	0	0	0	7	Medium	Observatory	EU	1+2 (3)	All stakeholders concerned by collabor
4	E&O 3.1	3	1	3	0	3	0	2	2	3	0	2	3	2	0	2	0	0	26	Medium	Observatory	EU+RC	1+2 (3)	All stakeholders concerned by collabor
5	E&O 3.2	3	2	3	3	3	0	0	0	3	0	3	0	0	2	3	1	3	29	Medium	Observatory	EU	1+2 (3)	All stakeholders concerned by collabor
6	E&O 3.3	0	0	3	0	3	0	0	0	3	0	0	0	0	0	3	0	0	12	Medium-Long	Observatory	EU+INT	1+2 (3)	All stakeholders concerned by collabor
7	E&O 3.4	0	0	3	0	3	0	0	0	3	0	0	0	0	0	2	0	0	11	Medium	Observatory	EU+RC	1+2 (3)	All stakeholders concerned by collabor
8	E&O 3.5	3	1	3	0	3	0	0	0	3	0	2	0	0	0	1	2	0	18	Medium-Long	Observatory	EU+RC	1+2 (3)	All stakeholders concerned by collabor
9	E&O 3.6	0	2	2	0	2	2	0	0	1	0	3	0	0	0	3	3	0	18	Medium-Long	Observatory	ALL	1+2 (3)	All stakeholders concerned by collabor
10	E&O 4.1	0	0	3	0	3	0	0	0	3	0	2	1	0	0	2	2	0	16	Short-Medium	Observatory	EU+RC	All	All stakeholders concerned by collabor
24	I&T 1.2	2	0	0	0	1	3	0	0	0	0	0	1	3	0	2	2	0	14	Long	DG Grow	EU with RC	UT, SA	
25	I&T 2.1	2	0	0	1	3	0	0	0	1	3	0	2	1	0	0	0	0	13	Medium	EC	EU	UT, SA	
26	I&T 2.2	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0	0	3	9	Medium	Observatory	International	UT, SA	
27	I&T 2.3	0	0	0	0	0	3	0	0	0	2	0	1	1	0	1	3	0	11	Medium	Observatory	International	UT, SA	
28	I&T 3.1	1	0	0	2	3	3	1	0	0	3	0	0	0	0	1	1	1	16	Medium	EU Chamber of Commerce	EU with RC	UT, SA	
29	I&T 3.2	0	0	2	0	3	3	0	0	1	0	0	0	0	0	1	2	2	14	Medium	EU Chamber of Commerce	EU	UT, SA	
30	I&T 3.3	3	0	0	0	3	3	1	0	0	0	0	3	0	0	1	0	3	17	Long	Observatory	International	UT, SA	
31	I&T 4.1	0	1	0	0	3	2	1	0	0	0	2	0	0	0	1	0	2	12	Medium	Observatory	EU with RC	UT, SA	
32	I&T 4.2	0	0	0	1	3	2	3	0	0	2	0	3	1	0	0	0	2	17	Medium	Observatory	International	UT, SA	
33	I&T 4.3	0	3	0	0	3	1	1	0	0	0	3	3	0	0	0	0	3	17	Medium	Observatory	International	UT, SA	
40	R&I 2.3	3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	8	Medium-Long	National governments, EU	Reference countries	SA, UT	
41	R&I 2.4	3	0	0	0	0	1	1	0	0	0	0	0	2	0	2	3	2	14	Medium-Long	National governments, exi	Reference countries	SA, UT	
42	R&I 2.5	2	0	0	0	2	0	0	0	0	0	0	0	0	1	1	3	0	9	Long	National governments, exi	Reference countries	SA, UT	
43	R&I 2.6	3	0	0	2	2	0	0	0	0	0	0	3	1	0	1	3	3	18	Long	National governments, exi	Reference countries	SA, UT	
44	R&I 2.7	2	1	1	1	2	0	0	0	0	0	0	3	0	0	0	1	3	14	Medium-Long	National governments, exi	Reference countries	SA, UT	
45	R&I 3.1	3	1	2	2	3	0	0	0	3	0	0	0	0	0	2	2	3	21	Medium	European countries and th	Reference countries	SA,UT	
46	R&I 3.2	3	0	2	0	0	0	0	0	3	1	0	0	0	0	1	2	3	15	Medium	European countries and th	Reference countries; third par	SA,UT	
47	R&I 4.1	3	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2	2	10	Short-Medium	European countries and th	Reference countries	SA,UT	
48	R&I 5.1	3	1	0	0	3	0	0	0	0	0	0	0	0	0	1	1	3	12	Medium-Long	European countries and th	Reference countries	SA,UT	
49	R&I 5.2	2	2	0	0	3	0	0	0	0	1	0	0	0	0	1	0	3	12	Medium-Long	EC; European countries an	Reference countries	SA,UT	
61	R&S 4.1	2	2	0	0	2	2	2	2	0	1	1	0	3	0	1	1	2	21	Medium	Observatory	International	UT, SA	
62	R&S 4.2	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0	0	3	9	Short	Observatory	International	UT, SA	
63	R&S 4.3	1	1	0	0	3	0	3	0	0	0	2	2	0	0	0	0	0	12	Short	Observatory	EU with RC	UT, SA, NW	
64	R&S 4.4	0	0	0	0	3	0	3	0	0	0	1	0	0	0	3	0	0	10	Short	DG Grow	EU	UT, SA, (NW)	
65	R&S 4.5	3	3	0	0	0	0	3	0	0	0	2	0	0	0	0	0	1	12	Short	DG Grow, Observatory	EU with RC	UT, SA, NW	
66	R&S 4.6	3	3	0	0	0	0	3	0	0	0	2	0	0	0	0	0	3	14	Short	DG Grow, DG RTD, States	International	UT, SA, (NW)	
67	R&S 5.1	3	3	0	0	0	0	0	3	0	0	3	0	0	0	0	0	3	15	Short	DG Grow, DG RTD, States	EU with RC	UT, SA, NW	Governments, policy makers, industry,
68	R&S 5.2	1	2	0	0	3	0	3	0	0	0	1	0	0	2	3	0	0	15	Short	Governments, policy make	EU	UT, SA, NW	
69	R&S 5.3	3	3	0	1	2	0	2	3	0	0	3	0	0	1	1	0	1	20	Short	DG Grow, DG RTD, Observ	International	UT, SA, NW	
70	R&S 5.4	3	2	0	0	0	0	0	3	3	0	0	0	0	0	0	1	3	15	Short	Observatory	International	UT, SA, NW	

Figure 10: Thematic analysis table example done for all actions.

The detailed analysis of the entire matrix resulted in the identification of actions that work around the same themes and therefore, might be synergetic. These potentially synergetic actions were then reviewed and discussed in more detail during a dedicated in-house workshop.

The thematic analysis turned out to be a very important step in the definition of the Cooperation Agendas presented in this document, as many of the synergies identified are related to the themes hereby mentioned.

3.1.5 Structural analysis

The next complementary method used to help with the identification of synergies was a structural analysis carried out with the help of the Micmac[16] software package. Structural analysis allows to describe a system – in this case the INTRAW actions and the themes defined during the thematic analysis (3.1.4 Thematic analysis) – with the help of a matrix connecting all its components through dependence and influence relations. By analysing the outcomes, a structural analysis gives information on the essential variables to the evolution of the system, while identifying the most important elements.

For the structural analysis a list of variables had to be defined as the first step: the 69 actions and the 17 themes defined in the thematic analysis exercise were used (*Figure 11*).

The next phase consisted of converting this information into a format that the Micmac software is able to process. A new matrix was therefore created as referred to in 3.1.4 Thematic analysis. In this matrix, only relevant values between actions and themes were considered and not between actions or themes alone themselves. This software only works with pre-defined values (0 – no relation, 1 – low relation, 2 – medium relation, 3 – high relation). The matrix also allows values of potential relations (value 4) between two variables. In the specific case of the work developed this type of value was not considered.

	A	B	CC	CD	CE	CF	CG	CH	CI	CJ
1										
2			79 : Investment	80 : Technology	81 : Data Gaps	82 : S. Supply	83 : Envirnonm	84 : Policy	85 : Agreements	86 : Structures
52		50 : I&T 5.1	2	3	0	0	0	1	0	0
53		51 : I&T 5.2	2	3	0	0	0	0	0	0
54		52 : R&S 1.1	1	0	3	1	1	1	1	1
55		53 : R&S 1.2	0	2	2	0	0	2	2	3
56		54 : R&S 2.1	0	1	2	0	2	1	0	0
57		55 : R&S 2.2	0	1	0	0	1	3	0	0
58		56 : R&S 3.1	0	1	3	2	0	1	0	1
59		57 : R&S 3.2	0	0	3	1	1	1	0	0
60		58 : R&S 3.3	0	0	1	1	1	1	0	0
61		59 : R&S 3.4	0	0	3	0	0	1	0	0
62		60 : R&S 4.1	1	1	0	3	0	1	1	2
63		61 : R&S 4.2	0	0	0	0	0	0	0	3
64		62 : R&S 4.3	0	2	2	0	0	0	0	0
65		63 : R&S 4.4	0	1	0	0	0	3	0	0
66		64 : R&S 4.5	0	2	0	0	0	0	0	1

Figure 11: Snapshot of the list of variables used for the MicMac structural analysis.

The next step is to use the results and interpretation tools provided by the software. These tools give visual information on the relations and the importance of those relations in the working system, obtained through the matrix filling, and they are closely related to that process. Two types of tools give the most valuable information for the identification of possible synergies between the action plans and the identified themes: the direct map (*Figure 12, Figure 13,* and *Figure 14*) and the direct graphs (*Figure 16, Figure 17,* and *Figure 18*).

[16] http://en.laprospective.fr/methods-of-prospective/softwares/59-micmac.html

The Direct influence/dependence map plots the influence vs dependence of the elements considered in the system in a 2D graph. This map represents the direct influences and dependences between the variables. In the specific case of the exercise developed, it is important to observe the representation of the themes rather than the actions or the entire system (*Figure 12*). The actions all appear plotted in the bottom left corner, varying from totally independent and non-influent to slightly dependent and influent, due to the way values were attributed in the matrix. Thus, the themes assume importance in the interpretation phase.

A highly dependent and influent theme, as 'Industry' (plotted in the top right corner), is of extreme importance to the system, as many actions are linked to it (56 actions in total). On the other hand, themes such as Substitution (10 actions), Outreach (12 actions), Investment (18 actions) and others, have low impact on the overall system, because only a limited number of actions are linked to them, and they are classified as more dependent and less influential to the whole scheme. The other themes are plotted between these two extremes, representing different combinations of dependence and influence (*Figure 14*). The themes are plotted in a straight, diagonal line in the graph, with varying, but proportional, values.

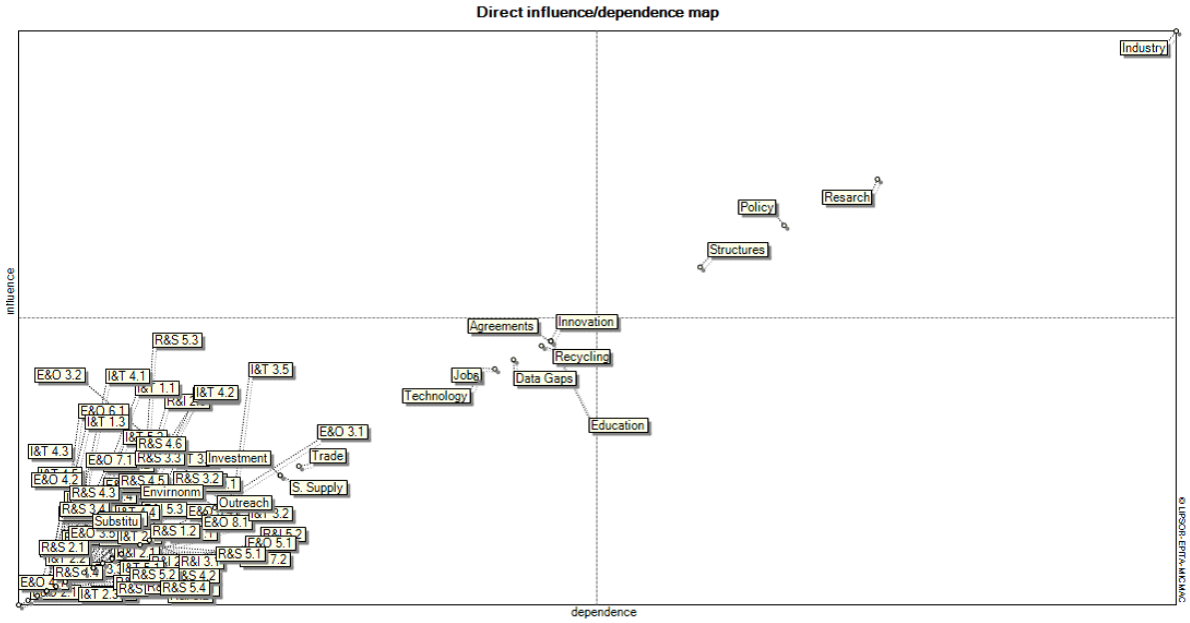


Figure 12: MicMac Direct influence/dependence map.

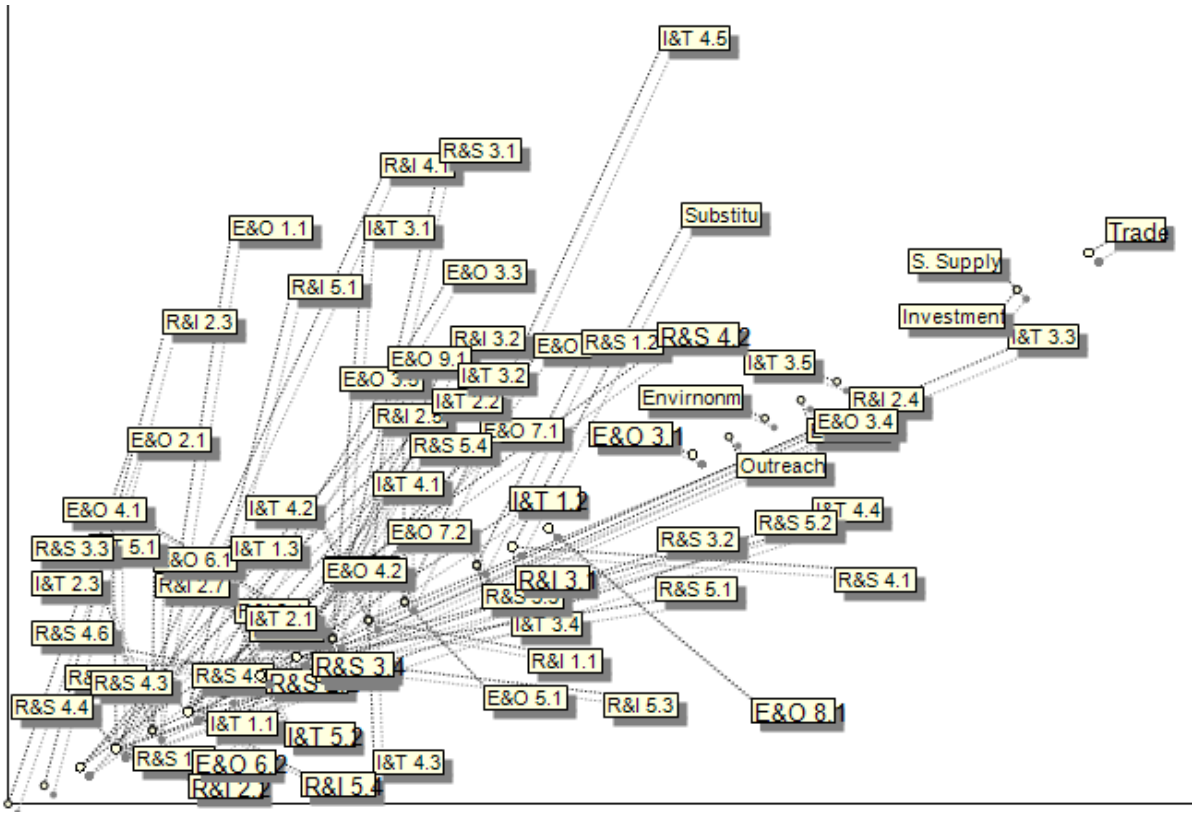


Figure 13: Close-up on lower left corner of the direct influence/dependence map.

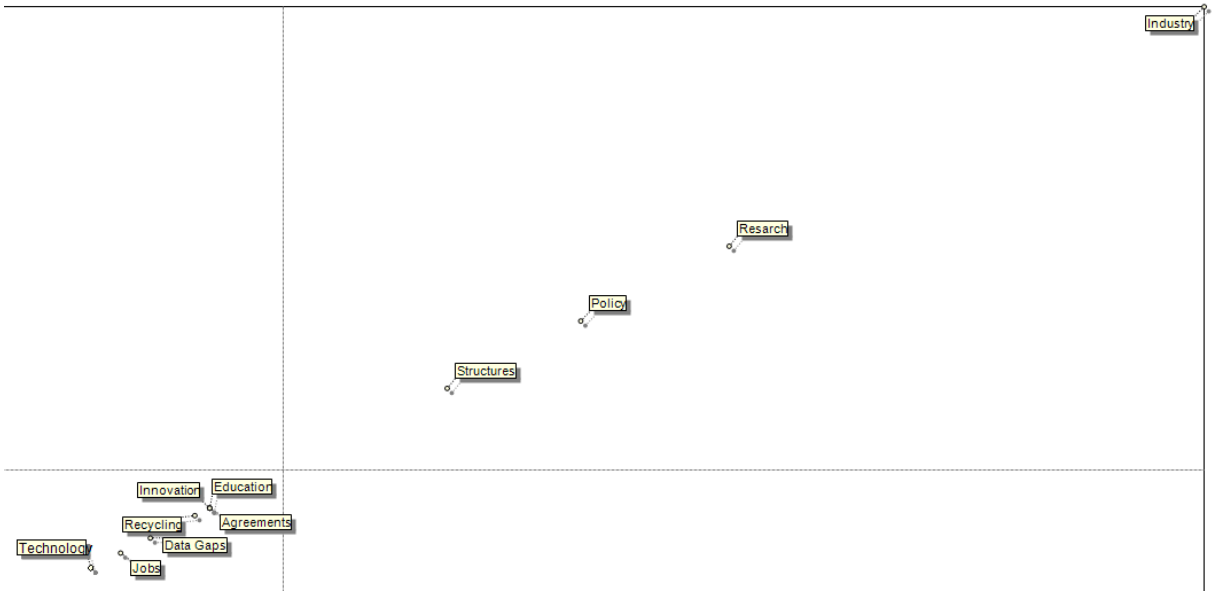


Figure 14: Close-up on the upper right corner of the direct influence/dependence map.

The direct graphs show the relations between the actions and the themes in a Direct influence graph (*Figure 16, Figure 17,* and *Figure 18*). This represents the influences between the variables. Relations are divided and represented, depending on how strong they can influence the system, in:

- Strongest influence;
- Relatively strong influence;
- Moderate influence;
- Weak influence;
- Weakest influence.

The strength of relations is directly dependent on the values. High values (3) mean stronger influences, while low values (1) mean weaker influences. Other key factors to consider is the system itself and how it behaves, for example when investigating sub-system of the whole (as seen in and *Figure 18*).

The direct influence tool can consider different consistency levels of the system - varying from 0 (no elements considered) to 100 percent (all elements considered). Only 3 different consistency levels are shown (5%, 50% and 100%) in this report, to visualise and demonstrate the executed work. At percentage level set to 5%, the graph displays elements only with very strong influential levels, and as the percentage increases, the analysis reveals more (in numbers), however less influential, elements.

The elements that pop up first during the analysis are the actions that influence (varying from weak to strong) each theme, or in other words, what action is important for a specific theme. An action can have relations with many themes, and a theme can have relations with different actions. For example, in *Figure 15*, the action R&S 5.4 has a great impact on the themes 'Research', 'Structures and services', 'Jobs', and 'Substitution', because these are the themes important to implementation and development of action R&S 5.4 and were valued high in the Thematic analysis matrix.

When different percentages of the system are considered it is also possible to see different levels of influences on the system. Firstly, this software tool presents the stronger relations and only after that the weaker relations start appearing, depending on how much of the system is being considered at a given time. With the entire system depicted (*Figure 17*) and with a careful analysis it is possible to identify the most and least relevant themes and actions for the system.

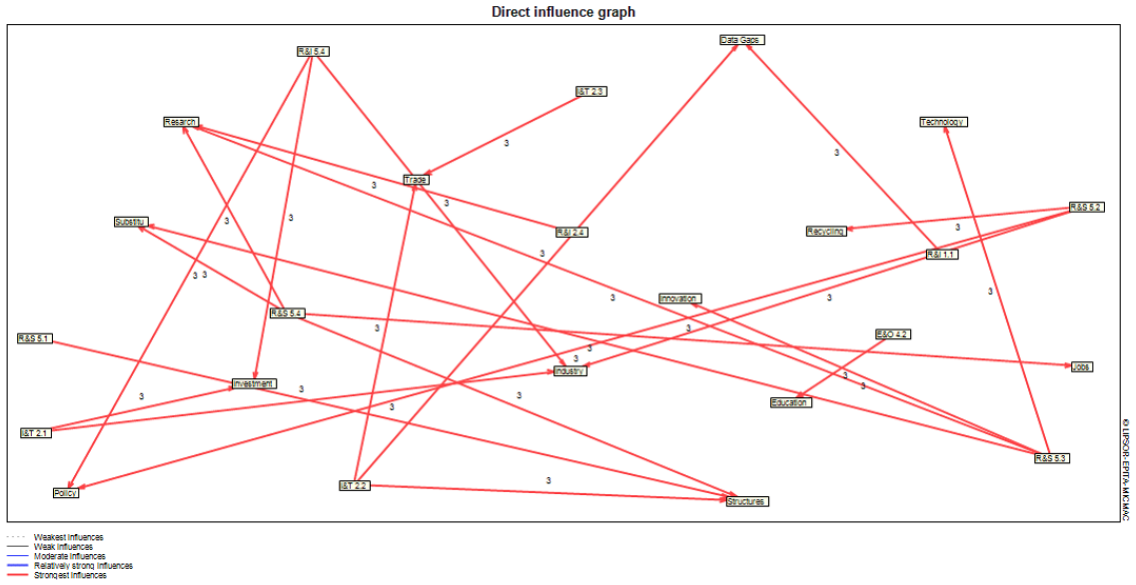


Figure 15: MicMac direct influence graph at 5% zoom.

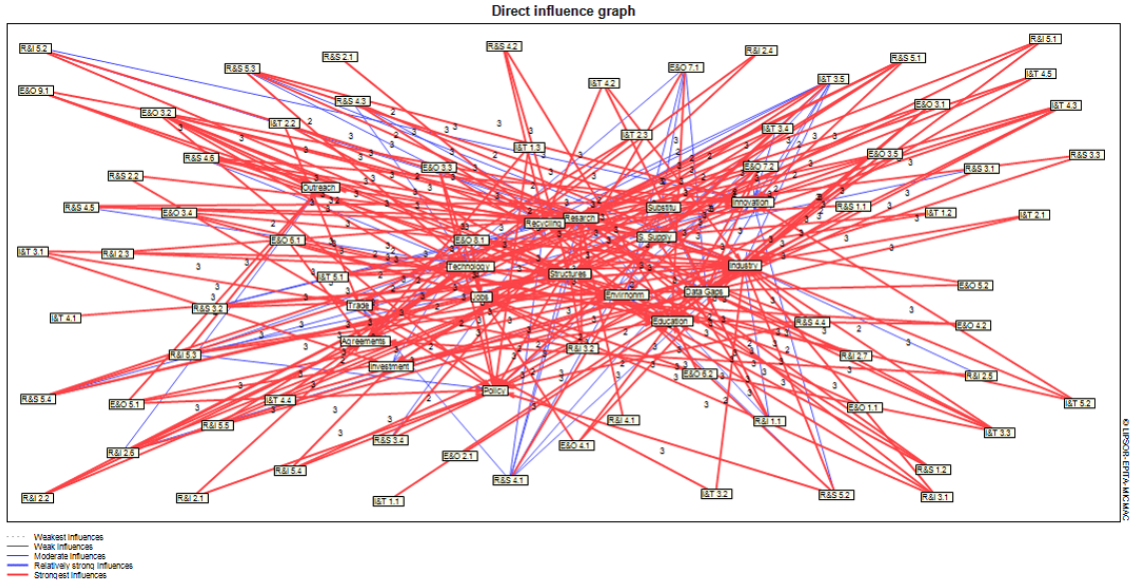


Figure 16: MicMac direct influence graph at 50% zoom.

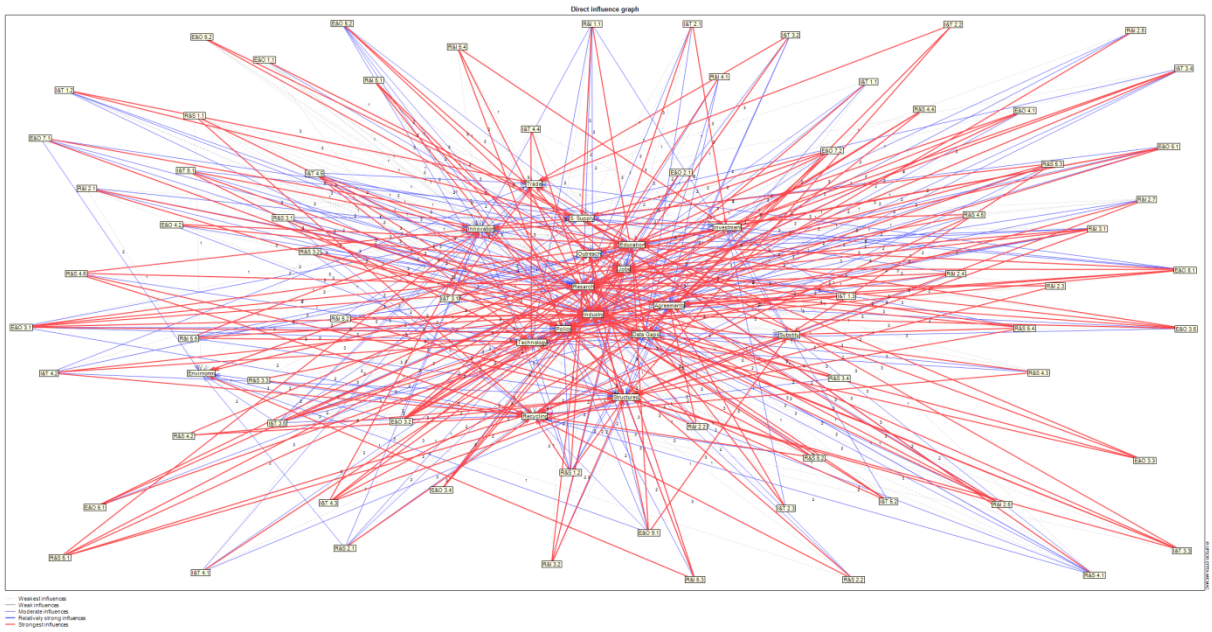


Figure 17: MicMac direct influence graph at 100% zoom.

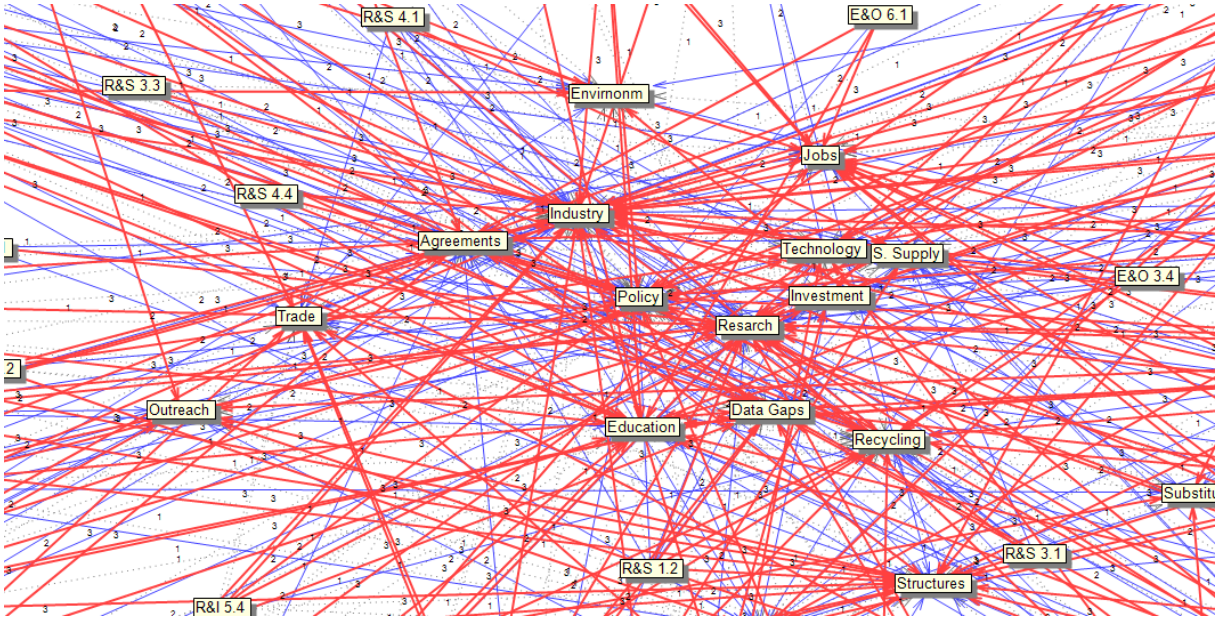


Figure 18: Close-up of MicMac direct influence graph at 5% zoom

The structural analysis allows to draw some immediate conclusions on a systemic level about the INTRAW Action Plans system composed by the actions and themes:

Direct influence/dependence map:

- The most influential themes are Industry, Research, Policy and Strategy, Structures and services. They are also considered the more dependent because they have a high number of actions directly linked to them.
- The least influential and dependent themes are Substitution, Outreach and Environment.

- The most influential actions to the INTRAW system are E&O 3.1, E&O 3.2, E&O 8.1 and R&S 4.1 as they cover a wide range of themes.
- The least influential actions are R&I 2.2, R&I 4.1, R&S 3.4 and R&S 4.2 as they focus on fewer themes.

Direct influence graph:

- Actions represented by few relation lines with the themes, e.g. R&I 2.3, E&O 2.1, I&T 2.2 and R&S 4.2, can be classified as specific-theme actions as they affect only specific themes (3-4 themes)
- Actions represented by a stronger and high number of relation lines with the themes, e.g. R&I 3.1, E&O 3.1, E&O 3.2, E&O 7.2, E&O 8.1, E&O 8.2, E&O 8.3, R&S 1.2, R&S 4.1 and R&S 5.1. can be classified as broader actions as they influence a wide range of themes.
- Themes that are influenced by a bigger number of actions can be considered as more important to the system. This is the case for Industry, Research, Structures and services and Policy and Strategy.
- Themes that are influenced by a small number of actions can be considered as less important to the system. Outreach, Substitution and Environment are classified in this category.

The two types of charts corroborate each other's information facilitating the delineation of actions that are likely to have a strong synergetic effect. This process should also involve the number of themes a specific action can influence and how strong those influences can be.

3.2 Integrating the INTRAW scenarios

The scenario method refers to a foresight technique, consisting on building systematic and internally consistent visions of plausible future states of affairs (Georghiou et al., 2008). The INTRAW scenarios (*Figure 19*) were developed under the guidance of WP2 leader, through personal/skype meetings and individual preparation. The methodology covered the following 5 steps:

1. Scoping the scenario: defining the scenario field and time horizon;
2. Selection of Influence factors: collecting and clustering the influence factors (sorted by PESTEL categories: Political, Economic, Social, Technological, Environmental, Legislative factors), Cause & Effect Analysis, elaboration of the more relevant influence factors, named "descriptors";
3. Projection of Descriptors: creation of plausible, mutually exclusive future projections with a definition for each descriptor;
4. Elaboration of the Scenarios: Cross Impact Analysis of the projections, data processing (ScenarioWizard 4.2[17]) and refining "raw" scenarios;
5. Scenarios interpretation and testing: creation of a storyline and illustration, presenting it to the INTRAW Panel of Experts and at the Raw Materials Week in dedicated workshops.

[17] http://www.cross-impact.de/english/CIB_e_ScW.htm

Figure 19: The INTRAW scenarios developed under WP2.

As a result of these steps, the INTRAW consortium identified 23 descriptors that can shape the future, made 1056 cause and effect relations and 529 cross impact analyses, created 54 future projections and distilled it into 3 internally consistent future scenarios:

- SUSTAINABILITY ALLIANCE: In 2050, the circular economy has become the norm in the big advanced economies, a new generation of political leaders has pushed forward a series of reforms that focus on increasing sustainability, not only in the raw materials industry. Almost every product is produced in an environmentally friendly way with the aid of green technologies. Decision makers are under pressure to meet public demands for more environmentally friendly solutions and policies.
- UNLIMITED TRADE: In 2050, the world of raw materials has experienced steady growth, mainly due to ever-growing consumption. International cooperation and dialogue have created new opportunities to produce and trade raw materials. Access to capital has led to industry integration, technology development and productivity improvements alike.
- NATIONAL WALLS: In 2050, the world of raw materials stagnated as social and demographic pressures triggered a long period of economic standstill, which eventually lead to a rise of protectionist measures. The absence of leadership and insufficient political engagement will not help to improve the situation. Each country fights for its own agenda. There is little progress in mining practices as reforms have stalled and private investments are low.

In the Action plan deliverables, the actions have been analysed for their robustness in each of these three scenarios. Further analysis is provided in D2.2 (Roadmap for the implementation of the Action Plans) where the efficiency of an action is evaluated related to the three future scenarios. Then, in this study the scenarios were further investigated with respect to their behaviour as drivers for possible gaps, constraints and/or strengths in the synergy elaboration process. During the definition of the synergistic actions and resulting Cooperation Agendas special attention was given to the distribution of actions in a way that most (minimum 80%) of the actions in each of the Cooperation Agendas remain relevant in at least two future scenarios.

3.3 Brussels Raw Materials Week Workshop

On the 8th of November 2017 an INTRAW workshop took place with the aims of validating the action plans with respect to the reference countries; identifying concrete synergetic actions for bilateral and multilateral cooperation; and to formulate final recommendations and agendas for bilateral and multilateral cooperation based on the action plans for this report.

For the exercise, the participants were divided in five groups – one group for each of the reference countries - of 8-10 people (*Figure 21*). Based on the Country reports (D1.2) developed in WP1 and Chapter 5 of Raw Materials Management in the EU of D2.1, the most defining aspects and strengths of the reference countries and the EU were listed per thematic field (Research & Innovation, Education & Outreach, Industry & Trade, Recycling & Substitution). The resulting lists of points for each country were validated by the INTRAW consortium during the consortium meeting the day before the workshop. During the workshop, the identified strengths were placed in a XY diagram were the X-axis represented the relative strength of the reference country and the Y-axis the relative strength of the EU (*Figure 20*). Common strength and common weaknesses provide opportunities for multilateral cooperation, while strength-weakness situations are drivers for bilateral cooperation. Also, the cross-cutting interrelationships between the points were examined.

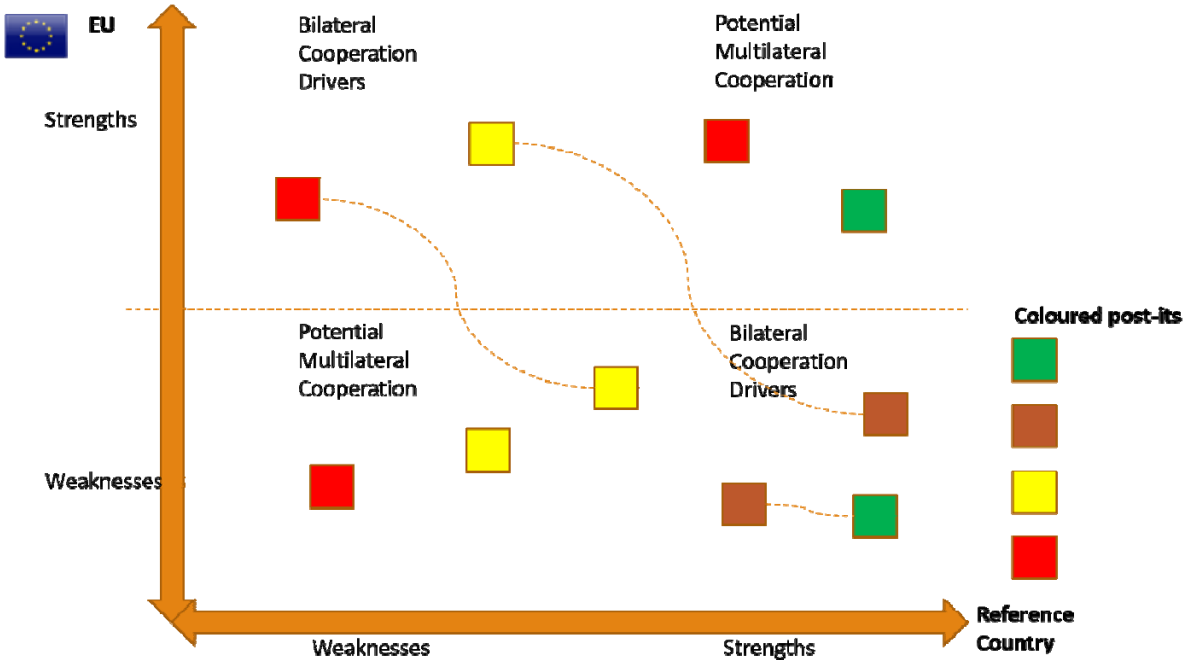


Figure 20: Set up of the type of diagram created in the workshop.

An example outcome of the workshop can be seen in *Figure 22*. At the end of the exercise, the five groups selected the top four potential areas for cooperation (Table 4) that were then presented to the whole audience. Several opportunities for trilateral cooperation arose in this session (Table 4):

- Japan – USA – EU Enhanced University-Industry R&D collaboration.
- Australia – USA – EU Cooperation to improve on communication and Social License to Operate.
- Canada - USA – EU Cooperation on enhanced geoscientific data availability.
- Australia – Japan – EU Improved international education by university collaboration.

Figure 21: The USA workgroup discussing potential areas for cooperation between the USA and the EU during the workshop in Brussels.

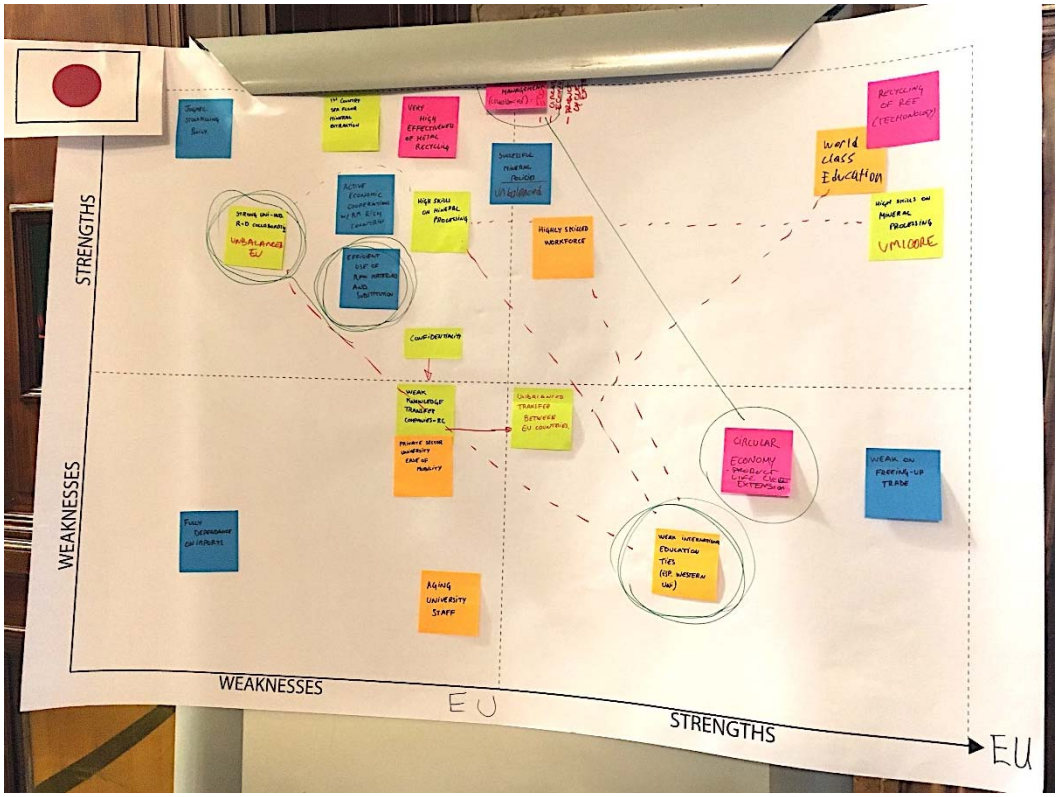


Figure 22: Outcome of the workshop on identifying potential areas of cooperation between the EU-Japan.

Table 4: The top four potential areas for EU-refence country cooperation. Colours represent similar areas identified by multiple countries.

	Australia	Japan	Canada	USA	South Africa
1	*Education & Outreach:* Social license to operate and public and community engagement.	*Research & Innovation:* University - Industry R&D collaboration High skills on mineral processing.	*Research & Innovation:* Canadian decentralised reactive market driven approach vs. EU strategic central government driven long-term approach.	*Research & Innovation:* University-industry collaboration on R&D.	*Research & Innovation:* Mineral processing technologies and research & development in mining machinery - focus on downstream technologies for South Africa.
2	*Research & Innovation:* Joint financing models/programs (Australia examples + good European practices). Bilateral funding arrangements.	*Industry & Trade:* Efficient use of raw materials and substitution.	*Research & Innovation:* Multilateral availability of geoscientific data.	*Industry & Trade:* Available, high quality geoscience data.	*Research & Innovation:* Deep underground mining. Skills, expertise, techniques etc.
3	*Education & Outreach:* Clusters/collaboration between universities on mining education.	*Recycling & Substitution:* Successful and integrated waste management Circular economy (product life extension).	*Research & Innovation:* Boosting the private R&D sector	*Industry & Trade:* Coordinated approach for I&T raw materials development.	*Recycling & Substitution:* Post mining landscape - looking beyond mining closure.
4	*Recycling & Substitution:* Recycling initiative, research and technologies.	*Education & Outreach:* International education ties.	*Industry & Trade:* Approaches for aging workforce and workforce diversity.	*Education & Outreach:* Communicating to the Public/Policy makers.	*Research & Innovation:* Mineral exploration and geological mapping - capacity and policies.

After the workshop a follow-up e-mail was send out to the participant to collect ideas to further specify the identified opportunities. The received feedback and suggestions were then used to refine the drafted cooperation agendas (Chapter 4) and to make country-specific recommendations that can be found in chapter 5.2 Cooperation opportunities at bilateral and multilateral level: additional suggestions & recommendations

3.4 Outcome of the exercise

The outcome of the first part of the exercise, aimed at identifying cross-cutting synergies, resulted in a total of eight portfolios of actions. The actions from the four Actions Plans (D2.3, D2.4, D2.5, and D2.6) where grouped in a way that they cover similar themes and work towards a common goal or agenda related to the raw materials sector's development. When these cross-cutting groups of actions are implemented simultaneously or consecutively, their effectivity is enhanced, hence creating synergy.

In addition, the Cooperation Agendas were designed to be 'future proof', with the majority (>80%) of the actions being robust in at least two future scenarios. During the workshop with the reference country experts in Brussels, the Cooperation Agendas were fine-tuned, and their level of relevance was evaluated for all bilateral cooperation scenarios between the EU and the reference countries (*Table 5*). The Cooperation Agendas contain recommendation that were condensed from the four Actions Plans (D2.3, D2.4, D2.5, and D2.6), tested in several future scenarios, and could serve as a strategic baseline for continuing cooperation with the reference countries. The 8 Cooperation Agendas resulting from the work developed in Work Package 2 are as follows:

- Cooperation Agenda 1: International Raw Materials Data Platform
- Cooperation Agenda 2: Securing raw materials supply
- Cooperation Agenda 3: Stabilising workforce
- Cooperation Agenda 4: Interdisciplinary approaches
- Cooperation Agenda 5: Encouraging investment
- Cooperation Agenda 6: Technological innovation
- Cooperation Agenda 7: Policies and frameworks
- Cooperation Agenda 8: Multilateral agreements

Table 5: The level of relevance of the 8 Cooperation Agendas for EU-Reference Country bilateral cooperation. The most relevant Agendas for each country are marked in green.

		Australia	*Japan*	*Canada*	*USA*	*RSA*
1	*Data*	2	3	3	3	2
2	*Supply*	2	3	1	3	1
3	*Workforce*	3	3	3	3	3
4	*Interdisciplinary*	3	3	3	2	2
5	*Investment*	2	2	3	2	3
6	*Technology*	3	3	3	2	3
7	*Policies*	2	2	2	3	2
8	*Agreements*	2	2	2	3	2

The Cooperation Agendas are introduced in detail and evaluated in the next Chapter.

4. CROSS-CUTTING SYNERGIES

The eight Cooperation Agendas are described and analysed below. This extended analysis includes the actions that together could form a Cooperation Agenda, their added value when implemented synergistically, as well as an assessment of the constraints and gaps that are relevant to consider for their implementation. Cooperation Agendas are described together with a description of the involved actions and their effects and a 5-step plan on how to implement the agenda and the relevance of the particular Agenda for the selected reference countries. The relation with the strategic goals mapped in D2.1 (Strategic plan for international knowledge-sharing) and the future scenarios for the raw materials sector, developed by the INTRAW project is also described.

A relevant analysis on the implementation of the different Cooperation Agendas and further recommendations related to them are done in both the Discussion (Expected results of the synergetic approach to INTRAW actions) and Recommendations chapters.

The cooperation agendas are listed in order from being more general and broad topics, that serve as a basis, to the more specific topics.

4.1 Cooperation Agenda 1: International Raw Materials Data Platform

Actions	R&I 1.1, R&I 2.6, R&I 2.7 E&O 7.2 I&T 2.1, I&T 2.2, I&T 3.3, I&T 3.4, I&T 3.5, I&T 4.2, I&T 4.3 R&S 1.1, R&S 1.2, R&S 3.1, R&S 3.2, R&S 3.4, R&S 4.3
Added value	Data is more valuable when it is accessible internationally in a uniform way
Constraints	Cooperation Agenda 7 and 8: A legal framework and agreements should be in place for all parties to be able to participate
Gap	Data on substitution, recycling and secondary raw materials are still separate from the primary raw material chain
Related to	Cooperation Agenda 2 - Securing raw material supply Cooperation Agenda 5 - Encouraging investment
Reference Country	Canada USA

Description

All Action Plans identify the need for more coherent and openly available data on all areas of the raw materials value chain, but most notably on exploration, trade and recycling. Clear and accessible information on raw materials is the basis to support policy decisions, financial investments and helps to identify opportunities in research and innovation. As the raw materials chain is part of a continuous and circular flow it is important to make sure that databases are created in a compatible manner, so databases can be combined and incorporated into each other at a later stage. Currently, data is either absent or only available in a scattered manner, making it hard to get a complete overview and make informed decisions at an international, national or even local level. About a quarter of the actions mentioned in the action plans address this issue in some way, indicative that this topic is cross-cutting and of high priority.

A first step, as indicated in actions R&I 2.6, R&I 2.7 and R&S 3.4, is to examine how existing databases can be unified and interconnected. This is an ongoing process taking place at several levels already, but needs to be further expanded and enhanced. Action I&T 4.3 mentions Big Data as a major challenge of the 4th Industrial revolution in mining companies, and this topic can be extended to all other aspects of the raw materials value chain as well.

A specific data need was identified (actions R&I 2.6, I&T 2.1, I&T 3.4 and I&T 3.5) for information that will support exploration, including both geoscientific data and information on permitting, fiscal and environmental legislations. The aim is to promote the exploration potential and boost investment (see Cooperation Agenda 5 - Encouraging investment). As suggested in action I&T 3.1, this could eventually lead to a database where specific investment opportunities can be promoted with a direct link to the available exploration data and administrative and legal requirements involved, making all the important information about exploration interconnected.

Actions I&T 2.2 and I&T 3.3 suggest gathering strategic information on the global mineral resources industry, on trade barriers, market drivers, recycling, trade flows, among others, and to create an international platform for track permitting and trade. In addition, action E&O 7.2 proposes to monitor and promote co-operation opportunities for raw materials' supply and provide intelligence on international trends, opportunities and risks. At the end of the resource value chain, action R&I 1.1 requests more accurate estimations of raw materials use in products and technologies.

Actions I&T 4.2, R&S 1.1, R&S 1.2, R&S 3.1, and R&S 4.3 call for a similar sequence of actions as identified above, focused on the recycling industry, namely; unifying and sharing the currently available data, creating new databases on secondary resources and mining waste and mapping the capabilities of recyclers. The overall impact could be higher if these actions are not isolated and focused on recycling and secondary resources only, but if the resulting databases can be linked to and integrated with the primary resource flows. However, where the primary resource industry looks to unify their databases on an international level, for secondary resources this is often not even implemented on a national level yet. The EU can play a leading role in this and lessons learnt from many EU projects, such as ProSUM, SMART GROUND and NewInnoNet could be shared with international partner countries.

Ideally, the resource numbers produced by mining and input from recycling should match those that are traded and subsequently incorporated in products and technology. Such global international raw materials data platform could be created and subsequently operated jointly with relevant target countries, in particular Japan, Canada and the US. Serving both industry and policy makers as it will help to timely identify potential bottlenecks like undersupply of raw materials compared to the demand for products. Once the current raw material streams are mapped, the next challenge is to identify future demand with emerging technologies and mitigate supply risks (see Cooperation Agenda 2 Securing raw material supply).

European institutions are already actively working on mineral intelligence systems. The European Union Raw Materials Knowledge Base (EURMKB, part of EIP SIP[18]) and the JRC Raw Materials Information System are already operational and could potentially serve as a basis for this work.

[18] https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/content/strategic-implementation-plan-sip-0

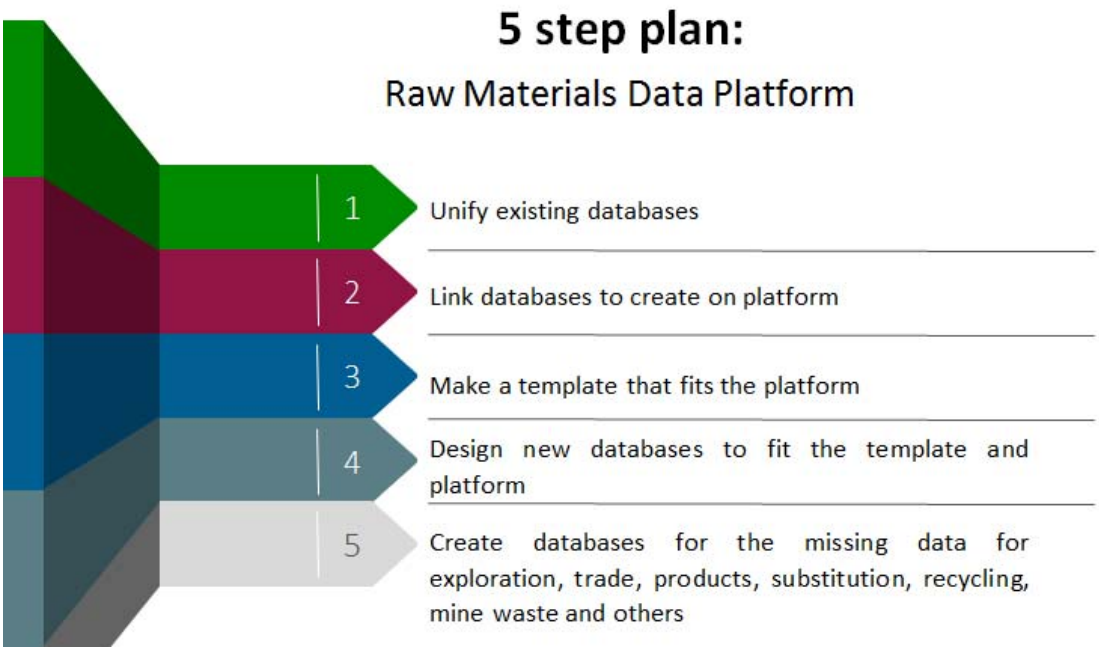


Figure 23: Cooperation Agenda 1 - Raw Materials Data Platform: 5 step plan.

Alignment with strategic goals, future scenarios and Reference Country priorities

A major challenge for this Cooperation Agenda is that full cooperation between all the involved parties is needed to optimize efficiency that requires frameworks, agreements and reciprocity between the parties. A challenge unrelated to the future scenarios is the amount of complex data to be collected and shared in a clear way. Big data is a globally emerging issue and much effort is currently being put into new procedures and technologies to handle this challenge. Collaboration with big data specialists with the most up-to-date techniques to work on a Raw Materials Data Platform should significantly reduce difficulties related to structure and amount of data.

The OECD already provides a tool selector for substitution, but this database has a focus on chemical substances and their related health threats (http://www.oecdsaatoolbox.org/). A database proposing and tracking successful substitution of toxic, scarce, or conflict raw materials in products and technology worldwide could be a useful addition to a Raw Materials Data Platform to be used by industry, research and policy makers alike.

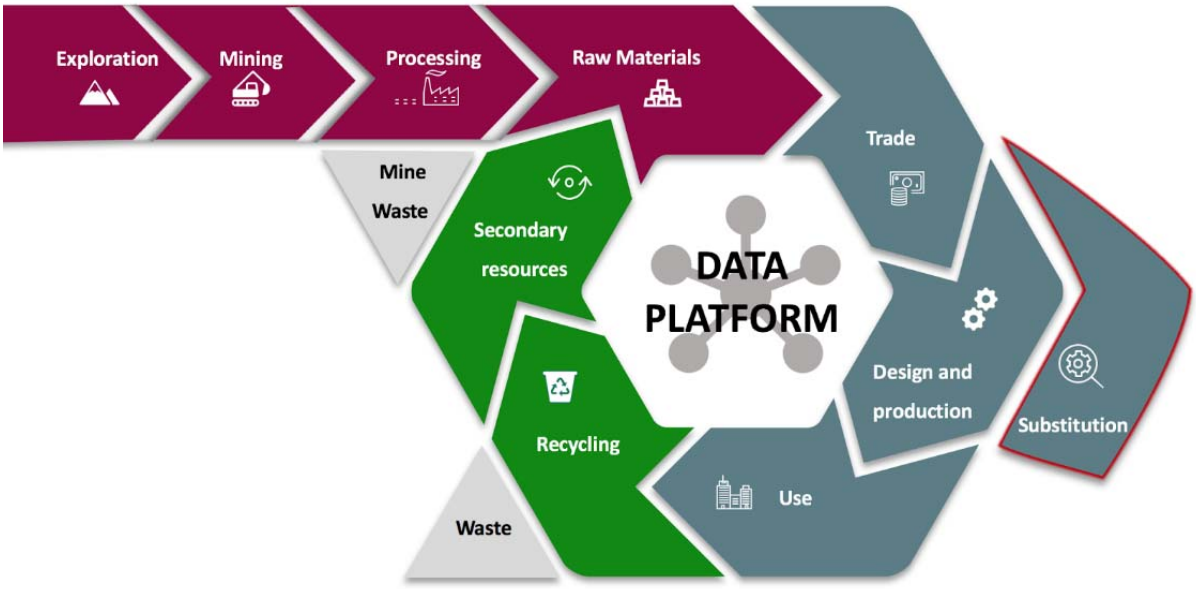


Figure 24: Cooperation Agenda 1 - Raw Materials Data Platform.

This cooperation agenda is deemed to be highly relevant for EU-Canada cooperation and was identified as one of the top 3 cooperation opportunities by the Canadian experts during the workshop in Brussels. Both the EU and Canada could benefit from more widely available geoscientific and more transparent regulatory information.

Cooperation on a standardised, openly available data platform is also highly relevant between the EU-USA. The cooperation measures could start with the establishment of a consistent baseline data, metadata, and data formats for production, demand, resource estimates, etc. These actions would advance the idea of a globally shared data platform to provide a transparent raw materials development beyond just the current USGS and spare industry trade data.

4.2 Cooperation Agenda 2: Securing raw materials supply

Actions	R&I 1.1, R&I 5.5 E&O 3.1, E&O 7.1, E&O 8.1 I&T 1.2, I&T 1.3, I&T 2.1, I&T 4.5, I&T 5.1 R&S 3.1, R&S 4.1
Added value	Minimize supply risks by a combination of actions focussing on a stable raw material input, trade and recycling
Constraints	National walls scenario, resource nationalism, lack of cooperation, conflict minerals, changing raw material needs (mine cycle vs industry needs), new CRMs
Support	Raw Materials Initiative (1. Fair and sustainable supply of raw materials from global markets; 2. Sustainable supply of raw materials within the EU; 3. Resource efficiency and supply of "secondary raw materials" through recycling) and the EIP on Raw materials activities), EIP on raw materials, DG Grow, RM industry
Related to	Cooperation Agenda 1: Raw Materials Data Platform Cooperation Agenda 3: Stabilising workforce

	Cooperation Agenda 6: Technological innovation Cooperation Agenda 7: Policies and frameworks Cooperation Agenda 8: Multilateral agreements
Reference Country	Japan United States

Description

Directly or indirectly, all actions identified in INTRAW support a common vision, which is reliable and unhindered mineral raw materials supply for the EU. Within this Cooperation Agenda, the actions that are listed directly present additional value, when implemented together, to secure the raw materials supply (*Figure 25*). The European Commission created the Raw Materials Initiative (RMI) and the EIP on Raw Materials to secure RM supply for the EU. The RMI defines three pillars: 1) Sustainable supply of raw materials within the EU; 2) fair and sustainable supply of raw materials from global markets; 3) Resource efficiency and supply of "secondary raw materials" through recycling. The synergetic behaviour of the following actions is closely investigated in relation to these three pillars.

Figure 25: Cooperation Agenda 2 - Securing EU Raw Material Supply.

To secure raw materials supply for the EU industry, the European Commission planned targeted measures to promote investment in extractive industries in Europe, through the following topics: Exchange of best practices; Good practice report; Guidelines on extraction; National minerals policy indicators; Knowledge base; Research and innovation. Actions that directly support RM supply from the EU market can be divided into two action lines: delivering skilled workforce for future EU mining activities and direct promotion of the European mineral industry. On the first action line, actions E&O 3.1 and E&O 8.1 address the challenge that translate into qualified staff being needed for a sustainable EU RM supply. Action E&O 3.1 identifies key players in the RM industry and maps their educational requirements. Action E&O 8.1 also contributes to the skilled European workforce by developing workforce plans, based on RC best practices experience, and use it to develop models for employment, skills requirements, training, redeployment, upskilling and cost control through RM commodity cycles. Based on this knowledge the EU can tailor its education system to provide skilled workforce to the EU RM industry, satisfying the skilled workforce need for the future of the sector.

Cooperation Agenda 3, Stabilising workforce, also supports this action line, however on a broader scale.

With the second action line, and with actions R&I 5.5, I&T 1.3, I&T 2.1, I&T 5.1, the European RM production benefits from direct support for the mineral industry to boost production. First, action I&T 2.1 suggests creating large scale exploration campaigns on European territory for a clear vision of the EU geo-economic potential. This initiative aims to discover and map new deposits, ready to be exploited as European RM need demands it. However, technological development may be required to these newer, some of them unconventional, deposits, which is supported by actions R&I 5.5 and I&T 5.1. These actions challenge the mining technology status quo by integrating new technological elements from other industries into the mining sector and developing new ones to access ultra-deep deposits. Cooperation Agenda 6 (Technological innovation) is closely linked with these actions. Furthermore, action I&T 1.3 addresses one more critical issue for securing European RM supply: Resource Nationalism. This action aims to identify a policy to develop cooperation rather than aggressive competition between individual EU nations, so the implementation of the initiatives mentioned above is secured. Having qualified workforce in Europe with clear geological knowledge on the EU territory, coupled high tech mineral industry and cooperative internal trade creates an attractive European environment to boost current production and to start new mining activities, to provide RM to the EU community from internal sources.

The EC has already worked out a Raw Materials Diplomacy framework to realise a fair and transparent global raw materials market. Action E&O 7.1 addresses the need for skilled trade officers to stabilise trade supply from global sources. It aims to create educational, briefing and outreach materials, and opportunities to educate staff and stakeholders responsible for EU RM source from trade. Besides skilled trade officers, the EU also needs well established bilateral and multilateral agreements with the RC countries and other RM producing countries. Promotion of cooperation, at any level, enables the EU to secure its strategic partners for future trade collaboration. This line is addressed in Cooperation Agenda 8, Multilateral agreements and further cooperation. Adding a harmonized stockpiling scheme (action I&T 1.2) element to the system, would help to avoid supply shortages, especially in the short term.

The Commission promotes resource efficiency through recycling by development of best practices in collection and treatment of waste, legislation, availability of statistics, supporting R&I and promotion of reuse and recycling. Many of the actions regarding Recycling and Substitution address the issue of harmonized, accessible data on secondary raw material resources. This issue is further elaborated in Cooperation Agenda 1 - Raw Materials Data Platform. Actions R&S 1.2, R&S 3.1 and R&S 4.1 support RM supply from secondary sources synergistically. Action R&S 1.2 identifies the need for a shared recycling research infrastructure, as a baseline, not only to save time and resources, but to secure sources of secondary resources. This action also makes use of existing platforms, such as PROMETIA, NEW_InnoNet and MSP_REFRAM among others at EU level. This action prepares the way for action R&S 3.1, which propose the creation of a harmonised database on collection/classification of secondary resources. Taking stock of these resources helps to review the quality and quantity of secondary raw materials in Europe. This action also helps to remedy future RM shortages from secondary resources. Concerning the continuous management of recycling and substitution, action R&S 4.1 proposes the creation of a spin-off (Observatory) to provide technical and financial assistance to EU industry and encourage R&D on recycling and substitution activities. This organisation could further enhance the resource efficiency within Europe and secure access to high-tech minerals of strategic importance to the EU.

Identifying and monitoring future RM demand is addressed by actions R&I 1.1 and E&O 5.1. These actions indicate that monitoring and predicting future RM demand is important to avoid shortages. Several European key industries go through structural changes, yet the effect of this transition on the RM demand it often not clear. The objective of action R&I 1.1 is to provide more accurate estimations

of raw materials for current products and technologies, and for future technologies that are expected to gain importance. Implementing these actions together would allow the EU to better prepare for future RM demand and to avoid resource shortages.

Alignment with strategic goals, future scenarios and Reference Country priorities

INTRAW D2.1 (Strategic plan for international knowledge-sharing) provides a gap analysis, also addressing the EU RM supply issue. One gap that has not been addressed by any action is the diversification of mineral production in the EU. While the EU RM production covers only part of its internal demand, countries like Canada and USA have high diversification of mineral production. Addressing this issue, aligned with future demand forecast, would decrease the EU RM import dependency. Further gaps were indicated, such as complicated permitting systems, diverse legal background, land use planning, social acceptance of mining and mineral exploration, which are directly and indirectly influencing the EU RM supply. These issues were mostly covered by the action plans, however with varying consistency.

Placing this Cooperation Agenda into the EU 2050 scenario concept, one can realise that the different scenarios favour different EU RM input pillars. In the Sustainable Alliance, recycling and substitution gain special importance, leaving the other two pillars behind. Within this scenario, European production is likely to decrease, due to real/stereotypical concerns of mining activity (e.g. environmental, safety reasons). Considering the Unlimited Trade scenario, trade barriers are eliminated, therefore RM are produced wherever it is most optimal, and the consumer countries have equally trade conditions to import them. In this viewpoint, it is not important to pursue recycling and EU production, but only the global trade pillar, due to the favourable trade conditions. In the National Walls scenario, one cannot rely on trade, but must work on internal RM production and recycling/substitution, to secure resources. This will result in an increased number of European operations, however at higher environmental costs, since mining technology development is at standstill, due to lack of international cooperation.

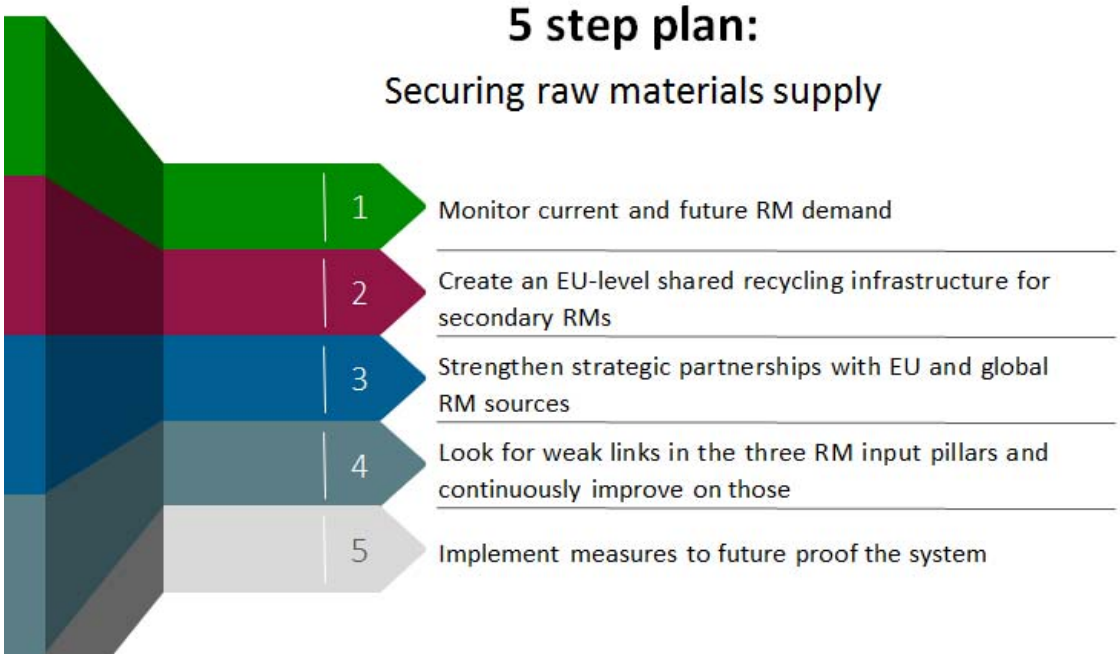


Figure 26: Cooperation Agenda 2 - Securing raw materials supply: 5 step plan.

This cooperation agenda is very suitable to expand on the ongoing EU-Japan and EU-US cooperation, as both countries face similar challenges and consider stable raw materials supply a strategic matter for national security and on the highest levels.

4.3 Cooperation Agenda 3: Stabilising workforce

Actions	R&I 3.1, R&I 3.2 E&O 1.1, E&O 2.1, E&O 3.1, E&O 3.2, E&O 3.3, E&O 3.4, E&O 3.5, E&O 4.1, E&O 4.2, E&O 5.1, E&O 5.2, E&O 6.1, E&O 6.2, E&O 8.1, E&O 9.1 R&S 5.4
Added value	A Cooperation Agenda of actions focussing on stabilising the raw materials workforce both in research and industry, preventing the loss of knowledge and skills in the RM sector
Constraints	Cooperation Agenda 7 - Policies and Frameworks. needs to be largely defined Workforce mobility will be a major challenge in the National Walls scenario
Gaps	Need for industry action and participation Need to restructure education on an EU level
Related to	Cooperation Agenda 2 - Securing raw material supply Cooperation Agenda 4 - Interdisciplinary approaches Cooperation Agenda 7 - Policies and frameworks Cooperation Agenda 8 - Multilateral agreements
Reference Country	All

Description

As identified in the Strategic Plan of D2.1 (Strategic plan for international knowledge-sharing), emigration of skilled European staff into countries and areas with larger mining activity, the loss of skills and a lack of fresh talent caused by industry downturns and the related widening generation gap are major workforce challenges in the raw materials sector. Strong implementation of actions on EU and RC level is essential to develop an employment model that is more stable and sustainable. As summarized in action E&O 8.1, the development of an EU wide workforce plan by forming synergies between actions such as matching training and educational provision with projected industry skills requirements and setting-up qualification networks; the development of models for employment through commodity cycles; and supporting workforce mobility, will all contribute to a strong and stable EU RM workforce and to a continuous uninterrupted supply of RM for the EU market (Cooperation Agenda 2 - Securing RM supply). This requires close cooperation with the RC, learning from RC experiences and best practices. Supporting skill exchange with the RC and a dialogue between industry and education is also needed.

Actions E&O 1.1, E&O 2.1 and E&O 3.1 describe the ground work needed to lay a foundation for later actions. The first steps consist of mapping the current educational landscape by identifying universities and training centres that are providing RM education (action E&O 1.1) and to list the common learning outcomes of these programs (action E&O 2.1). Subsequently, as proposed by action E&O 3.1, the

needs of key RM employers should be identified. In line with action E&O 5.1, the cooperation between industry and universities could be intensified by setting-up joint programs to ensure a better understanding of the most pressing topics. As both latter actions propose, knowledge and student exchange between the EU and RC is important to facilitate the full range of educational requirements. The above-mentioned series of actions is not only important in higher education, but also in vocational training provision in the EU and RC. Also on this level, structural differences should be identified, and joint programme schemes should be initiated. As emphasised in action E&O 3.2 it is also important to keep an eye on expected future developments and ensure continuous dialogue between industry and educational facilities to guarantee that the required skills will be sustainable in the future. This could ultimately lead to an integrated qualification and professional recognition scheme for professionals proposed as proposed in action E&O 6.1.

With a highly skilled workforce in place, the loss of knowledge-base during industry downturns and subsequent skill shortages during upturns should be prevented. Action E&O 3.3 propose that EU governments act and work with the industry to change recruitment and retention practices. This action can involve an active role by EU governments in the form of training bursaries for workers that become unemployed due to a downturn, as proposed in action E&O 3.4.

Staff mobility, between countries and regions, as well as between industry and academia or between related sectors, is another solution that can contribute to solving the issue of skill loss in downturns. As stated in the already mentioned action E&O 6.1, the development of an integrated qualification and professional recognition scheme will lead to a globally recognized skillset and will ease the transfer of staff between the EU and RC. However, as stated in action E&O 8.1, policy recommendations are required to facilitate the necessary work permits. Another requirement for international mobility is a solid knowledge of languages. For this reason, action E&O 4.2 aim to surpass the language barrier by implementing English, French and Spanish languages within vocational mining training programmes. Action E&O 3.2 calls for new exchange programmes with the Reference Countries to facilitate the exchange of research. In extension to these actions, R&S 5.4 proposes to establish researcher mobility programmes with Japan and the USA specifically on the topic of substitution of critical raw materials.

Staff movement can also take place between different sectors. Action R&I 3.1 calls for career schemes for young professionals where cooperation schemes for industry and research should be closely aligned. Then, action 3.5 proposes to improve the exchange between working in industry on one side and in education and research on the other. It is important that experts working in industry can easily return to academia and education to guide and mentor the future RM workforce generation. Finally, action E&O 6.2 proposes, to ease the transition between the stable quarrying and the volatile mining sector, by integrating quarrying and mining education and training in one certification.

Lastly, to ensure a sustainable supply of qualified graduates, it is proposed by actions E&O 5.2 and E&O 9.1, that raw materials and geosciences are promoted as an exciting career opportunity in primary and secondary schools.

Figure 27: Cooperation Agenda 3 - Stabilize Workforce.

Alignment with strategic goals, future scenarios and Reference Country priorities

The main potential issue regarding this Cooperation Agenda is the need for cooperation, not only between the EU and the RC, but also within EU countries themselves and between several sectors that currently largely operate in parallel. Workforce is the cornerstone of industry and although no I&T actions directly identified the need to contribute to the development of the workforce, it is obvious that a strong contribution from industry is needed to make the proposed educational shifts possible. In addition, setting-up international agreements and frameworks (Cooperation Agenda 7 and Cooperation Agenda 8) are essential to facilitate exchange programmes, and would be the base of further educational development. This vision could easily be disrupted in the case of the National Walls scenario, where the establishment of agreements and frameworks at international level would be almost non-existent.

An issue identified in D2.1 (Strategic plan for international knowledge-sharing), but not addressed by any of the actions, is the problem of the relatively very high number of EU universities that provide RM education in their curriculum. The result is a scattered and heterogeneous knowledge and thus, first efforts should be made to structure the programmes within the EU itself before attempts are made to do this on a global level.

There is a risk, however, of losing diversity and specialisation of knowledge following the creation of integrated qualification and more rigid education requirements. To ensure a workforce with a diverse skillset, an interdisciplinary approach with possible cooperation with other sectors, for instance the raw materials life cycle, should not be left apart (see Cooperation Agenda 4 on interdisciplinary approaches). This will also increase researchers' mobility in case of abrupt changes in the extractive industry.

With the ever-growing lack of easily accessible and feasible exploration and exploitation scenarios, the raw materials and mining sector are rapidly shaping into the "mine of the future" concept, trying to become more reliable and environmentally aware than it has been in past generations. To keep up with present and future technical developments and new policies and frameworks, universities and training centres need to focus in creating an educative framework that can shift with the demands of

an ever-changing industry. This requires a strong investment in education and international cooperation, as well as avant-garde research and implementation of policies.

As a mature, developed country, Australia is facing a loss of skills and aging population, which is affecting the raw materials workforce in both research and industry, with corresponding loss of knowledge and skills throughout the minerals value chain. It is necessary to invert this tendency as much in Australia as in the EU.

Also for EU-Canada cooperation, this theme was identified as one of the top 3 cooperation opportunities by the Canadian experts during the workshop in Brussels. Canada faces issues with an aging workforce and needs to recruit and retain talent.

"Greying" workforce is an issue for both the EU and the USA, however skilled workforce is a common strength. Producing global raw materials and mining workforce would give a clear picture on a current mineral industry Human Resources landscape. This assessment would show the ability of institutions to provide skilled workers to meet industry demands and would help to tackle common weaknesses and benefit common strengths.

South Africa does produce a highly skilled and young workforce. However, a substantial portion of graduates leaves the country to work abroad (brain drain).

Figure 28: Cooperation Agenda 3 - Stabilising workforce: 5 step plan.

4.4 Cooperation Agenda 4: Interdisciplinary approaches

Actions	R&I 2.3, R&I 2.4, R&I 2.7, R&I 3.1, R&I 3.2, R&I 4.1, R&I 5.1, R&I 5.5 E&O 1.1, E&O 3.1, E&O 3.2, E&O 5.1, E&O 7.2 I&T 5.2 R&S 4.2, R&S 4.5, R&S 4.6

Added value	Improve channels for interdisciplinary research in raw materials with a special focus on recycling. Foster, in the EU and with the reference countries, research initiatives holding an integral approach to the raw materials value chain, framed by sustainable practices and Circular Economy.
Gaps	Need to improve exchange between research and industry Diversification of EU mineral resources is desired
Constraints	Reduced potential for international cooperation (National Walls Scenario) Constrained access to novel practices and technologies
Related to	Cooperation Agenda 6 - Technological innovation Cooperation Agenda 8 - Multilateral agreements
Reference Country	Australia Canada USA

The Raw Materials Initiative (2008) identified a wide range of constraints and challenges to be overcome in the EU when it comes to raw materials – from market conditions and supply availability to changing patterns of consumption highlighting the need for more sustainable practices and technical and political challenges to access mineral raw materials' sources. These are pressing points towards more interdisciplinary and holistic approaches for the future of raw materials supply in the EU. Throughout the different action fields various gaps were identified and addressed through the action plans in that sense. Cooperation Agenda 4 "Interdisciplinary approaches" identifies converging points and emphasises the need for acknowledging interdisciplinary approaches with a strong potential to yield greater benefit for the sector, supporting a more synergistic implementation of the related actions.

Based on the action plans and respective actions, Cooperation Agenda 4 is built on 4 main components (*Figure 28*):

- Research;
- Joint Programmes;
- Networking;
- Supporting activities.

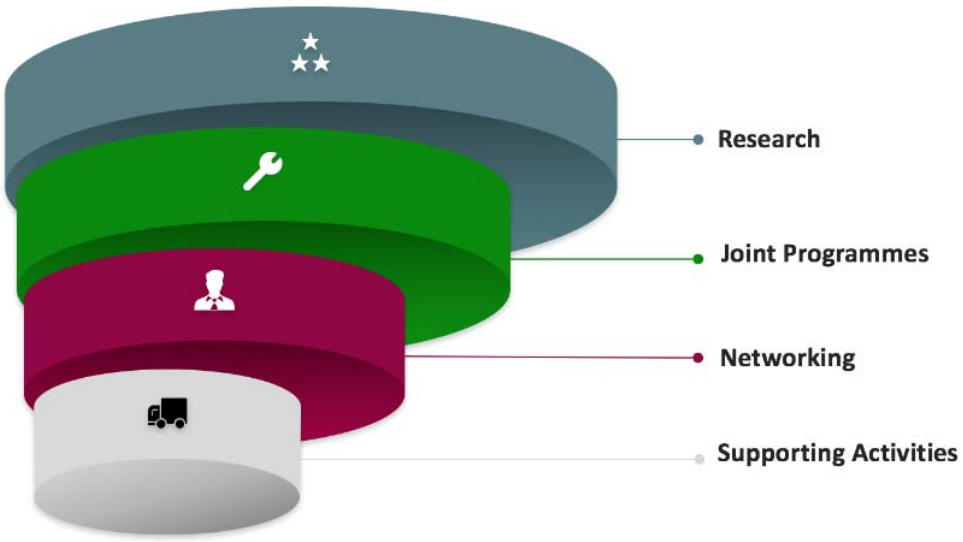


Figure 29: Cooperation Agenda 4 - Interdisciplinary approaches.

Regarding Research & Innovation actions, there is a clear focus on mapping, evaluating and prioritising research areas in the EU and the RC (R&I 2.4, R&I 3.1 and R&I 4.1). The targeting of interdisciplinary topics can be integrated to such assessments. For instance, the principle of reciprocity (R&I 2.7) can facilitate the identification of strategic interdisciplinary research areas. Supporting activities can also improve research identification and evaluation. Extending this assessment to universities, training centres (E&O 1.1) and key players in the industry and identifying their requirements (E&O 3.1), as well as working groups addressing research potential in the e.g. 'mine of the future' employment models can enhance the capacity of interdisciplinary integration to a wide variety of relevant actors.

Such approaches can serve as a basis for adapting interdisciplinary research potential and priorities into (joint) programmes within the EU itself, and between the EU and RC in bilateral and multilateral agreements (see Cooperation Agenda 8 - Multilateral agreements and further cooperation). The creation of programmes related to Circular Economy (E&O 7.2) and recycling (R&S 4.2 and R&S 4.6) are particularly appealing in that sense, as the former inherently entails multi-disciplinary concepts and the latter, in order to be increasingly acknowledged, requires interdisciplinary approaches – from product design and technology integration to substitution as a function of a variety of factors. Existing programmes can be expanded (R&I 2.3 and R&I 3.2) also qualitatively by integrating other disciplines deemed relevant and with a potential to improve the scope of the raw materials existing programmes. The mapping and evaluation of research topics previously mentioned would have a supporting role to such implementation.

Notwithstanding, fostering networking hubs with interdisciplinary background can also boost the implementation of interdisciplinary research synergies. Actions targeting general (E&O 5.1) and specific interdisciplinary topics such as integration of technologies (R&I 5.5 and I&T 5.2) and recycling (R&S 4.5) can facilitate identification and matchmaking through networking events and workshops, improving necessary interlinkages between different disciplines and attracting necessary investment to enable further implementation. Intermediary organisations (R&I 5.1) can better structure and support this process.

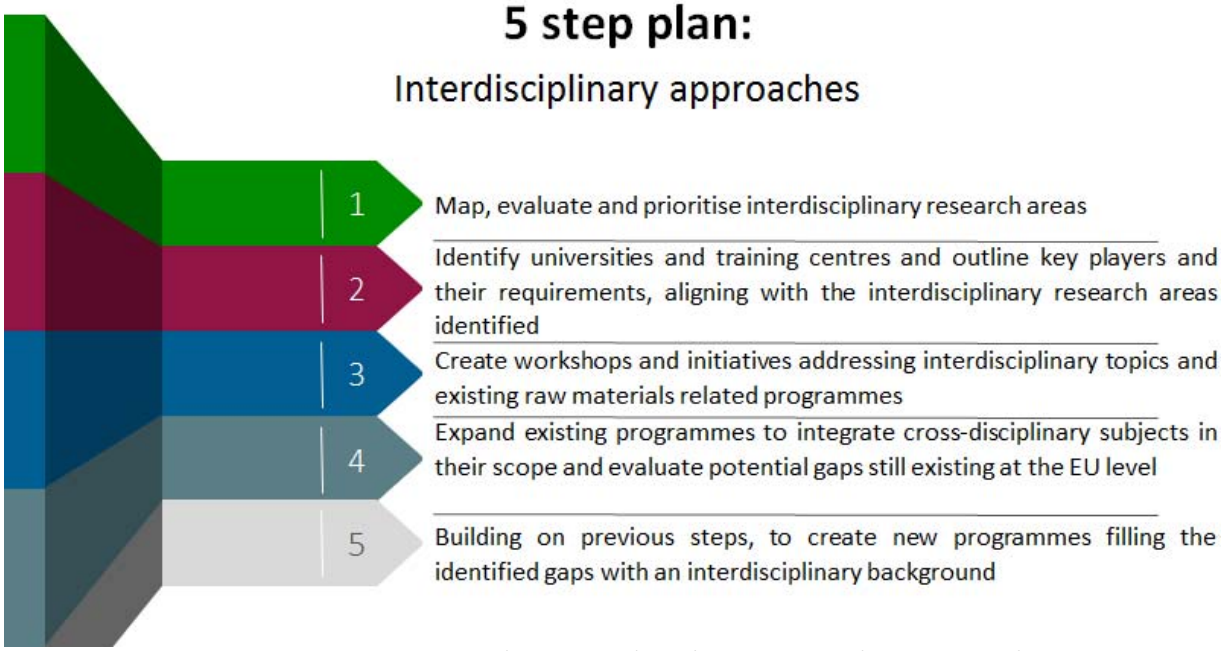


Figure 30: Cooperation Agenda 4 - Interdisciplinary approaches: 5 step plan.

Alignment with strategic goals, future scenarios and Reference Country priorities

As identified in the Strategic plan for international knowledge-sharing (D2.1), promising initial research results are rarely translated to industrial actions. Following the example of the RC, a more integral long-term strategy should be developed to improve the application of new developments and innovation.

Another problem identified in the Strategic Plan (D2.1) is the EU's lack of diversification of mineral production compared to the RC. A more holistic strategy for the extractive and the recycling industries, focusing on the full range of minerals, would benefit the EU and additional actions could be developed accordingly.

Interdisciplinary research relies strongly on international cooperation, advancing of research schemes and educational programmes, and investment in new practices and technologies. In all future scenarios, interdisciplinary approaches can be mapped, evaluated and prioritised accordingly. The different scenarios might change the drivers of interdisciplinary research, but not obstruct it entirely. For instance, a National Walls scenario might press for interdisciplinary solutions to compensate the lack of access to multilateral cooperation and foreign resources, whereas a Sustainability Alliance scenario would set more normative directions for research. Less constrained scenarios such as Unlimited Trade can pose a more promising environment for fully-fledged interdisciplinary research implementation. It can be said, thus, that different futures might present different drivers and impacts on the degree of outreach of interdisciplinary research. However, in any case, such synergy would remain of significant importance and should be accounted for as to implement robust actions that can respond in a timely and concrete manner to the different futures and challenges.

Although Australia is rich in minerals, it lacks skills and integration in other areas of the raw materials sector, like recycling and substitution, which are becoming important global trends. Cooperation with the EU in this aspect would be very beneficial by filling the gap with knowledge on those fields. This cooperation agenda could also be implemented for Canada as in general their current approach is

one-sided resource market driven, and recycling, product design or substitution are not optimal integrated yet.

Collaboration between different sectors, in particular industry and universities, has been identified by the Experts as a critical success factor. The USA and the EU could both benefit in adopting interdisciplinary approaches and frame their actions considering multiple domains. This would require the recognition that the breadth of raw materials or mining capabilities is spread across universities in different countries and that research investments must be framed with that borderless view. Another cooperation measure could be the establishment of multi-national research priorities among the raw materials industrial sector to identify the critical research challenges, on which the universities can focus on.

4.5 Cooperation Agenda 5: Encouraging investment

Actions	R&I 2.6, R&I 5.4 I&T 2.1, I&T 3.1, I&T 3.2, I&T 3.4, I&T 3.5, I&T 4.1, I&T 4.2
Added value	The implementation of actions in a coordinated manner as to generate maximum investment interest from companies in the raw materials sector.
Constraints	Social license to operate This Cooperation Agenda could only reach its maximum potential if implemented jointly with Cooperation Agenda 7 - Policies and frameworks and Cooperation Agenda 1 – International raw materials data platform.
Gaps	Lack of active presence of multinational RM companies in the EU Lack of EU RM stock exchange and related quality guarantees Lack of recent geological data for exploration
Relates to	Cooperation Agenda 1 – International raw materials data platform Cooperation Agenda 2 – Securing Raw Material Supply Cooperation Agenda 6 - Technological innovation Cooperation Agenda 7 - Policies and frameworks
Reference Country	Canada USA South Africa

Description

Investment is a main driver for innovation, and economic growth and is a key element to a strong and successful raw materials sector. Several actions aim to boost investment into the raw materials industry and propose several ways to achieve this. The alignment and order of implementation of these actions is crucial to ensure a maximum impact. Roughly, the action plans propose three ways to increase investors' interest, related to enhancing legal and fiscal policies, improving data availability and providing networking opportunities. This would also be the best working order to attract investment to the European raw materials sector.

Actions R&I 5.4 and I&T 3.4 address the need for improved legal and fiscal agreements as a primary condition to increase EU's attractiveness to investors. Action R&I 5.4 proposes that EU fiscal models for the mining industry should be adjusted with investment policies in Canada and Australia used as benchmark, as these countries are leaders in generating (inter)national investment interest into both

exploration and mining. Action I&T 4.1 proposes even further adjustments by promoting the best practices in business models and technological solutions from these countries. Action I&T 3.4 also asks for clarity in fiscal and environmental, legal and land use regulatory regimes. This action advocates for a transparent EU-wide mineral tenement and permitting system based on the example of two of the leading European mining countries Ireland and Finland, with a clear online interface.

Actions R&I 2.6 and I&T 2.1, I&T 3.1, I&T 3.4, I&T 3.5 and I&T 4.2 all aim to increase investment interest by means of improving data availability. As such, these actions are also part of Cooperation Agenda 1 - Raw Materials Data Platform. Actions R&I 2.6, I&T 2.1 and I&T 3.4 focus on data availability for the exploration industry and call for a EU-wide uniform exploration platform. Action I&T 3.5 proposes targeted research investment to enhance exploration, mining and mineral processing methodology, to make the EU a leader in raw materials technology (see Cooperation Agenda 6 - Technological innovation) and expand the inventory of EU deposits. This will indirectly also lead to an increased investment interest for businesses, by enabling new production possibilities for mining companies. A more direct way to rise investment interest is proposed in action I&T 3.1, where a database covering specific investment opportunities is proposed with a direct link to the available exploration data and administrative and legal requirements involved. As mentioned before, action I&T 4.2 aims to promote investment in the recycling industry by enhancing data availability. As the EU mineral endowment is limited and many regions know strong land use conflicts, the latter might turn out to be a key component for future investment strategies.

Finally, action I&T 3.2, similar to action E&O 7.1, addresses the need to inform and educate diplomats and trade commissioners on the topic of mineral raw materials, so they can be equipped with specific mineral resources negotiating competences. This will result in improved industry cooperation, growth and improvement of bilateral and multilateral agreements (see Cooperation Agenda 8 - Multilateral agreements) and hence increased investment attractivity. The E&O action also touches on increasing mining industry networking and cooperation opportunities in the EU, as also discussed in action I&T 3.1. The latter aims for an increased participation of European entities in global events related to raw materials.

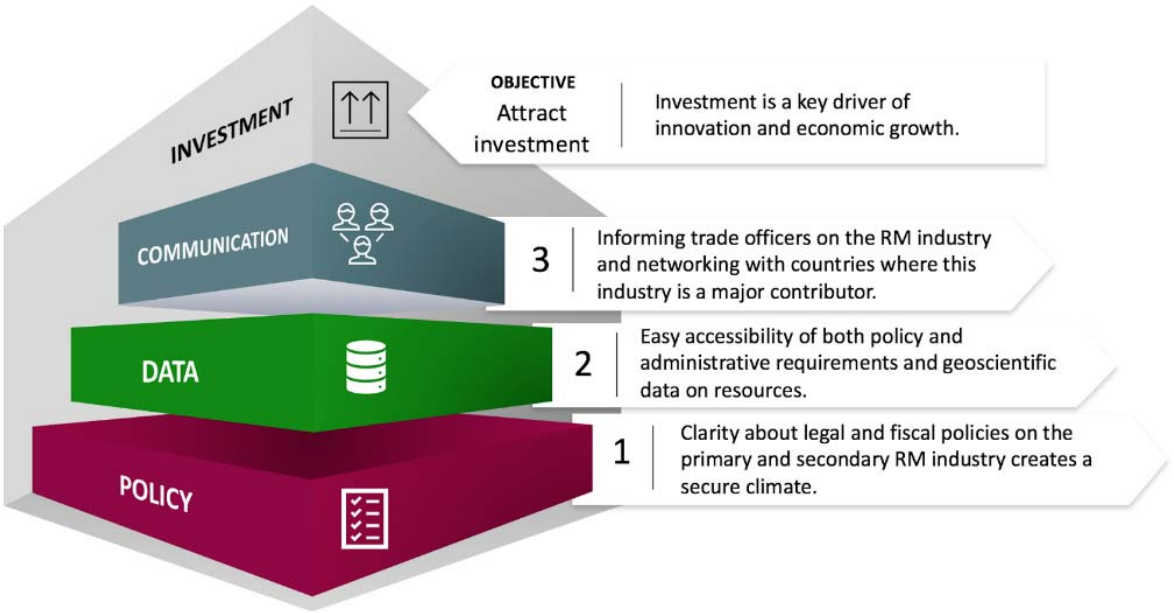


Figure 31: Cooperation Agenda 5 - Encouraging investment.

Alignment with strategic goals, future scenarios and Reference Country priorities

Investment is crucial and feasible in all scenarios. The actions are well aligned to the current situation and fit best to an Unlimited Trade future. Further unidentified opportunities to attract investment may also exist in a Sustainable Alliance scenario, where for instance there might arise a lot of interest for investment in (research on) innovative sustainable technologies in both primary and secondary raw materials production.

Mineral exploration stands at the base of increasing EU mining activity which is one of the pillars of the RMI (Cooperation Agenda 2 – Securing Raw Material Supply) and currently, mineral exploration in the EU lags compared to the RC. The action plans address the strategic goal of increasing mineral exploration activity in a well-organised manner. As identified in the country analyses (D1.2) and strategic plan for international knowledge-sharing (D2.1) the governments of the leading RC strongly support activities and programmes with the objective to obtain increased understanding on mineral deposits and geological setting. The actions referred in the action plans are more focused on synthesising existing data, where it is equally (or even more) important to keep generating current information and it is highly recommended that the European Commission invests in data collection (big scale geological mapping, geophysics and geochemical programs) by geological surveys as suggested by action I&T 2.1. There is an identified absence of major multinational mining companies in Europe (D2.1) and new data might further convince these entities to fund work programmes and innovative research on mining opportunities in Europe.

One further possible enhancement, is to act on the role of stock exchanges to finance the mining industry as identified during the gap analysis and described in the Strategic Plan (D2.1). Public listing ensures strong quality control and assurance in exploration and mine development through the compulsory uniform reporting systems. Enforcing a uniform European reporting system would make operations much more transparent and credible and might motivate exploration and mining corporations to prioritize Europe as their preferred work location.

As EU mineral endowment is limited and many regions know strong land use conflicts, recycling might turn out to be a key component for future investment strategies.

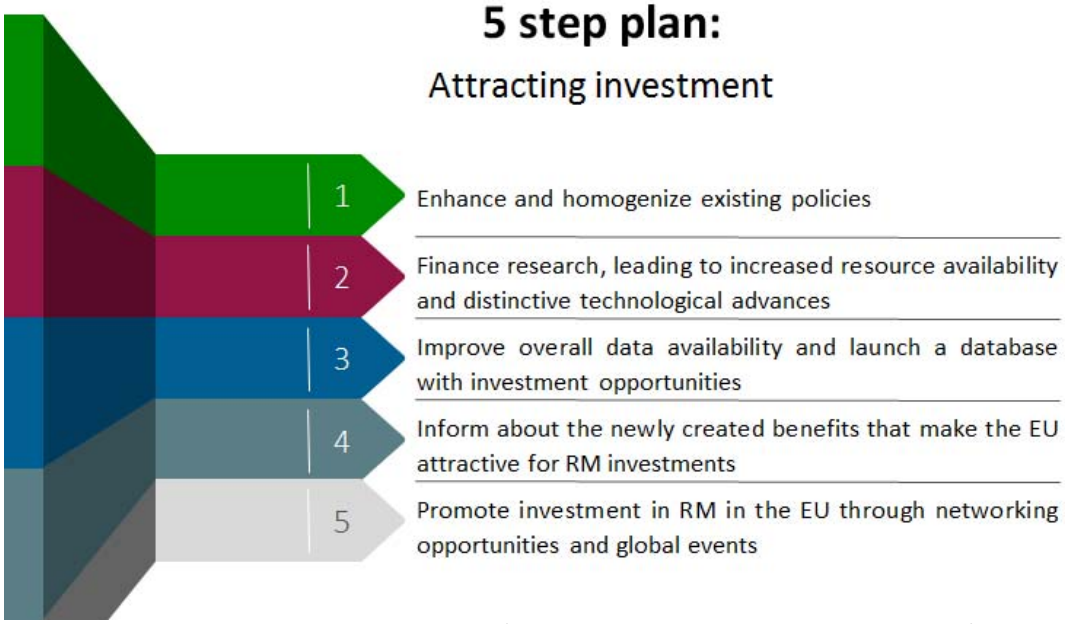


Figure 32: Cooperation Agenda 5 - Encouraging investment: 5 step plan.

This cooperation agenda could drive EU-Canada cooperation, capitalising on the Canadian experience with its' optimal investor climate due to data availability and government incentives. If the EU could develop a portfolio of similar measures to attract investment, Canadian and European companies can both benefit from the increased investment certainty in the EU raw materials sector.

With regards to EU-USA cooperation financial tools shall be framed in a multidisciplinary, but coordinated way. This can start with identification and establishment of funding schemes by private industry, Venture Capital, and government agencies to support research across sectors and countries.

South Africa would also like see an increased investment particularly in its exploration sector. Current exploration investments in South Africa are in a low and initiatives for reducing risks by generating better exploration techniques and practices can turn investors again into business. A combination of government incentives with the introduction of new techniques for mapping and assessing the geology and the mineral resources potential as well as providing sufficient data would help boost investments in exploration activities.

4.6 Cooperation Agenda 6: Technological innovation

Actions	R&I 5.5 I&T 4.4, I&T 4.5, I&T 5.1, I&T 5.2 R&S 5.4
Added value	Innovative and disruptive ideas tend to emerge in cooperative settings. Better coordination of existing and potential initiatives can enhance the efficiency and effectiveness of technological innovations for the EU and RF.
Constraints	Cooperation Agendas 1, 5 and 7 are key enablers to set a fruitful environment for technological innovation. Different future scenarios can set different constraints and incentives to technological innovation.
Gaps	Shared knowledge platforms and research infrastructure
Relates to	Cooperation Agenda 2: Securing raw materials supply Cooperation Agenda 3: Stabilising workforce Cooperation Agenda 4: Interdisciplinary approach Cooperation Agenda 5: Encouraging investment Cooperation Agenda 7: Policies and frameworks Cooperation Agenda 8: Multilateral agreements
Reference Country	All

Description

Innovation can be defined as the introduction of something new, e.g. a product or a process, that leads to the creation of social and economic value. Thus, it is primarily driven by economic motives and typically of induced nature. The Innovation System concept, with its focus on the flow of technology and information among people and organisations, and the interaction between these actors, is key to setting a framework of synergistic implementation for technological innovation. In the technology sense, it can be defined as a dynamic network of agents interacting in a specific economic/industrial area under an institutional infrastructure in the generation, diffusion and utilisation of technology (Carlsson & Stankiewicz, 1991).

In general, innovations can be subdivided in:

- Core Innovations: optimizing existing products;
- Adjacent or incremental: expanding the outreach of the current technology; and
- Transformational or disruptive: breakthroughs, new and high impact innovations.

In the mining industry, new technologies have been directed at improving operational efficiency in increasingly challenging environments - including at depth - with sustainable approaches. As identified by Deloitte (2015)[19] extractive industries are in an urgent need of innovation that can lead to:

- Reducing costs to operate;
- Improving asset productivity;
- Increase safety in operations;
- Reducing operational risks;
- Reducing costs to develop assets.

Actions I&T 4.4, I&T 5.1 and I&T 5.2 are directly supporting new innovations in mining. Action I&T 5.1 comprises the development of deep mining technologies, which is a point of common challenge mainly for the EU, Canada and South Africa. To put forward such cutting-edge technological capacity, the role of METS companies and funding is crucial. Joint ventures (action I&T 4.4) - also with the RC, especially Australia - and research funding priority (action I&T 5.2), considering cooperation with South Africa and Canada should include special attention on putting efforts in enhancing technologies used in mining at depth in a collaborative and synergistic manner. South Africa pioneered in ultra-deep underground mining and Canada possesses strong initiatives such as the UDMN (Ultra deep mining network).

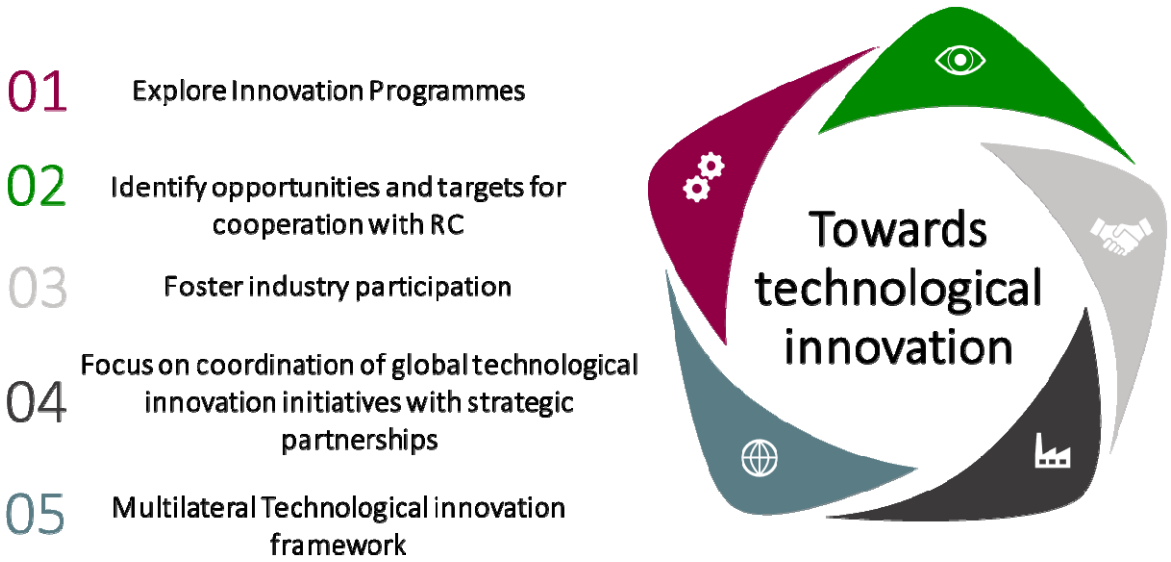


Figure 33: Cooperation Agenda 6 - Technological innovation.

[19] Monitor Deloitte (2015) Innovation State of Play – Mining Edition 2015. 19p.

This should be further expanded onto other areas where innovation can play a key role both at primary and secondary level of raw materials production. The latter, for instance, could be boosted by specific mobility schemes for researchers from the RC (action R&S 5.4).

Many well-established technology providers in the raw materials sector are based in the EU, where they also own manufacturing plants. Action I&T 4.5 can foster the alignment and boosting of such capacity with the strategic needs identified in cooperation with the RC. This action should be also extended to start-ups.

As the rate of technological change increases, disruptive ideas tend to emerge from more collaborative environments with a cross-disciplinary appeal. That is why it is important for the sector to amplify its search space in terms of research and development for other industries as well (action R&I 5.5 and Cooperation Agenda 4).

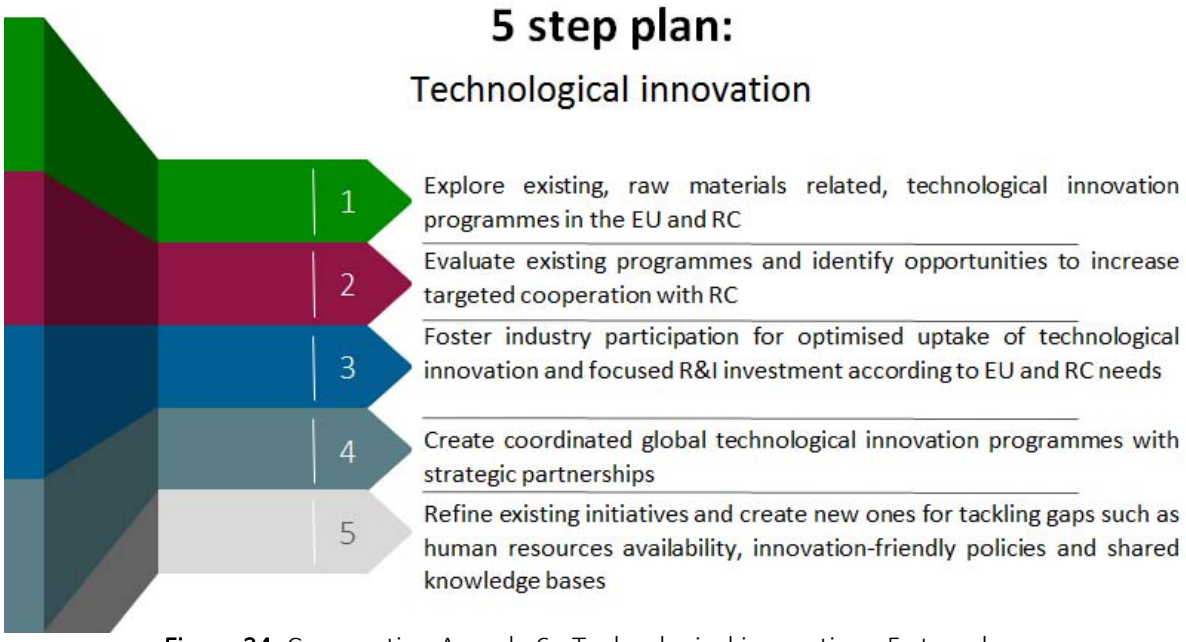


Figure 34: Cooperation Agenda 6 - Technological innovation: 5 step plan.

Alignment with strategic goals, future scenarios and Reference Country priorities

As set out in D2.1 (Strategic plan for international knowledge-sharing), the pathways for international cooperation regarding the innovation topic provide an overview on how to tackle more specific and strategic gaps. Technological innovations are especially subject to:

- Finding synergies and streamlining advanced research programmes with international cooperation: a better coordination of existing programmes with opportunities and gaps identified for the EU and the RC to advance research for increased innovation capacity.
- Strengthen the international cooperation between research institutions and industry: the previous item should be expanded to include industry actors for sharing expertise and practical experience, increasing the market uptake capacity for technological innovations.
- Funding technological research and development in developing countries: as mineral resources are unevenly spread in the world, cooperation should not be limited to first order interested parties, but rather consider the involvement of any actor that could have a strategic role in a particular field. For technological innovation, research schemes and funding

in other regions of the world with rich mineral endowment, such as Latin America and Africa, can be of strategic importance to create networks and links, increasing EU and RC competitive strengths in the global raw materials market.

Different futures set out different landscapes for technological innovation. However, technological breakthroughs act directly in shaping the future itself, as they can open brand new conditions for the related domains of impact. Technological innovation should be well aligned with foreseen constraints to tackle future challenges, acknowledging that there is no single future. Therefore, it should also be systematically assessed and evaluated to better identify opportunities, potential breaks and hidden threats.

Technological innovations can be oriented for more sustainable futures facilitating the development of a 'preferred' future, one such as portrayed by the 'Sustainability Alliance' scenario, where greener technologies are the norm and secondary sources of raw materials have an increased share in the raw materials supply. More constrained scenarios for international cooperation, such as 'National Walls', can set different boundary conditions, where countries might have to rely in innovation as a solution for constrained trade and cooperation as well as identify more targeted, bilateral, cooperation with countries that are e.g. closer ideologically and/or politically: aligned in regional economic blocs, for instance.

Australia is the world leader in the METS sector. Still, it needs to improve and find new ways to develop the mining sector, including the exploration field, mainly related to deeper mining and post-mineralisation cover exploration, due to depletion of easy to find and exploit mineral prospects.

This cooperation agenda is also relevant for EU-Canada cooperation, as both the EU and Canada strive to be at the forefront of technological developments in the raw materials sector. During the workshop in Brussels it was agreed by the experts that both the EU and Canada have a lot of room for improvement when it comes to private sector R&D. The EU has already installed organizations (e.g. EIT Raw Materials) to support the industries R&D sector and in Canada a proposal for a mining Innovation Supercluster (Clean Low-energy Effective Engaged and Remediated) was just submitted by a consortium of renowned Canadian institutions. This could open a window of opportunity for cooperation on developing these new mutually beneficial sustainable technologies.

South Africa also has a major interest in technology development, with a focus on mineral processing and deep mining, that are of specific interest to the EU too. Synergies can be achieved through extended participation of partners like MINTEK in the European Research and Innovation Projects.

Cooperation between the EU and the USA is highly relevant in the field of technological innovation. The USA is in the frontier of the newest technologies and investing, mostly privately, significantly in its related research. The EU is also a world class player in the related research fields, although if the joint research network would reach global level, rather the European level, the innovation impact would significantly increase. Fostering cooperation in this field would be not only cost effective, compared to competition, but also enable countries to work together on the latest technological challenges, sharing expertise and transferring knowledge.

4.7 Cooperation Agenda 7: Policies and frameworks

Actions	R&I 2.1, R&I 5.4 E&O 2.1, E&O 3.4, E&O 7.1, E&O 8.1 I&T 3.3, I&T 3.4 R&S 2.1, R&S 2.2, R&S 3.3, R&S 4.4, R&S 5.2
Added value	A legal policies and framework scheme is best and easier to set-up when a complete picture of the purposes and requirements is painted.
Constraints	Diversity within the EU and reference countries when applying new policies and frameworks Frameworks and policies need to be revised and adapted over time
Gap	Lack of more policies regarding land use planning and other topics Lack of harmonization in local/member state mineral policies and frameworks
Related to	All Cooperation Agendas
Reference Country	All - USA

Description

Clearly defined cross-cutting policies and frameworks in the RM sector are essential to the development of the sector itself. All the actions listed in the above table state the need to improve legal policies and frameworks regarding all the fields referred in the action plans (Research, Innovation, Education, Outreach, Industry, Trade, Recycling, Substitution) and others (finance, environment, policy, etc) that will help their continuous evolution. Cooperation and sharing of experiences with the reference countries, in particular with the US, could support this Agenda.

Being one of the pillars for its future sustainability, the EU needs to competent working policies and legal frameworks into practice at EU and member-state level. The lack of policies in the RM sector is one of the major problems the EU has faced in the past decades, being one of the reasons for a slow development and resource dependency face to others. The EU recently started to solve these challenges with the development of EU programmes, such as Horizon 2020, and with projects like Minatura2020, STRADE, MILO and MIN-GUIDE, that are developing policy and framework related studies to benefit the European RM sector. By examining and following the best practices and guidelines from the RC, the EU can apply relevant and effective policies internally and vice versa. The development of better policies and frameworks have, as an excellent basis, the Reference Countries' own policies and frameworks' strengths, from which the EU can greatly benefit – this was one of the major objectives from INTRAW, well addressed in the various action plans (D2.3, D2.4, D2.5 and D2.6) and country reports, in which each the strengths of policies of each Reference Country was extensively studied.

The requirements for the further development of policies and frameworks has been identified in D2.1 (Strategic plan for international knowledge-sharing) recurrently in the Gap Analysis. The actions envisaged in D2.3, D2.4, D2.5 and D2.6 try to cover those gaps efficiently. Most of the proposed

policies and frameworks schemes in these reports are in line with the identified problems and intend to solve them.

Establishing cross-cutting legal frameworks and policies within the raw materials scope is a necessary condition to allow for further collaboration levels with other parties and is strongly envisaged by actions R&I 2.1, R&I 5.4, E&O 2.1, E&O 3.4, E&O 7.1, E&O 8.1, I&T 3.3, I&T 3.4, R&S 2.1, R&S 2.2, R&S 3.3, R&S 4.4 and R&S 5.2. These actions intend to establish clear policy and framework recommendations to be applied by the EU, with recommendations and guidelines gathered from the Reference Countries. Putting these into practice will push the EU forward in the RM sector and allow for better and more productive collaboration measures with other parties (i.e. the Reference Countries).

However, the first step to establish new policies and frameworks should be to implement action R&I 2.1, R&I 5.4, I&T 3.3 and I&T 3.4 as they define mechanisms to aggregate and promote the minerals industry by creating legal bodies and policies to make international cooperation easier, developing a financial framework for investing in mining, assessing information regarding mineral resources' industries and set a series of new policies that include mineral safeguarding, land use planning and environmental regimes, among others. With the creation and implementation of these active frameworks and policies, as a basis, the European RM industry can be securely developed around it.

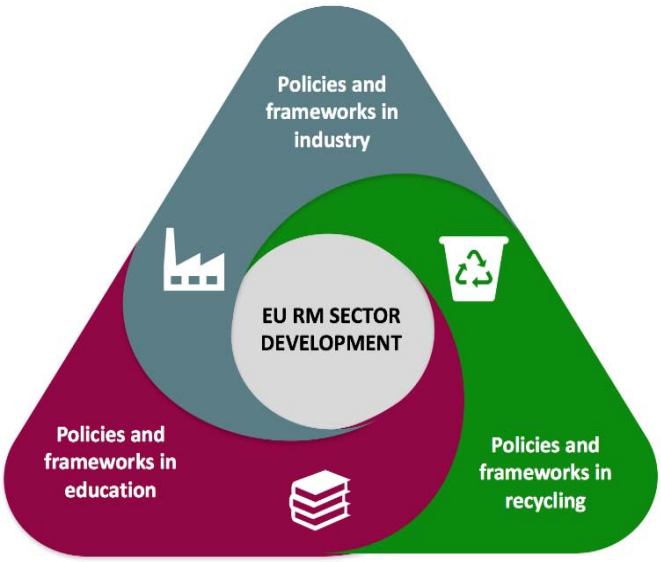


Figure 35: Cooperation Agenda 7 - Policies and Frameworks.

The development of the RM sector needs to continue with other important policies, now regarding recycling and substitution, and that are addressed by actions R&S 2.1, R&S 2.2, R&S 3.3, R&S 4.4 and R&S 5.2. These actions aim to harmonize the different policies and frameworks within the EU for better waste management, that will ultimately benefit recycling, involving it in the circular economy concept. These include a review of actual existing policies, advancing with a common waste policy afterwards for all the EU member states. Regulations for collection and recycling of metals, minerals and electronics are also envisaged.

With a new and/or actualized and adequate pool of policies and frameworks related to industry and recycling, what needs to follow is the establishment of policies regarding the education system: actions E&O 2.1, E&O 3.4, E&O 7.1 and E&O 8.1 propose to create a set of policies and/or frameworks to apply in the RM learning sector. These actions will help to define the learning curve, adapting it to

the current needs in the sector, and to better prepare professionals for the future. Feeding adequate education frameworks into the RM learning sector will benefit all the other RM areas, further down the line, as education acts as the basis for all the system.

With a strong pool of cross-cutting frameworks and policies into practice, it will be easier to define bilateral and multilateral agreements, that will enhance cooperation in the RM sector: research, industry, education and recycling, as fundamental areas, will all receive a great boost thanks to this (Cooperation Agenda 8 - Multilateral agreements and further cooperation).

There is a need to monitor the implementation of European policies against the backdrop of global developments. Maintaining a strong policy agenda will depend on the strength of the EU in the Raw Materials sector - which will improve in the next few years thanks to its new vision on the topic.

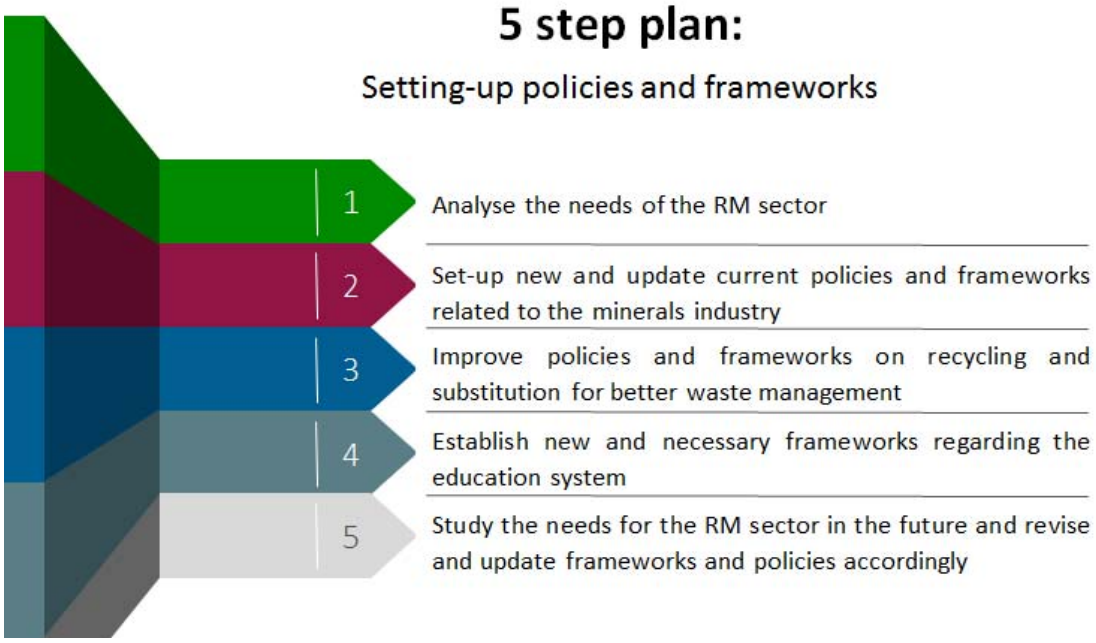


Figure 36: Cooperation Agenda 7 - Setting-up policies and frameworks: 5 step plan.

Alignment with strategic goals, future scenarios and Reference Country priorities

Gaps related to mineral resources' availability and raw materials policy and legal frameworks were previously addressed in D2.1 (Strategic plan for international knowledge-sharing), Chapter 6. These included gap analyses on the lack of policies and/or frameworks in land use planning, diversification of mineral production, mineral exploration, local/member state policies, legal system, mineral policy, reporting and inventory systems, and in administrative and permitting systems. The further development of policies will help the EU fight these major gaps found in its structure. All the gaps identified in D2.1 are, therefore, addressed, although at different in-depth levels, by the actions mentioned in this Cooperation Agenda. One example of a gap is the lack of strong and effective policies and/or frameworks regarding land use planning and defined policies at local/national level within the EU regarding the RM sector. Therefore, there is still a need to cover these topics for a better and more proficient integration of the EU into the Raw Materials sector, than the one currently observed.

The establishment of policies and frameworks are envisaged to work in all the future scenarios, as these can still be applied to EU's member states and are independent from scenarios consideration.

Clearly defined policies and frameworks in the RM sector are the basis for the development of the raw material sector. It would benefit the sector to set-up legal policies and frameworks in a more standardized way at an EU level. Close cooperation with all the reference countries would be beneficial to ensure an optimal result for the EU, while the reference countries can also benefit from the gained insights. This cooperation agenda is in particular relevant for bilateral cooperation with the USA as RM policies development in both the EU and the US are matters of national security, increasingly top-down driven and face similar national & global challenges.

4.8 Cooperation Agenda 8: Multilateral agreements

Actions	R&I 2.2, R&I 2.3, R&I 2.4, R&I 2.5, R&I 2.6, R&I 2.7, R&I 3.2, R&I 4.1, R&I 5.1, R&I 5.2 E&O 1.1, E&O 3.2, E&O 3.5, E&O 4.1, E&O 5.1, E&O 5.2 I&T 1.1, I&T 1.3, I&T 2.1, I&T 2.2, I&T 2.3, I&T 3.1, I&T 3.2, I&T 4.4, I&T 5.1 R&S 1.2, R&S 3.4, R&S 4.5, R&S 4.6, R&S 5.1, R&S 5.3
Added value	The establishment of agreements with the Reference Countries will greatly contribute to cooperation in the Raw Materials sector. Cooperation in RM is an essential vision in Scenario 1 – Sustainable Alliance and Scenario 2 – Unlimited Trade.
Constraints	International agreements could be difficult to put into practice in Scenario 3 – National walls
Gap	More agreements with the Reference Countries; the gap will be filled after Cooperation Agenda 7 (Policies and frameworks) is adequately put into practice
Related to	All Cooperation Agendas
Reference Country	All - USA

Description

Setting-up cooperation agreements, at bilateral and multilateral level, will be essential for the further development of international cooperation between the EU and its counterparts. Many of the actions defined in the INTRAW action plans will require the establishment of several types of agreements connected to Research, Education, Industry, Trade, Finance, Structures and services, among many others. By capitalising on best practices from the RC, the EU can establish profitable agreements not only with them, but also with other external parties, achieving new levels of synergies that involve better international cooperation in the Raw Materials sector.

Cooperation is a term closely related to the creation of agreements and, usually, is a result from those. The need for cooperation is present through most of the defined actions, linking the EU with the Reference Countries (and third-party countries) at many levels. The positive effect of cooperation is stronger when there are good and adequate agreements in practice that can benefit both sides.

The establishment of agreements and further collaboration measures and activities with the RC and other third parties, is relevant in actions R&I 2.2, R&I 2.3, R&I 2.4, R&I 2.5, R&I 2.6, R&I 2.7, R&I 3.2, R&I 4.1, R&I 5.1, R&I 5.2, I&T 1.1, I&T 1.3, I&T 2.1, I&T 2.2, I&T 2.3, I&T 3.1, I&T 3.2, I&T 4.4, I&T 5.1, R&S 1.2, R&S 3.4, R&S 4.5, R&S 4.6, R&S 5.1 and R&S 5.3. These actions incite the different parties to accomplish several types of agreement (in a broader sense of the word) to achieve the desired beneficial collaboration results, essential for the development of the RM sector, and especially important for the EU. Actions related to cooperation can be divided into three sub-topics: Agreements, Joint activities and Further cooperation measures.

Establishment of concrete agreements with the RC is obtained through actions R&I 2.4, I&T 1.1 and I&T 1.3. These actions envisage agreements that will reflect precise actions in the RM sector for raw materials' sustainable production and trade cooperation. These englobe reviewing and defining priorities in RM, furthering collaboration and the establishment of agreements to ensure the provision of resources and to avoid EU resource nationalism. The EU is currently falling behind its peers (i.e. RC) when it comes to production and trade of RM, so the need to form agreements that can benefit and improve the European RM sector, is real.

The creation, promotion and facilitation of Joint programmes/workshops/projects and other joint activities between the EU and RC can greatly help the development in the RM sector and are defined in actions R&I 2.2, R&I 2.3, R&I 4.1, E&O 3.5, E&O 4.1, E&O 5.1, I&T 2.1, I&T 4.4, R&S 4.5, R&S 4.6, R&S 5.1 and R&S 5.3. Joint programmes in the most different study areas of the RM sector will allow for collaboration and development of those same areas, as there will be a joint effort made by the EU and its partners to push them forward - specific cases of research and innovation, education, industry and trade and, recycling and substitution. Most of the actions also envisage the contribution and collaboration with and between academia and industry partners in the creation and development of such joint programmes (I&T 2.1, I&T 4.4, E&O 3.5, E&O 4.1 and E&O 5.1). These include creation of exploration platforms, new funding schemes, industry-education transferability of people and skills and adequate education programmes. Actions R&S 4.5 and R&S 4.6 aim to create joint programs on recycling and actions R&S 5.1 and R&S 5.3, joint programmes on substitution of raw materials. With actions R&I 2.2, R&I 2.3 and R&I 4.1 the creation, promotion and evaluation of new and existing joint programmes will be put into practice, guaranteeing that the EU stays in the forefront of development and collaboration within the RM sector.

Finally, other forms of active cooperation between the EU and other parties are needed to guarantee that cooperation always works: seen on actions R&I 2.5, R&I 2.6, R&I 2.7, R&I 3.2, R&I 5.1, R&I 5.2, E&O 1.1, I&T 2.2, I&T 2.3, I&T 3.1, I&T 3.2, I&T 5.1, R&S 1.2 and R&S 3.4. In these many different collaboration schemes and objectives are mentioned. The implementation of actions R&I 2.5, R&I 2.6, R&I 2.7, R&I 3.2, R&I 5.2, E&O 1.1, R&S 1.2 and R&S 3.4 aim to develop and upgrade infrastructures and services at an international level, focusing on research in different areas - links between different countries, organizations and SMEs are ensured through these actions. The result will be easier, faster and better collaboration efforts between different actors. Actions I&T 2.2, I&T 2.3, I&T 3.1, I&T 3.2 and I&T 5.1 intend to establish cooperation schemes for the RM industry and for the trade and exploration of resources by facilitating the conditions for that to occur - related to track permitting, commerce, exchange of information and creation of new exploration structures, all envisaged within collaboration.

Agreements with third parties will be easier to integrate into the RM sector once adequate policies and frameworks are in practice within the EU. With this, cooperation in the RM sector will improve, alongside with many areas closely related to it, such as industry, research, innovation, recycling and education. With profitable agreements, collaboration activities will be a natural step afterwards. The need to maintain those joint efforts must be real and tangible, so endeavours will have to be considered, from EU and third-party sides, to maintain and nourish the collaboration measures.

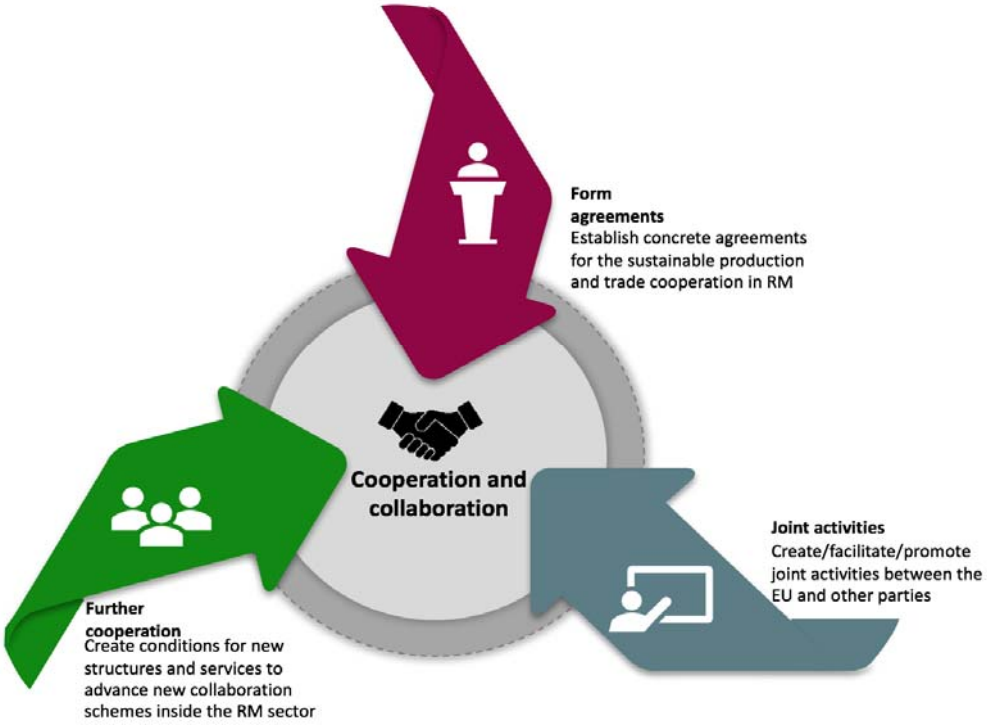


Figure 37: Cooperation Agenda 8 - Multilateral Agreement.

Agreements with third parties will be easier to integrate into the RM sector once adequate policies and frameworks are in practice within the EU. With this, cooperation in the RM sector will improve, alongside with many areas closely related to it, such as industry, research, innovation, recycling and education. With profitable agreements, collaboration activities will be a natural step afterwards. The need to maintain those joint efforts must be real and tangible, so endeavours will have to be considered, from EU and third-party sides, to maintain and nourish the collaboration measures.

In the long-term it will be of extreme importance that the EU prepares itself and assesses its needs well before in time, so it can prepare good agreements and further collaboration measures and joint efforts in the most needed areas, to achieve the desired development.

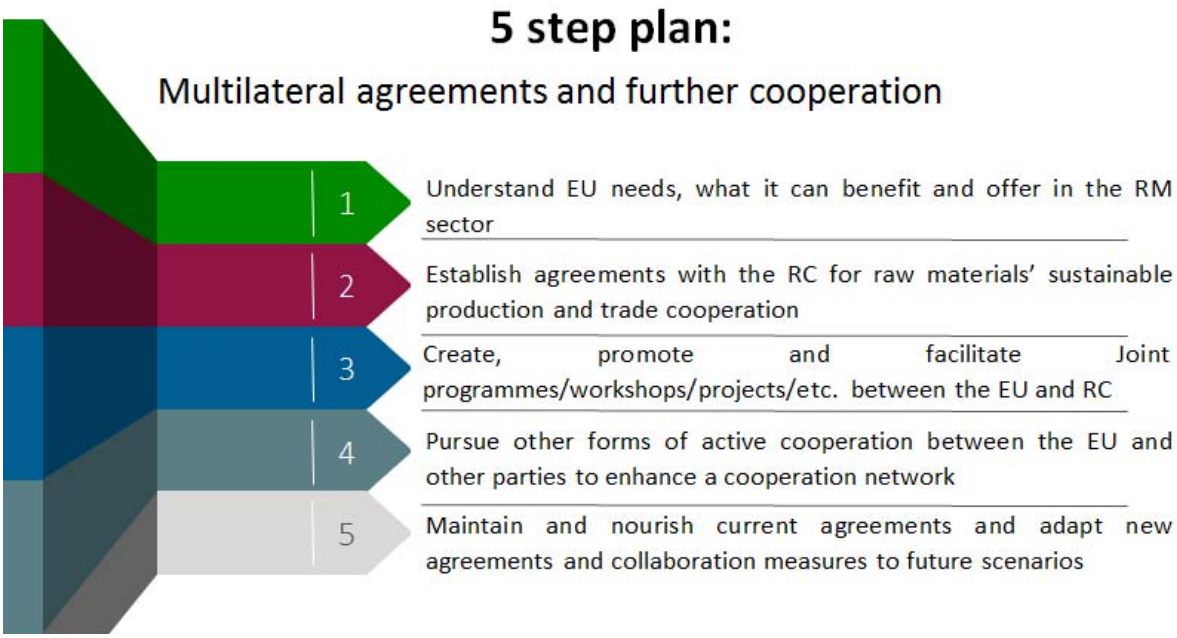


Figure 38: Cooperation Agenda 8 - Multilateral agreements: 5 step plan.

Alignment with strategic goals, future scenarios and Reference Country priorities

The need for an improvement towards the establishment of bilateral, multilateral and trade agreements was identified through the work on INTRAW's D2.1 (Strategic plan for international knowledge sharing). That need is being covered by some of the actions – mostly regarding trade and production – and might be covered in the future by the setting-up of concrete policies that will open proper conditions to establish agreements with other parties, especially the RC (in line with Cooperation Agenda 7). It is, therefore, needed that the EU start and maintain collaboration with relevant countries, so it can continue its development through the gains in agreements.

Establishment agreements and collaboration schemes will work in all the future scenarios, with some serious constraints under Scenario 3 – National Walls. Although, it would, at some level, still be possible to have agreements with other parties in this specific scenario, they would be much weaker. In fact, the establishment of agreements with other parties is the basis of Scenario 1 – Sustainable alliance and Scenario 2 – Unlimited trade and they can be seen as critical in those visions. Setting-up agreements, at bilateral and multilateral level, will be essential for the further development of international cooperation on raw materials between the EU and the reference countries.

5. RESULTS AND RECOMMENDATIONS

The purpose of this deliverable is to explore potential synergetic opportunities that can arise from the implementation of the actions described in the four action plans while considering the constraints defined in the Roadmap for their implementation (D2.2). The overall aim has been to define "portfolios of actions" with added value that can be obtained from the synergetic implementation of several actions. The work that has led to the definition of these action portfolios (i.e. Cooperation Agendas) included studying pre-identified interlinkages, the development of matrices focussing on the action plans' pathways, a thematic analysis and finally, a structural analysis. These processes ultimately led to the identification and classification of the eight Cooperation Agendas mentioned in this report.

It is expected that the new International Raw Materials Observatory, launched in the European Union by the INTRAW project will be the main driver for implementation of the Action Plans and the Cooperation Agendas.

5.1 Added value of the Cooperation Agendas

As described earlier, numerous studies have proven that cross-cutting synergies between different areas are possible and that implementing steps from different fields in a synergetic way can be beneficial. In this report, cross-cutting synergies between the fields of Research and Innovation, Education and Outreach, Industry and Trade, and Recycling and Substitution, amongst other sub-fields within the raw materials sector have been considered, leading to reduced costs, increased feasibility, amplified impact, greater efficiency, etc.

Table 6: List of identified synergies and their added values.

Synergy / Cooperation Agenda	Added values
International raw materials data platform	Data related to raw materials (primary and secondary sources, geological data for exploration, etc) is more valuable if it is available and shared between cooperating countries in a uniform way.
Securing raw materials supply	Minimize the supply risks of mineral raw materials while working together with strategic international partners that are in a comparable situation. A combination of actions that give input from European resources, trade and recycling is desirable.
Stabilising workforce	Taking actions that focus on stabilising the raw materials workforce internationally, both within research and industry, can reduce the loss of knowledge and skills in the raw materials sector.
Interdisciplinary approaches	Improving and creating new channels for interdisciplinary research in the raw materials sector, while focussing on recycling, will benefit the entire raw materials value chain.

Synergy / Cooperation Agenda	Added values
Encouraging investment	Attracting more investment into the raw materials sector with strong European involvement is only possible with a coordinated international approach of actions targeting investors and companies.
Technological innovation	Innovative and disruptive ideas that lead to innovative technologies and further improvement of the European raw materials sector will arise from increased cooperation with the reference countries, in particularly with SMEs.
Policies and frameworks	Cross-cutting policies and frameworks will mobilise new stakeholders and will facilitate high-level dialogues with the reference countries.
Multilateral agreements	Establishing actual agreements, both bilaterally and multilaterally with the Reference Countries will enhance cooperation in the Raw Materials sector.

The simultaneous implementation of the four Action Plans could boost international cooperation on raw materials, but this will require substantial initial investment and political commitment not just from within the EU but also on the part of the Reference Countries. By comparison Cooperation Agendas offer cost-efficient and yet robust action portfolios on a bilateral or multilateral basis, in case funding is limited and the launch of the Action Plans is delayed.

5.2 Cooperation opportunities at bilateral and multilateral level: additional suggestions & recommendations

During the course of implementation of WP2 (and in particular Task 2.6) several suggestions were noted for cooperation on a bilateral (sometimes multilateral) basis that could be considered for immediate follow-up activity after the completion of INTRAW. These suggestions refer to concrete actions, frameworks and sometimes projects that could constitute the basis of bilateral networking between the EU and target countries. The following propositions for concrete cooperation measures are extracted and summarised here from the work of WP2 and in particular the INTRAW Experts Workshop, organised in November 2017, Brussels.

5.2.1 EU-Australia cooperation

Australia is one of the world leaders in mining technology, services and exploration; strong in education and research in the raw materials sector. But challenges remain, mainly related to recycling and substitution of mineral raw materials. Other challenges the country faces are related to public engagement and social license to operate, some legal policies at administrative level and growing production costs in mining. Considering the EU's strengths, weaknesses and gaps within the raw materials sector, as studied throughout WP2, with special focus on D2.1 (Strategic plan for international knowledge sharing), a number of recommendations for active cooperation between the EU and Australia are summarised below:

- Social license to operate (SLO) and public and community engagement – These factors are problematic for the mining industry in Australia and in Europe and can be a target of mutual discussions, possibly socio-economic research for improvements, as the public has growing concerns regarding mining activities. Collaborative workshops could be organised specifically focussed on Social License to Operate issues, and featuring presentations from representatives of the mining industry and mining countries, including representatives from non-mining areas, but controversial industries that have a good success history in community engagement. Following this step would allow better public engagement with the raw materials sector, while also facilitating the social license to operate for mining companies in the EU and Australia.
- Joint financing models/programs & bilateral funding arrangements – Australia is very strong in joint financing models and programs involving the industry, academia and the government. Europe still has room for improvement with respect to this aspect, although some good examples already exist. A collaboration package involving overseas joint programs in the raw materials sector can be pursued.
- Clusters/collaboration between universities on mining education –Australia has one of the best university-clusters on mining education in the world; in the EU there is a lack of coordination between universities and mining courses and thus, education. The development of focussed collaboration on resource-related education, acting as an extension of current arrangements, as the EU already has collaboration measures between universities in practice. Clusters could be promoted by identifying universities with relevant teaching strengths and developing a database of specialities that is available both to potential students and to universities. Selective teaching and research collaboration with overseas universities should also be encouraged, where EU-university clusters might be enhanced with expertise that may not be readily available in the EU at the moment.
- Recycling initiative, research and technologies – Australia, due to its large mineral endowment, has a weak recycling sector, including research and technologies, regarding mineral raw materials. Also, substitution has not been actively pursued. In contrast, the EU, due to its mineral import dependency, has been relying on and improving its recycling sector as well as research on the substitution of mineral raw materials, making it progressively stronger. Creating a common funding scheme for research and innovation between Australia and the EU to develop new and improve existing recycling technologies in the mineral sector, which would in turn contribute to the mining industry sustainability and to better public perception on mining in both continents. The EU has already started to invest in recycling technology and Australia can be an active partner in this type of collaboration. One of these examples is the trilateral agreements with Japan and the USA – a bilateral agreement with Australia could also be implemented.
- Policy strategies to secure the supply of certain mineral resources, for both the EU and Australia. This topic is further explored from the EU-perspective in 4.2 Cooperation Agenda 2: Securing raw materials supply. From the Australian side there is still a need to define this kind of policy. Thus, both parties would benefit from cooperation within this area.
- Improve the exploration performance under post-mineralisation cover - Australia will soon have to improve their exploration portfolio as easy-to-access deposits become depleted. Europe now has some advantage in terms of thinking ahead and developing technologies for mineral exploration and extraction under more difficult circumstances. A collaboration on this topic on a bilateral or multilateral level with South Africa and possibly Canada is desirable. It could include forming a (research) cluster to further the technology innovation and funding towards novel exploration methods. One possible step would be to improve on the prospects already found by the UNCOVER and various AMIRA and CSIRO projects in Australia. Programmes addressing both the prediction and detection of mineral deposits from regional to individual ore-body size should be prioritised. They should encompass new geoscientific knowledge from research, new detection technologies

and associated data compilation and acquisition, which could result from a cooperation on a research and respective funding levels.

- Reduce exploration risks - In the last 20 years, half of Australia's share of global exploration investment in Australia has moved offshore to countries where the technical risk of exploration is considered lower. The same has happened with European based mining companies that preferably work overseas. Reduction of exploration risks both in the EU and Australia would make exploration activities more attractive and could boost mining in those areas. Exploration risks can be reduced by using strategies based on geology, statistics, and economics. Among the possible sources of risk in exploration are: variation of deposit sizes and grades among deposit types, variation in deposit sizes and grades within types resulting from local or regional differences in geologic settings, variation in economic returns by type, price changes, and discovery probabilities, given existence of deposits. Investing in research and innovation in exploration and mining is the way to go, having a complementary funding scheme from both parties to develop ways to reduce exploration risks in the EU and Australia.
- Promotion of raw materials – There is an identified lack of communication between organisational bodies within the raw materials sector. Having NGOs to promote the raw materials issues (e.g.: their need to society) to the relevant policy makers would allow for a better understanding on the needs and challenges of the sector. Furthermore, NGOs from both areas should try to collaborate and launch coordinated efforts and messaging on both continents.
- Identify multi-national research priorities among the raw materials industrial sector (Research & Innovation) – It is necessary to understand the future needs of the raw materials industry to adjust the research priorities in the sector. A set of actions within this scope would aim to identify the critical research challenges for the Reference countries and EU raw materials industrial sector.

Promoting, facilitating and managing collaborative industry-funded research projects may also provide a good opportunity for the INTRAW International Raw Materials Observatory to take an initiative. Industry funding and subsequent research in the raw materials sector can be sourced from both within and outside the EU. The AMIRA[20] model in Australia may provide a useful preliminary template, which can be complemented on by the Observatory. The AMIRA model can be built on and improved by including an effective post-project knowledge dissemination program. To support industry-research brokerage and to make it more effective for the raw materials sector, the Observatory would benefit from a highly credible advisory board with extensive networks within the research communities in Europe and overseas.

5.2.2 EU-Japan cooperation

Japan´s resources policy includes i) securing the supply of primary raw materials via agreements with other countries ii) direct investments of private capital in overseas mining projects and iii) domestic research and investment into recycling & substitution.

Japan has probably the most sophisticated recycling industry in the world, with recycling rates of metals above 98% and, in 2007, just five per cent of Japan's waste ended up in the ground, compared to 48 per cent for the UK in 2008. Japan's appliance recycling laws ensure that the great majority of electrical and electronic products are recycled, compared with 30–40 per cent in Europe. Of these appliances, 74–89 per cent of the materials they contain are recovered. Perhaps more significantly, many of these materials go back into the manufacture of the same type of product. This is the 'closed-loop' holy grail of recycling, essential for a truly circular economy (INTRAW, D 2.5).

Japan has a government-driven strategy to secure the access to mineral resources for its industry and to maintain a highly qualified knowledge base for science, technology and innovation (STI). This strongly

[20] Australian Mineral Industry Research Association http://www.amira.com.au/

centralised, top-down strategy offers immediate entry points for bilateral cooperation with Japan concerning raw materials.

The government agency JOGMEC supports international cooperation. This concerns, for example, overseas geological surveys and exploration campaigns (on land and on the deep-sea floor) to help Japanese companies secure mineral interests, it provides equity capital (for asset acquisition), loans and liability guarantees for metal exploration and development by Japanese companies, and works in the development of human resources. This framework offers an entry point for European companies and institutions to develop joint ventures with their Japanese partners.

Japan has a strong manufacturing industry. To limit the impact of potential supply shortages Japan has long defined policies to avoid such shortages (e.g. through funding international mineral exploration) and has defined R&D policies that aim to reduce dependencies on materials (especially rare earth elements). The European Commission has been stepping up policy measures since the 2008 launch of RMI with increasing focus on international cooperation. A joint EU-Japan policy initiative in support of joint mineral exploration globally would likely have the support of EC and Japanese decision makers.

Japan has the best-developed national recycling and substitution strategy. The Japanese national Critical Raw Materials strategy develops national research programmes aiming at promoting new technologies for the substitution of materials. For example, substitution of indium in transparent electrodes used in liquid crystal panels, substitution of dysprosium in rare-earth magnets and substitution of tungsten in carbide tools, among others. Such topics are also addressed under the "Climate Action, Environment, Resource Efficiency and Raw Materials" theme of H2020 and a tighter connection between H2020 and its Japanese counterparts should be encouraged. The Japanese Science and Technology Agency is planning to continue co-funding projects in open Horizon 2020 calls, and there are also new opportunities through the European Research Council-Japan Society for the Promotion of Science cooperation arrangement.

The strong technological and innovation culture in Japan is a fundamental driver for the development of its industry. As a result, there are several running programmes that could offer cooperation opportunities between research institutions from the EU and Japan. Japan's government is continuously investing into research with the aim of substituting scarce chemical elements in industrial processes. Japanese firms are also investing into the recycling industry (the most developed in the world) and into improving the efficiency of raw materials use. Japan's largest public R&D management organisation, NEDO (New Energy and Industrial Technology Development Organisation) coordinates technology development activities in collaboration with the industrial, academic and governmental sectors in rare earth elements (REE), platinum-group metals (PGM) and tungsten (INTRAW, D 2.1). NEDO launched a six-year R&D project (2017-2023) that aims at developing technologies to enable efficient recycling of CRMs including minor metals. In addition to launching joint R&D initiatives on the basis of these running programmes, the Marie Sklodowska-Curie Actions are an important instrument to promote individual researchers' mobility between the EU and Japan.

Similarly to work carried out in Europe's "Technology Platforms", Japan also develops a Strategic Technology Roadmap (STR) that includes detailed roadmaps on particular technologies, which are aggregated into Technology Overviews, which themselves are aggregated into sets of scenarios (METI, 2010). Japan also conducts a large-scale Delphi survey to get insight into what policies will be needed in science, technology, and innovation policy – the process is focussed on major national and global challenges and aims to identify how important specific technologies are, when they are likely to be developed and who should be responsible for their development. A strengthened EU-Japan Science Policy Forum could facilitate the deepening of mutual understanding on key policies related to the future of raw materials and in particular CRMs.

Altogether the establishment of streamlined mechanisms for joint funding of research and innovation projects of mutual interest as well as increased support to researchers' mobility could help EU-Japan

cooperation to reach new levels. The scheme developed by the Japan Science and Technology Agency (JST) in close cooperation with the European Commission is a good example for the joint funding of projects. When working with Japan it needs to be considered that Japan has three independent public non-university organisations, namely the National Institute of Advanced Science and Technology (AIST), the RIKEN Research Institute and the National Institute for Materials Science (NIMS) that carry out R&D (oriented towards industry needs). All promote supporting/enabling technology development, including simulation, measurement and characterisation technologies as well as developing and maintaining common databases. AIST also benefits from the interconnections among manufacturing, nanotechnology and materials research and targets social and environmental challenges.

5.2.3 EU-Canada cooperation

Canada has a very strong mining and exploration industry and advanced raw materials research and education sector. The needs of the raw materials sector are usually met by market-driven quick responses, but a long-term strategy is sometimes lacking. Other challenges that Canada faces are an ageing workforce and technological development outpacing skills and education. The EU faces similar workforce and skillset challenges, but exercises a strong strategic approach to provide for its industry's raw material needs which includes a strongly developed recycling sector. Four main areas for potential bilateral cooperation between Canada and the EU can be highlighted here. These areas consist of aspects in which either the EU or Canada or both can grow by supporting each other by implementing mutually beneficial cooperation opportunities. These identified potential areas for cooperation are:

- Canada's decentralised reactive market driven approach versus the EU's strategic central government driven long-term approach are complementary and can identify and provide opportunities that both regions can benefit from when resulting knowledge is shared effectively.
- In Canada, the private sector is obliged to file and make available most of its data and wide governmental data is constantly actively collected and made available to drive the industry. The lack of regulation of the exploration sector by the stock markets in the EU, makes that data is not yet provided in a uniform manner across the region. Here the EU can learn from the Canadian example and both the EU and Canada will benefit from more widely available geoscientific and transparent regulatory information. This is directly related to 4.1 Cooperation Agenda 1: International Raw Materials Data Platform.
- As for technology R&D, privately developed technology is often not shared for the benefit the whole industry. Common approaches to support and open the mining R&D sector, possibly with government support, could be explored to benefit the entire industry and make the sector more able to respond to disruptive developments. This cooperation opportunity is related to 4.6 Cooperation Agenda 6: Technological innovation.
- Both the EU and Canada face challenges of an ageing workforce and workforce diversity (Industry and Trade). In both regions the gender balance is not optimal yet. Furthermore, Canada can still improve the inclusion of indigenous populations in its workforce, while the EU needs to focus on training and integrating immigrants. If workforce diversity and integration can be optimised, then this will provide part of a solution to the expected problems of an ageing workforce. This cooperation opportunity is related to 4.3 Cooperation Agenda 3: Stabilising workforce.

It is recommended that the potential areas for cooperation opportunities are further discussed at immediate party-to-party level with the appropriate representatives for the fields of R&I, E&O, and I&T in the EU and Canada. Engaging high level national industry groups like the PDAC (Prospectors and Developers Association of Canada), MAC (Mining Association of Canada) and CIM (Canadian Institute of Mining and Metallurgy), as well as government entities like NRCAN (Natural Resources Canada) and the GSC (Geological Survey of Canada) and connecting them with their European counterpart entities

like the EIT Raw Materials and EuroGeoSurveys. This could be a task to be facilitated by the INTRAW Observatory.

A potential platform for cooperation on Research & Innovation could arise, if the Canadian CLEER Mining Innovation Supercluster gets funded. The CLEER (Clean, Low-energy, Effective, Engaged and Remediated) Supercluster – prepared on behalf of the mining sector by CMIC, CEMI, CIMRE, COREM, IMII, and MSTA – represents a CAD$700 million investment ($450M in cash and $244M in-kind from 162 partners across Canada). This CLEER Supercluster will transform the mining sector's productivity, performance, and global competitiveness by harnessing innovation across the ecosystem to tackle global challenges of water, energy, and environmental footprint, with bold targets of 50% reductions in each area by 2027. CLEER will execute its strategy through tapping into regional clusters of expertise within British Columbia, Alberta, Saskatchewan, Ontario, and Quebec. Through collaborative activities, CLEER will engage Canadian mining services and supply (MSS) sector, anchor companies, R&D innovation support organisations, post-secondary institutions, and partners from a wide variety of other sectors across Canada, including clean technology. It would be beneficial to both parties if the CLEER Supercluster could cooperate with e.g. the EIT Raw Materials.

5.2.4 EU-USA cooperation

The USA represent one of the largest economies in the world, alongside China and Europe. Its key strength and enablers are the availability of high quality geological data, large mineral endowments, high quality institutions, and significant internal market. The country is facing some similar difficulties to those of Europe: greying workforce, level of university-industry cooperation, and coordinated public/policy maker awareness on the mineral sector. During the INTRAW experts workshop in Brussels in November, several concrete cooperation measures were identified by the Expert panel. These findings utilised the outcomes of the previous assessments, turning them into concrete and tangible suggestions.

University-industry cooperation has been considered as a real game changer. It is directly connected with numerous factors and if a country can improve on this collaboration level, the connected factors are improving with it. There are four concrete areas where the EU can cooperate with the USA to enhance university-industry cooperation:

- Identify ways to establish coordinated funding schemes by private industry, VC, and government agencies to support research across sectors and countries.
- Formally recognise that the breadth of raw materials or mining capability and expertise is spread across universities in different countries and that research investment must be framed with that borderless view.
- Develop a forum/registry/meeting designed to match companies that have an interest in partnering with universities to produce research projects that address specific industrial challenges, or that help the companies to build a viable educational pipeline to provide scientists and engineers that are immediately able to step into industrial/mining jobs.
- Establish multi-national research priorities among the raw materials industrial sector to identify the critical research challenges, that universities can focus on.

Available, high quality geoscience data has been considered as a key historical enabler for the USA, which now has the best and highest quality, openly available geoscience datasets. Even though there are current threats, e.g. closing of libraries, the EU and USA can work together, potentially also with Canada, to raise the standards of global or European level geoscience data availability. There are numerous potential measures for this issue, starting with:

- Translate publication abstracts from the European geological surveys into English, starting with "cornerstone" publications, such as bedrock geology, maps, high citation index publications, etc.
- Establish consistent baseline data, metadata, and data formats, for production, demand, resource estimates, etc.
- Leverage the standards to building out globally shared data to provide transparent raw materials development beyond just the current USGS and sparse industry trade data.

Coordinated approach for I&T raw materials development was also selected as important topic. The USA and partly also the EU, lack any central coordination for raw materials development, which makes them less robust for future challenges:

- Examine areas where industry processes and standards vary based on local laws or talent and establish working groups to harmonize through promotion of best practices to improve efficiencies in I&T – this could be in taxes, environmental compliance schemes (e.g. bonding), property/royalty rights, etc.
- Building on a recognition that full coverage of needed talent in RM requires tapping across many universities in many countries. Provide a consistent messaging of talent needs to those universities.

Communicating the different segments of the raw materials sector to the general public and to the policy makers. This is a weakness for both the USA and EU and was also identified as a major topic by Australia, as it currently holds back the mineral industry. To tackle this issue, joint efforts must be made in the form of the following points:

- Formal collaboration and discussions between US and EU NGOs that communicate on raw materials to the public and policy makers should make a concerted effort to collaborate to launch uniform efforts and messaging on both continents.
- Producing materials to raise public awareness of all segments of the raw materials chain, from source (bedrock) to end-of-life (remediation), including uses, applications, and potential for recycling and/or repurposing. These materials could range in level for appropriate materials to communicate to school-age children, to materials that provide the best current information to aid policy-makers to make informed decisions.
- NGOs in the US and to a lesser degree the EU should each promote Raw Materials issues to their policy makers. Sharing best practices and communication between these groups might create a higher level of impact.

In terms of the workforce, producing global raw materials and mining workforce reports would give a clear picture of the current mineral industry Human Resources landscape. This could start with an analysis of the EU, and could be expanded to be a global report. These reports could use the American Geosciences Institute's Workforce and Student Training reports as an example of what can be achieved. Reports could include information on Employment Data for each sector of the raw materials chain on a country-by-country basis; Projected changes in employment in each sector in each country; Projections for countries or segments in which growth and opportunity will be greater versus locations/segments that will experience contraction; State of training for jobs in the supply chain. This is an assessment of the ability of institutions to provide skilled workers to meet industry demands.

5.2.5 EU-South Africa cooperation

South Africa is a traditional player in global raw materials provision especially for PGM, ferrochromium, vanadium and gold production. In the final decades of the 20th century the country made a major contribution in development of new mining techniques for operating in deep

underground environments as well as producing a highly skilled workforce to work in such extreme conditions. In the 21st century South Africa is still recognised as an important source of mineral raw materials on a global demand scale and on providing quality education for the raw materials value chain, especially in mining and minerals engineering. However, that does not mean the country does not face challenges in the present situation and into the future. Numerous factors, such as lack of exploration activities, downstream technologies incentives and input resources restrictions (e.g. energy, water, labour and productivity) related to mining operations suggest a necessity for South Africa to properly address these emerging issues in a timely and effective manner. During the INTRAW Experts Workshop held in Brussels, four initiatives were identified to be recommended on a bilateral basis between South Africa and the EU, tackling the identified issues and assessing them terms of multilateral cooperation potential. These potential areas for cooperation are:

- Mineral processing technologies and research & development in mining machinery: South Africa strongly focussed on upstream research & innovation in the raw materials value chain and has recently recognised the need to shift the focus into downstream technology development – processing, refining and recycling. South Africa possesses a major actor in that field: MINTEK (South Africa's national mineral research organisation), with strong potential to catalyse developments in cooperation with the EU. The European Union is closer to the forefront of research & development of technology and machinery focussing on downstream activities and already cooperating with South Africa through its Framework Programs, such as FP6 and the Project BIOMINE (Biotechnology for Metal bearing materials in Europe), which included MINTEK, South African universities (Cape Town and Stellenbosch) and industry (De Beers ltd). MINTEK is also the only non-EU member of the European Technology Platform on Sustainable Mineral Resources, which assists in formulating policy and research directions for the EU minerals sector.
- Deep underground mining: Access to land in the surface, environmental legislation, lack of shallow mineral deposits among other issues sparkled a strong interest in Europe to find and exploit deep underground deposits. Since the beginning of the century, the world has seen 75% of new base metals discoveries happening at depths greater than 300m[21]. Projects such as I2Mine undertook a major effort in advancing intelligent and sustainable deep underground mine production systems. On a global level, however, South Africa stands out traditionally for mining at greater depths, excelling in expertise and skills to work in such conditions. Strategic cooperation in related topics are key for realizing Europe's mineral potential and decrease its reliance on imports for critical metals, whilst also providing support for advancing research & development in related topics in South Africa.
- Post-mining landscape: Post mining landscapes and utilization has been increasingly a subject of studies in Europe and other mining regions. Socio-environmental and economic concerns drive the need for studies considering the future of regions and communities affected by mining operations in these domains. It is currently well acknowledged that ideally all mining projects must include aspects of covering the valorisation of potentialities arising with the end of the economic exploitation of the mineral endowment on a local level. The Eden project[22] in the UK certainly constituted an important case study in that sense. However, the ReSource project in central Europe provided a strong benchmark and can certainly indicate great insights on potential practices and further development areas across the globe. South Africa has a high density of mining operations in relative terms and demonstrates strong interest in tackling the social, economic and environmental issues for post-mining activities. There is therefore a great potential of cooperation between the EU and South Africa with benefits for both sides – extending EU capacities by incentivizing cooperation in specific topics, with

[21] The Future of Mining in South Africa (2014) Deloitte. https://www2.deloitte.com/content/dam/Deloitte/za/Documents/energy-resources/ZA_Mine_of_the_Future_06022015.pdf

[22] http://www.edenproject.com/

explicit inclusion of South Africa as participant, whilst aiming for the generation of improved practices for the South African models of mine closure and post-mining activities informing policy-makers, companies and other stakeholders.

- Mineral exploration activities: Europe is undertaking a massive effort in increasing its capacity on gathering and providing data with regards to its mineral availability in a standardised and harmonized way. This extends also into research and innovation for exploration activities and uncovering undiscovered mineral resources. Data on minerals is the backbone for development of the raw materials sector. At the same time, exploration activities host major risks and the lowest investment success rate in the value chain. Therefore, it is crucial to advance both in techniques for mapping and assessing the geology and the mineral resources potential as well as providing sufficient data for boosting investments in exploration activities. Current exploration investments in South Africa are very low compared to historic levels and initiatives for reducing risks by generating better exploration techniques and practices can turn investors again into business. In parallel, this should be guaranteed by an appropriate regulatory environment and policy implementation.

6. CONCLUSION

INTRAW has developed cooperation pathways and a roadmap for the implementation of 70 actions covering four key strategic areas of mineral raw materials: 1) research and innovation (R&I), 2) education and outreach (E&O), 3) industry and trade (I&T) and 4) recycling and substitution of strategic raw materials (R&S). The individual actions that are contained in the four Action Plans are aiming to foster the international knowledge transfer and collaboration on raw materials between the EU and the five reference countries: Australia, Canada, Japan, South Africa, and the United States. If implemented in full, these Action Plans will place Europe in a leadership position and on centre stage of international cooperation on raw materials with technologically advanced countries.

The parallel implementation of these four Action Plans would require substantial political and financial commitment. The aim of D 2.7 has been to identify internally cooperation areas that allow the synergetic implementation of a limited number of Actions, corresponding to different policy and technological agendas. During the development of this work previous studies and deliverables from WP1 and WP2 were used as baseline. The four individual Action Plans and the three INTRAW Scenarios were used in a complementary manner together with reference country perspectives. Input from these resources were used for the creation of the following eight Cooperation Agendas: CA1) Raw Materials Data Platform, CA2) Securing raw materials supply, CA3) Stabilising workforce, CA4) Interdisciplinary approaches, CA5) Encouraging investment, CA6) Technological innovation, CA7) Policies and frameworks, and CA8) Multilateral agreements.

The resulting eight Cooperation Agendas are portfolios of actions that are relevant on a bilateral, and occasionally on a multilateral basis. During the definition of these Agendas special emphasis was given to recommend a portfolio of actions that together are synergetic (i.e. can potentially create additional values), “future-proof” (i.e. applicable across the future scenarios that have been investigated for INTRAW) and mutually beneficial (i.e. considering reference country priorities, strengths as well as opportunities with regards to cooperation with the EU).

On a third level this report has also reviewed and listed several specific topics that represent immediate cooperation opportunities with the reference countries. These opportunities fit very well within existing cooperation schemes and could be facilitated without substantial financial investment.

Altogether INTRAW and D2.7 recommend continued international cooperation on raw materials at three possible levels corresponding to three different levels of required financial investment:

1. Implementing the Action Plans according to the Roadmap (D2.2)
2. Implementing some of the Actions according to the Cooperation Agendas thus stimulating new forms of cooperation (Chapter 4 of this report)
3. Enhancing existing cooperation, focussing on singular issues based on immediate priorities (Chapter 5 of this report)

At the time of writing this report it is unclear how much financing will be made available for continued international cooperation on raw materials. We recommend that the INTRAW International Raw Materials Observatory takes an active role in monitoring and adjusting the agendas outlined in this report. Findings of such monitoring activity could be published in the format of annual follow-up policy briefs on the status of international cooperation on raw materials in general and the status of implementing the actions and suggestions formulated by INTRAW in particular.

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INTRAW Deliverable D2.4 (2017): Action plan to enhance international education and outreach activities on raw materials

INTRAW Deliverable D2.5 (2017): Action plan to enhance international industrial and trade policies on raw materials

INTRAW Deliverable D2.6 (2017): Action plan for the management, recycling and substitution of strategic raw materials

APPENDIX 1: LIST OF ACTIONS

Field	Pathway	Code	Action
Research & Innovation	1. Robust RM planning - to match supply with demand on national / European Level	R&I 1.1	Create a mechanism to monitor global technological changes and exploitation/trade constraints on RM supply chains
	2. Integration of research and knowledge in the raw material strategy and policy on a common approach with the Reference Countries	R&I 2.1	Enable the participation of organisations from the RC in all EU programmes that have relevance for raw materials
		R&I 2.2	Promote RC participation in H2020 (and the new framework programme from 2020) with emphasis on raw materials
		R&I 2.3	Develop and launch new EU-RC international co-funded R&I programmes
		R&I 2.4	Create a bilateral basis related to raw materials R&I and set up a framework for reviewing and defining key priorities of RM research
		R&I 2.5	Promote (and enhance) long-term R&I cooperation with relevant countries, regions and organisations along the value chain
		R&I 2.6	Create and/or maintain bilateral/international research and exploration infrastructure and services
		R&I 2.7	Facilitate exchange between EU RM networks and their counterparts in the RC for the implementation of joint call for proposals
	3. Developing young researcher /professionals career schemes on an international basis	R&I 3.1	Continuously monitor R&I / industry cooperation schemes from the EU and RC
		R&I 3.2	Develop programmes to support the exchange of researchers between the EU and RC
	4. Finding synergies and streamlining advanced research programmes with international cooperation	R&I 4.1	Monitor emerging opportunities for multilateral cooperation between EU and RC research institutions on raw materials topics
	5. Strengthen the international cooperation between research institutions and industry	R&I 5.1	Encourage facilitators to take up roles in strengthening the linkages between R&I and the industry sector
		R&I 5.2	Strengthen global cooperation between research institutions and SMEs by promoting the participation of European SMEs in R&I projects of RCs
		R&I 5.3	Set up a social and environmental research programme via international cooperation between Europe and the RC on mining and minerals
		R&I 5.4	Align (step wise) incentives for R&I with EU-RC R&I cooperation agendas
		R&I 5.5	Demonstrate the "mine of the future" in Europe with the help of international cooperation and best practices
Educaton & Outreach	1. Joint educational programmes with the Reference Countries	E&O 1.1	Develop of joint international educational programme schemes with universities and training centres from the RCs and the EU
	2. Developing an international qualification framework for mining geology, mining engineering, mineral processing and related programmes	E&O 2.1	Create a list of the common learning outcomes and required skills in the EU and the RC
	3. Increased interaction and collaboration between industry and universities on an international basis	E&O 3.1	Identify the educational requirements of key players in the RM industry and development of corresponding higher education collaboration schemes
		E&O 3.2	Establish an industry- education working group to research potential 'mine of the future' employment models
		E&O 3.3	Governments from EU and RC to work with global industry to change recruitment and employment practices to avoid cyclic retrenchment and skills loss
		E&O 3.4	Develop recommendations on mining skills and workforce plans, supported by government training bursaries and scholarships through commodity cycles
		E&O 3.5	Create industry–education partnerships and forums within EU and between EU and RC to facilitate staff transfers delivering skills &

Field	Pathway	Code	Action
			knowledge transfer
	4. Joint international technical and vocational training in English	E&O 4.1	Initiate joint vocational educational programmes in the EU and in the RC
		E&O 4.2	Develop and promote teaching methodologies that embed language skills in English, Spanish and French within vocational mining training programmes in the EU and in the RC
	5. Collaboration activities on outreach within EU, RC and wider international mineral producing countries	E&O 5.1	Develop joint interdisciplinary educational materials to create a shared understanding of legacy issues around mineral production, public attitudes, concerns and future mineral supply needs and options
		E&O 5.2	Goverments, industry, education and training providers in the EU and RC to collaborate in explaining new career opportunities and benefits of an automated raw materials industry
	6. Professional structures and recognition	E&O 6.1	Professional bodies to advance an integrated qualification and mutual professional recognition scheme, facilitating ease of international mobility
		E&O 6.2	Produce integrated quarrying and mining education, training, CPD and development structures, professional certification and competency definitions
	7. Mineral diplomacy	E&O 7.1	Educate regulators, legislators, politicians and other stakeholders to improve EU wide RM and mining policy development
		E&O 7.2	Develop internationally recognised education programmes based on circular economy principles
	8. International policy	E&O 8.1	Develop, in cooperation with the RC, new models for managing commodity cycles
	9. Raising interest in geosciences & mining at primary and secondary school level	E&O 9.1	Raise further public awareness and interest in geoscience and RM on a global scale
Industry & Trade	1. Bilateral agreements for mineral resource production and buy-ins	I&T 1.1	Enhance long-term cooperation with mining companies from RC and other third party countries on the provision of raw materials
		I&T 1.2	Advance European/international stockpiling schemes on a bilateral and multilateral basis
		I&T 1.3	Foster regional cooperation, twinning and information sharing between EU and RC regions
	2. Widening and strengthening trade agreements on raw materials with the Reference Countries	I&T 2.1	Expand the EU minerals knowledge information system into a global minerals knowledge information system
		I&T 2.2	Develop an EU-RC platform providing information on permitting procedures
		I&T 2.3	Enhance cooperation with the RC on mineral raw materials global governance
	3. Increase of EU integration on minerals policy making and harmonising legal, administrative and fiscal policies following the best practices in the Reference Countries	I&T 3.1	Increase the capacity of EU and RC Chambers of Commerce to actively participate in information provision on materials' trade, investment and procurement
		I&T 3.2	Develop a multilateral platform on raw materials intelligence
		I&T 3.3	Periodic assessment of barriers affecting international raw materials trade
		I&T 3.4	Foster dialogues with RC on best practices on attracting investments for mineral exploration, exploitation and processing
		I&T 3.5	Create EU-RC cooperation mechanism on land use planning and environmental regulatory regimes
	4. International cooperation on technology integration, management systems and solutions	I&T 4.1	Promote an international best practices portfolio via concrete case-studies in mineral exploitation
		I&T 4.2	Periodically collect and disseminate key data (from the EU and RC) on recycling
		I&T 4.3	Define, with the RC, a harmonised methodology for collecting, processing and exchanging big data on raw materials
		I&T 4.4	Support the creation of joint ventures of METS (mining equipment, technology and services) companies from the EU and RC

Field	Pathway	Code	Action
		I&T 4.5	Establish incentives to encourage international cooperation of EU SMEs with METS from the RC
	5. Financing technological research and development in developing countries	I&T 5.1	Design and promote a co-funded mechanism for Joint Investment on ultra-deep mining technology
		I&T 5.2	Expand the action of the KIC Raw Materials to the RC
Recycling & Substitution	1. Reducing uncertainties and data gaps on secondary raw materials within the EU and internationally, with a special regard to the Reference Countries	R&S 1.1	Foster international standardisation and unification of data on recycling and secondary raw materials
		R&S 1.2	Develop shared recycling research infrastructure on a bilateral/multilateral basis focusing on the identified common priorities of EU and the RC
	2. Integrate recycling into waste management	R&S 2.1	Comparative assessment of waste management best-practices in Europe and in the RC with focus on mining waste
		R&S 2.2	Advance recommendations for the development of a common waste management policy in the EU and RC
	3. Complementing primary mineral resource databases with data on secondary raw materials in cooperation with the Reference Countries	R&S 3.1	Create a mechanism to exchange sensitive information on secondary resources and critical raw materials
		R&S 3.2	Develop an international inventory of mining waste
		R&S 3.3	Advance a global standard for data sheets of secondary materials
		R&S 3.4	Develop standards for data exchange between the EU Raw Materials Information System and equivalent databases from the RC
	4. Joint research and innovation programmes on recycling	R&S 4.1	Establish a joint multilateral EU-RC task force to harmonise policies and initiatives related to high-tech minerals of strategic importance
		R&S 4.2	Development of research and training programmes on processing of raw materials and recycling, in the frame of existing multilateral cooperation
		R&S 4.3	Periodically review recycling technologies and capabilities in the EU and in the RC
		R&S 4.4	Cooperate on extended producer responsibility (EPR) or eco-design requirements, affecting the recyclability of electronic wastes and ELV between the EU and the RC
		R&S 4.5	Facilitate scientific matchmaking and identification of research topics on recycling under existing multilateral cooperation schemes and agendas
		R&S 4.6	Establish a joint Japan-EU-US cooperative research and innovation funding programme on recycling of raw materials
	5. Cooperation on substitution research and technologies	R&S 5.1	Advance a joint research cooperation scheme in product design aiming the substitution of critical raw materials
		R&S 5.2	Advance a common international legal framework for eco-design to promote reparability, durability and recyclability of products
		R&S 5.3	Organise joint workshops on substitution of critical raw materials to facilitate the development of new multilateral cooperation schemes and agendas beyond 2020
		R&S 5.4	Establish a mobility/researcher exchange programme between the EU and RC on the substitution of critical raw materials